



# Essays on economic geography, migration and transport infrastructurg

Florin L. Cucu

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Institut d'études politiques de Paris  
ÉCOLE DOCTORALE DE SCIENCES PO  
Programme doctoral en économie  
Département d'Économie  
Doctorat en sciences économiques

# Essays on Economic Geography, Migration and Transport Infrastructure

Florin Lucian Cucu

Thesis supervised by  
Thierry Mayer, IEP de Paris  
defended on XX June 2020

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Institut d'études politiques de Paris  
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# Trois essais en géographie économique, migration et infrastructure routière

Florin Lucian Cucu

Thèse dirigée par  
Thierry Mayer, IEP de Paris  
soutenue le XX juin 2020

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# Contents

<b>Introduction</b>	<b>15</b>
<b>Résumé</b>	<b>27</b>
<b>Roads, Migration and the Spatial Sorting of US High-Skilled Workers</b>	<b>43</b>
1.1 Introduction . . . . .	45
1.2 Data and Summary Statistics . . . . .	51
1.2.1 Data Sources . . . . .	51
1.2.2 Sample Statistics and General Trends . . . . .	52
1.3 Identification Strategy . . . . .	54
1.3.1 Highway Measures and Baseline Specification . . . . .	54
1.3.2 Instrumental Variable . . . . .	55
1.4 Reduced-Form Effects of Highways on the Skill Composition . . . . .	58
1.4.1 OLS Results . . . . .	58
1.4.2 IV Results . . . . .	60
1.4.3 Migration Outcomes . . . . .	63
1.4.4 Sorting, Suburbanization and Other Robustness Checks . . . . .	64
1.5 The Theoretical Framework . . . . .	66
1.5.1 Consumer preferences . . . . .	66
1.5.2 Residential choices . . . . .	67
1.5.3 Production . . . . .	69
1.5.4 Expenditure Shares . . . . .	70
1.5.5 Aggregate Labor Income . . . . .	71
1.5.6 Housing Costs . . . . .	71
1.5.7 General Equilibrium . . . . .	71
1.6 Model Simulations . . . . .	73
1.6.1 Heterogeneous Migration Elasticities . . . . .	73
1.6.2 Heterogeneous Migration Costs . . . . .	75
1.7 Estimating the Model . . . . .	78
1.7.1 Model's Parameters . . . . .	78
1.7.2 Parameterization of Migration and Trade Costs . . . . .	78
1.7.3 Estimating the Migration Fréchet Shape Parameters . . . . .	82

1.7.4	Inverting the Model . . . . .	84
1.8	Counterfactual Experiments . . . . .	87
1.8.1	Model Predicted Reduced-Form Effects on Skill Composition . . . . .	87
1.8.2	Removing the Interstate Highway System . . . . .	88
1.8.3	Reducing Migration and Trade Costs . . . . .	91
1.8.4	Robustness Checks and Sensitivity Analysis . . . . .	93
1.9	Conclusion . . . . .	95
1.10	Appendix . . . . .	96
1.10.1	Data Description . . . . .	96
1.10.2	Literature Review . . . . .	98
1.10.3	Overview of the US Interstate Highways System . . . . .	102
1.10.4	Amenity Index . . . . .	103
1.10.5	Robustness Checks . . . . .	105
1.10.6	Existence and Uniqueness of an Equilibrium . . . . .	109
1.10.7	Generating The Hypothetical Economy . . . . .	111
1.10.8	Additional Tables . . . . .	113
1.10.9	Additional Figures . . . . .	123
1.11	Bibliography . . . . .	131
	<b>Medieval Markets and Regional Development in the Long-Run</b>	<b>137</b>
2.1	Introduction . . . . .	139
2.2	Data . . . . .	143
2.2.1	Market data . . . . .	143
2.2.2	Medieval Population Data . . . . .	144
2.2.3	Contemporary Data . . . . .	145
2.2.4	Other Data . . . . .	146
2.3	Historical Background . . . . .	147
2.3.1	The commercialization of England c. 1100-1300 . . . . .	147
2.3.2	Market Establishment and Commercialization . . . . .	148
2.3.3	Economic Decline after 1300 . . . . .	150
2.4	Local Markets and Medieval Development . . . . .	154
2.4.1	A measure for medieval wealth . . . . .	154
2.4.2	Regional economic development and market density . . . . .	154
2.4.3	Medieval economic growth and market survival . . . . .	156
2.4.4	Discussion . . . . .	158
2.5	Economic Contraction and Market Rationalization . . . . .	160
2.5.1	Population expansion and contraction as drivers of market success . . . . .	160
2.5.2	Determinants of market success . . . . .	160
2.5.3	Discussion . . . . .	165
2.6	Medieval Markets and Development in the Long-Run . . . . .	167

2.6.1	Market density and regional development . . . . .	167
2.6.2	Medieval markets and local development . . . . .	168
2.6.3	Robustness Checks . . . . .	170
2.6.4	Discussion . . . . .	172
2.7	Conclusion . . . . .	176
2.8	Appendix . . . . .	177
2.8.1	Data Description . . . . .	177
2.8.2	Literature Review . . . . .	179
2.8.3	Additional Tables . . . . .	182
2.8.4	Additional Figures . . . . .	186
2.9	Bibliography . . . . .	190
<b>Asylum Policies, International Tensions and Trade Flows</b>		<b>197</b>
3.1	Introduction . . . . .	199
3.2	Data . . . . .	203
3.2.1	Data Sources . . . . .	203
3.2.2	Descriptive Statistics . . . . .	204
3.3	Asylum Policy and Interstate Tensions . . . . .	206
3.3.1	Asylum Policies as a Tool of Foreign Policy . . . . .	206
3.3.2	Normative and Interest-Based Determinants of Asylum Policies . . . . .	207
3.3.3	International Incidents and Asylum Recognition Rates . . . . .	210
3.4	Gravity Model and Estimation . . . . .	214
3.4.1	Gravity Equation . . . . .	214
3.4.2	Estimation . . . . .	215
3.5	Asylum Policies and Trade Flows . . . . .	217
3.5.1	Baseline Results . . . . .	217
3.5.2	Results by Industry . . . . .	219
3.6	Conclusion . . . . .	223
3.7	Appendix . . . . .	224
3.7.1	Data Description . . . . .	224
3.7.2	Case Study: Turkish Refugees in Germany . . . . .	230
3.7.3	Additional Tables . . . . .	233
3.7.4	Additional Figures . . . . .	240
3.8	Bibliography . . . . .	242



# List of Figures

## Introduction

1	Spatial Sorting and Migration, 1950-2000 . . . . .	16
2	Medieval Markets and Contemporary Development in England . . . . .	17
3	Recognition Rates for Russian Asylum Seekers in Three EU Countries . . . . .	18

## Résumé

4	Concentration spatiale et migration des travailleurs qualifiés, 1950-2000 . . . . .	28
5	Marchés médiévaux et développement régional . . . . .	29
6	Taux d'admission pour les demandeurs d'asile russes dans trois pays de l'UE . . .	30

## Roads, Migration and the Spatial Sorting of US High-Skilled Workers

1.1	Migration by Distance and Mode of Transportation . . . . .	46
1.2	Educational Outcomes by Urban Status . . . . .	53
1.3	Constructing the Orientation-Based Instrument . . . . .	56
1.4	Treatment Effects under Heterogeneous Migration Elasticities . . . . .	74
1.5	Treatment Effects under Heterogeneous Migration Costs . . . . .	76
1.6	Distribution of Productivity and Amenities . . . . .	85
1.7	Migration and Trade Costs Based on Distance . . . . .	90
1.8	Distribution of Welfare Losses if IHS Is Removed . . . . .	91
1.9	Primary Interstate Highways and Metropolitan Areas, 2000 . . . . .	123
1.10	The Interstate Highway System . . . . .	124
1.11	Modeling the Economy . . . . .	125
1.12	Treatment Effects for Heterogeneous Migration Elasticities . . . . .	126
1.13	Treatment Effects for Heterogeneous Mobility Costs . . . . .	127
1.14	Distribution of Productivity and Amenities . . . . .	128
1.15	Migration and Trade Costs Based on Travel Times . . . . .	129
1.16	Distribution of Welfare Losses if IHS Is Removed . . . . .	130

## Medieval Markets and Regional Development in the Long-Run

2.1	Evolution of Medieval Markets, 1200-1350 . . . . .	149
2.2	Market Towns by 1600 . . . . .	152
2.3	Medieval Markets and Late Medieval Growth . . . . .	155
2.4	Population Change and Market Dynamics . . . . .	161

2.5	Distribution of Distance to Nearest Leading Town . . . . .	165
2.6	Nighttime Lights and Market Survival in Northumberland . . . . .	173
2.7	CDFs for Main Variables by Urban and Surviving Status . . . . .	186
2.8	Nighttime Lights . . . . .	187
2.9	Nighttime Lights, Population Density and GDP per capita . . . . .	188
2.10	Cells with Surviving/Failed Medieval Markets . . . . .	189

### **Asylum Policies, International Tensions and Trade Flows**

3.1	Evolution of Asylum Applications in the EU . . . . .	200
3.2	National Trade Shares for Different Categories of Goods . . . . .	220
3.3	Sources of Missing Recognition Rates . . . . .	228
3.4	Recognition Rates for Turkish Asylum Seekers in Germany . . . . .	231
3.5	Annual Average Statistics . . . . .	240
3.6	Annual Trade Shares for Different Categories of Goods . . . . .	241

# List of Tables

## Roads, Migration and the Spatial Sorting of US High-Skilled Workers

1.1	OLS Regressions of the Determinants of MSA College Share, 1950 – 2000 . . . . .	59
1.2	IV Regressions of the Determinants of MSA College Share, 1950 – 2000 . . . . .	61
1.3	Regressions of the Impact of Highways on Migration, 1950 – 2000 . . . . .	64
1.4	Impact of Highways on the College Share in Central Cities and their Suburbs . . .	65
1.5	Parameter Values . . . . .	79
1.6	Migration and Trade Gravity Equations . . . . .	80
1.7	Estimating the Fréchet Shape Parameters . . . . .	83
1.8	Model-Predicted Effects of Highways on the College Share . . . . .	88
1.9	Average Welfare Impact of Removing the Interstate System . . . . .	89
1.10	Welfare Effects under Different Counterfactuals . . . . .	92
1.11	Principal Component Analysis for Amenity Indices . . . . .	104
1.12	Summary Statistics by Year . . . . .	113
1.12	Summary Statistics by Year (continued) . . . . .	114
1.13	Annual Average Mileage in Major and Minor MSAs . . . . .	114
1.14	Regressions of the Impact of Highways on the Number of Workers . . . . .	115
1.15	First Stage Results of IV Regressions . . . . .	116
1.16	IV Regressions with Alternative Instruments . . . . .	117
1.17	OLS and IV Results for Different Samples . . . . .	118
1.18	Additional Robustness Checks . . . . .	119
1.19	Migration and Trade Gravity Equations . . . . .	120
1.20	Estimating the Fréchet Shape Parameters . . . . .	120
1.21	Average Welfare Impact of Removing the Interstate System . . . . .	121
1.22	Welfare Effects under Different Counterfactuals . . . . .	121
1.23	Robustness Checks Counterfactuals . . . . .	122

## Medieval Markets and Regional Development in the Long-Run

2.1	Medieval Markets by Type, Region and Year of Establishment . . . . .	151
2.2	Medieval Markets and Late Medieval Growth . . . . .	158
2.3	Determinants of Market Survival . . . . .	163
2.4	Medieval Markets and Long-Run Growth . . . . .	168
2.5	Medieval Markets and Long-Run Growth . . . . .	170

2.6	Medieval Market Locations – Descriptive Statistics . . . . .	182
2.7	Medieval Markets and Long-Run Growth . . . . .	183
2.8	Medieval Markets and Long-Run Growth – Robustness Checks . . . . .	184
2.9	Medieval Markets and Long-Run Growth - Alternative Classifications . . . . .	185

**Asylum Policies, International Tensions and Trade Flows**

3.1	Recognition Rates for Turkish Asylum Seekers . . . . .	201
3.2	Normative and Interest-Based Determinants of Asylum Policies . . . . .	209
3.3	International Incidents and Asylum Policies . . . . .	211
3.4	Asylum Policies and International Trade Flows . . . . .	218
3.5	Asylum Policies and European Imports by Industry . . . . .	221
3.6	Asylum Policies and European Exports by Industry . . . . .	222
3.7	Event Classes and Categories in the GDELT Database . . . . .	226
3.8	Determinants of Missing Recognition Rates . . . . .	229
3.9	List of Countries . . . . .	233
3.10	Summary of Events . . . . .	234
3.11	Normative and Interest-Based Determinants of Asylum Policies – Robustness Checks	235
3.12	International Incidents and Asylum Policies – Finer Classification of Events . . . .	236
3.13	International Incidents and Asylum Policies – Robustness Checks . . . . .	237
3.14	Asylum Policies and International Trade Flows – Results on Persistence . . . . .	238
3.15	Asylum Policies and International Trade Flows – Robustness Checks . . . . .	239

# Introduction

One of the recurrent empirical findings in economic geography is the remarkable variation in economic development across space. The ten richest countries account for more than two thirds of the world's GDP and half of its population. Yet, those same ten countries make up less than a third of the world's land area (The World Bank, 2020). In addition to considerable cross-state differences, economic activity is highly concentrated within countries as well. In the United States (US), counties within 80 kilometers of an ocean or the Great Lakes coast account for 51% of the national population, 57% of civilian income but only 13% of the continental land mass (Rappaport and Sachs, 2003). This dissertation proposes three studies analyzing the factors driving variation in the spatial distribution of economic activity and its persistence over time.

The first chapter examines the spatial concentration of US high-skilled workers. Over the last several decades, urban areas with an initially higher share of college graduates further expanded their graduate population, while simultaneously experiencing higher wage and rent growth. The divergence in the location of high-skilled and low-skilled workers had important implications for welfare inequality (Moretti, 2013; Diamond, 2016) and may have generated substantial welfare costs insofar as the resulting distribution was inefficient (Fajgelbaum and Gaubert, 2020). Achieving a better understanding of how heterogeneous workers sort across locations is therefore essential in order to mitigate inequality and design optimal spatial policies.

The geographic concentration of skilled workers went hand in hand with an increase in the sorting of internal migrants. As fig. 1 below illustrates, there is a strong and positive correlation between changes in the college share from 1950 to 2000 and changes in the share of graduates among migrants arriving in a city. In other words, metropolitan areas with larger increases in their college share attracted disproportionately more high-skilled migrants than other locations. This suggests that internal migration was an important part of the geographic sorting of college graduates.<sup>1</sup>

Building on these stylized facts, the first chapter establishes a relationship between geographic sorting and improvements in market access, as measured through better highway connections to the transport network. Duranton and Turner (2012) show that the construction of the Interstate Highway System (IHS) had a large, positive impact on subsequent urban growth. An increase of 10% in a city's initial stock of highways led to an increase in employment of 1.5% over the next 20 years. I complement their results by showing that the IHS also affected the skill composition of

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<sup>1</sup>Differences in the local production of skill could also explain asymmetric gains in graduate shares. However, I find that changes in the college share are only moderately correlated with changes in college enrollment rates.

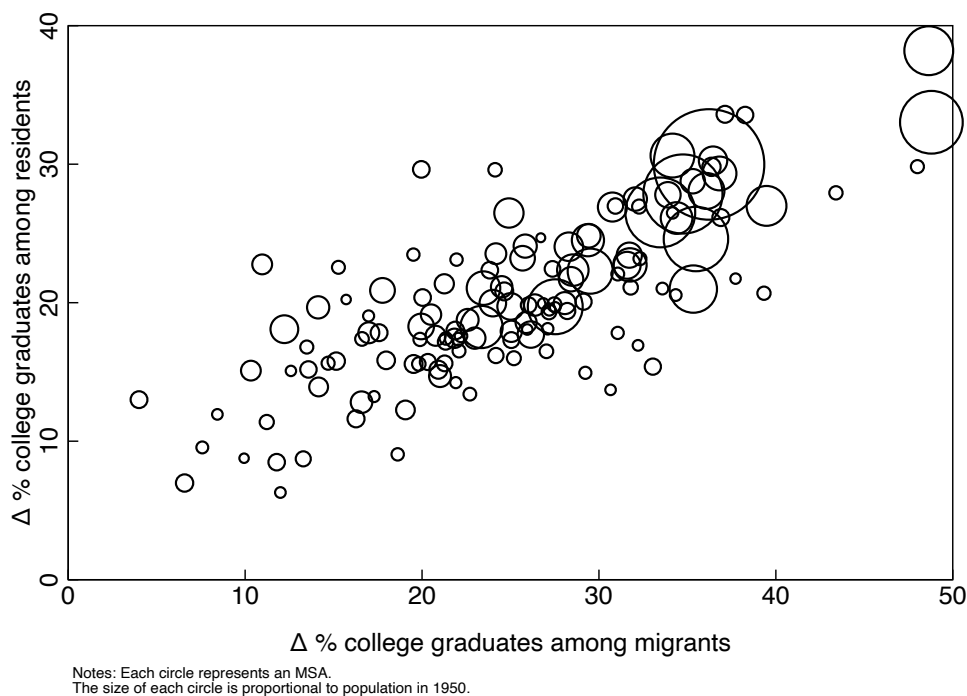


Figure 1: Spatial Sorting and Migration, 1950-2000

metropolitan areas and, in particular, the skill mix of incoming migrants.

The second chapter deals with the persistence of regional patterns of development over the course of many centuries. Following the seminal work of Davis and Weinstein (2002), a growing body of literature has shown that the spatial distribution of economic activity is highly resilient, even in the face of large negative shocks like wars or pandemics. For instance, the massive bombing of Japanese cities during World War II had no long-run effects on the distribution of population, with most cities returning to pre-war growth trends by 1965.

My contribution to this literature is to show that today's distribution of economic activity in England and Wales has medieval origins. From 950 to 1350, long-distance trade increased significantly in Western Europe, prompting historians to evoke a Commercial Revolution (Lopez, 1976). Even though economists have paid less attention to it, internal trade was expanding considerably at that same time. The need to accommodate higher volumes of transactions led to the emergence of new forms of organization. In England, institutional innovation materialized into the proliferation of weekly markets that catered to local communities of buyers, food producers, craftsmen and merchants (Britnell, 1996).

Not all markets were destined to become important trade centers and many of them disappeared following the severe population contraction of the fourteenth century. By 1600, only one in three markets established in the middle ages was still functioning. The legacy of surviving markets was nonetheless long-lasting. As Figure 2 demonstrates, modern population density correlates highly with the number of surviving medieval markets.

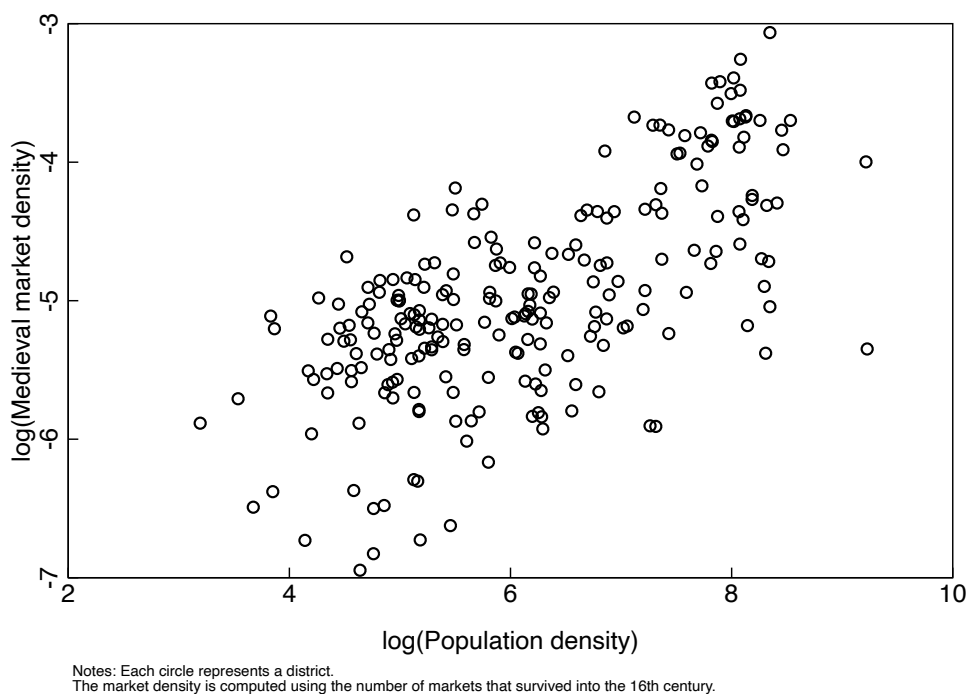


Figure 2: Medieval Markets and Contemporary Development in England

The third chapter of this dissertation addresses the determinants of a specific type of international migration, namely refugee flows, and, political economy considerations that shape admission policies in the European Union (EU). The EU remains one of the main destinations for asylum seekers. During the 2008-10 period, the EU-15 member states received 25% of the world total of asylum applications (Chin and Cortes, 2015).<sup>2</sup> The processing of these demands, however, varied across states, such that asylees from the same country of origin faced different probabilities of being granted refuge depending on the country where they filed their demand.

As an example, Figure 3 plots recognition rates for Russian asylum seekers in three destination countries: France, Germany and Great Britain. The recognition rates correspond to the fraction of processed applications that led to the grant of refugee status. Despite receiving similar numbers of demands (approximately 4300 applications per year), recognition rates were 8.5 percentage points higher in France than in Germany. Great Britain received much fewer applications throughout the entire period (225 per year), yet its recognition rates were significantly lower from 2002 to 2007. In 2008, admission rates surged and remained higher than in France and Germany for the remainder of the period. The different treatment of asylum applications from the same country of origin raises the possibility that non-humanitarian factors, such as strategic interests or national security concerns, play an equally important role in determining who gets to stay and who does not.

In this chapter, co-written with Ludovic Panon, we argue that asylum policies are informed by diplomatic considerations. Our study builds on previous work in the political science literature

<sup>2</sup>The EU-15 consists of all EU member states prior to the 2004 enlargement: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.

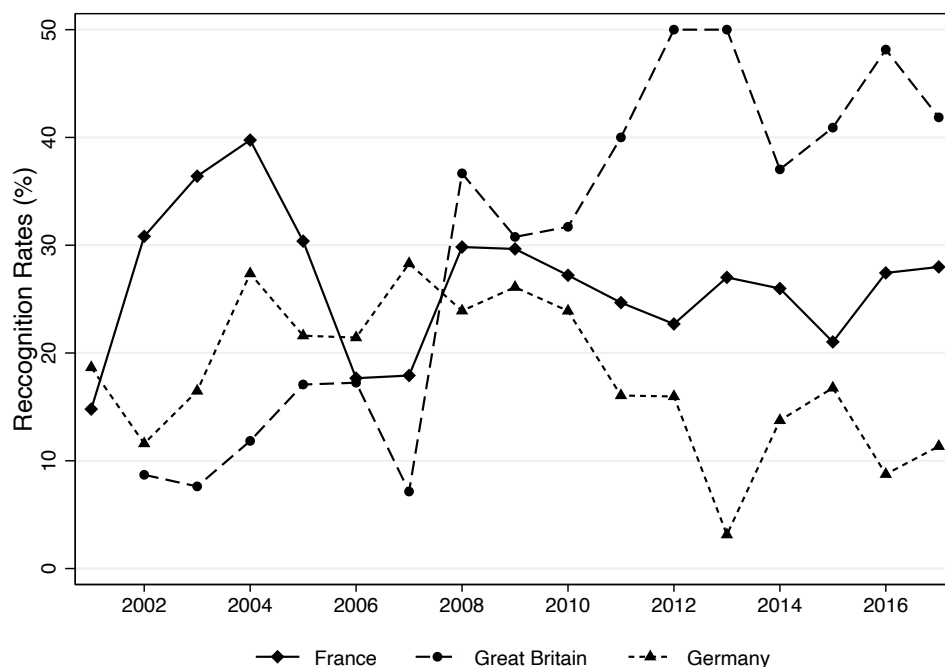


Figure 3: Recognition Rates for Russian Asylum Seekers in Three EU Countries

that highlights the intricate relationship between refugee admissions and international relations. In brief, for similar levels of conflict and political terror in the seconding country, governments are more likely to admit refugees from rival countries than from partner states. The chapter also highlights the potential of international tensions to confound the estimated relationship between international trade and migration flows.

## Chapter 1: Roads and the Spatial Sorting of US Workers

Improvements in the transportation infrastructure have far-reaching effects on the distribution of economic activity (see Redding and Turner, 2015 for a review of this literature). Existing empirical studies have shown that the construction of the IHS in the US shaped inter-regional trade flows (Duranton, Morrow, and Turner, 2014), boosted urban growth (Duranton and Turner, 2012), facilitated suburbanization (Baum-Snow, 2007), led to regional specialization (Chandra and Thompson, 2000), increased the demand for skill in rural areas (Michaels, 2008) and spurred innovation (Agrawal, Galasso, and Oettl, 2017). This chapter provides evidence that a better transport infrastructure can also affect the skill composition of urban areas and, in particular, the skill composition of migrant flows.

Recent work in economic geography has highlighted the importance of spatial linkages in determining the allocation of economic activity. Improvements in the transport infrastructure, through their effect on the geography of trade and migration costs, have the potential to generate significant

redistributions of population. Using a quantitative spatial model, Redding (2016) demonstrates that insofar as some regions experience larger reductions in trade costs than others (for instance, they have better connections to the road network), population reallocates to these locations and away from others. These effects, however, need not be homogeneous across skill groups. Workers may differ in their migration elasticities, such that similar changes in real wages lead to asymmetric migration responses. Migration costs may be skill-specific as well. In particular, low-skilled workers could face higher barriers to mobility. These considerations imply that the migration responses of high and low-skilled workers to an improvement in the transport infrastructure may be significantly different. If that were the case, the aggregate welfare effects documented in the literature mask significant heterogeneity.

The contribution of this chapter is to highlight the distributional effects of transportation infrastructure. In particular, I provide evidence of a causal effect of the construction of the IHS on the well-documented geographic sorting of high-skilled workers. I also estimate the parameters governing the migration patterns for different skill groups and, using a quantitative spatial model, quantify the welfare gains that accrued to each. Finally, I follow Morten and Oliveira (2014) and decompose these effects into trade and migration components. This allows me to identify the mechanisms accounting for the increase in welfare inequality.

The first part of this chapter estimates the reduced-form effect of interstate highways on the fraction of residents of a metropolitan statistical area (MSA) who graduated from college. To this aim, I construct a database of 307 MSAs for which I observe educational, socio-economic and transport infrastructure outcomes in every Census year from 1950 to 2000. Since the allocation of roads is likely endogenous to local labor markets, I make use of two instrumental variables. The first instrument, based on Baum-Snow (2007), corresponds to the number of interstates in an initial plan from 1947 that would be open to traffic if local construction rates were equal to national rates. All specifications includes MSA-specific fixed effects. This implies that identification comes from within-city variation in the number of highways over time. Arguably, national construction rates are orthogonal to local labor markets. The exogeneity condition of the instrument is therefore likely to hold. The second argument, based on Michaels (2008), exploits the geographic orientation of the interstate network. Specifically, the IHS follows a north-south and east-west orientation. Moreover, it was designed to connect the major urban and industrial centers of the 1940s. I conjecture that being oriented east-west or north-south relative to a better connected major city increases the probability that a smaller-sized MSA was allocated a higher number of interstates. The instrument then becomes the aggregate stock of highways in the two nearest major MSAs oriented east-west and north-south, respectively. Since the number of instrumental variables exceeds the number of endogenous variables, I can perform standard over-identification tests. Passing the Sargan-Hansen over-identification test would mean that either both instruments are valid or they are both invalid and there is a systematic correlation between the instruments and the error terms. Given that the instruments build on different rationales, this last scenario seems very unlikely.

Regressions of the college share on the number of interstate highways yield positive and highly

significant coefficients. The ordinary least squares (OLS) estimator produces a coefficient of approximately 0.4 and significant at 1%. To address concerns about the endogeneity of transport infrastructure, I also present results from instrumental variable (IV) regressions. IV estimates are slightly larger: an additional interstate highway caused a 0.6 percentage point increase in the college share. The difference between OLS and IV suggests a downward bias of the former. This is consistent with Duranton and Turner (2012)’s finding that locations experiencing negative employment shocks were allocated a higher number of highways. Equally important, I provide evidence that interstates led to increased geographic sorting among migrants. The share of college graduates among the residents born in a different state increased by 0.8 percentage points with each additional highway. Lastly, over-identification tests produce  $p$ -values well above 0.1. I cannot reject the null hypothesis that my instruments are jointly valid.

In order to quantify the welfare gains associated with the construction of the IHS, the second part of this chapter introduces a quantitative spatial model featuring heterogeneous workers. The model assumes two types of workers, high-skilled and low-skilled, who differ along two fundamental dimensions. First, even though both types are geographically mobile, each worker appreciates the quality of life in a city in a different way. The model assumes that both the average and the dispersion in these individual preferences are specific to every skill category, implying asymmetric migration elasticities across workers. Second, whenever workers decide to relocate to another city, they incur a bilateral migration cost. Following Monte, Redding, and Rossi-Hansberg (2018) and Morten and Oliveira (2014), these costs take the iceberg form and are expressed in terms of utility. They are assumed to include not only the monetary costs of moving and subsequent visits, but also the psychological costs of living away from one’s family and friends. Importantly, migration costs may depend on the existing road infrastructure and are skill-specific.

Taking the model to the data requires a parameterization of trade and migration costs. I assume that bilateral costs are a function of geographic distance, with the elasticity depending on the number of highways connecting the MSAs of origin and destination to the national road network. I estimate the parameters governing migration decisions using data on inter-metropolitan flows from the 2000 Census. Finally, I use the quantitative framework to recover the local productivity and amenity levels that rationalize the observed distribution of economic activity. Armed with these quantities, I use the model to undertake several counterfactual experiments.

The first exercise seeks to assess the performance of my theoretical model. To this aim, I use estimates of the migration and trade costs from 1950 to 2000 and search for the distribution of population that satisfies the equilibrium conditions of the model. This allows me to construct a sample of counterfactual populations and estimate the effect of highways on the college share as predicted by the theoretical framework. The resulting coefficient is of the same order of magnitude as the one obtained using real data. Specifically, the quantitative model is able to replicate 60% of the observed effect.

The second exercise considers a hypothetical removal of the IHS and computes the ensuing welfare losses for both types of workers. I find that high-skilled workers would experience a decline

in average welfare of 12.5%, whereas low-skilled workers would lose 11.75%. While these effects are large, they are in line with findings in Morten and Oliveira (2014) and Fajgelbaum and Redding (2014). Decomposing the losses into trade and migration components reveals an interesting pattern. Higher trade costs lead to similar losses for both types of workers. This is due to the assumption that both types of workers spend the same share of their income on tradable goods. Consequently, higher prices will affect them to the same degree. Bigger migration costs, on the other hand, have a larger impact on high-skilled workers. Intuitively, high-skilled workers are more likely to migrate to begin with and thus more likely to incur the higher costs of relocating. I also confirm Morten and Oliveira (2014)’s finding that the trade component accounts for the largest share of the welfare effects arising from improved transport infrastructure.

In summary, this chapter provides evidence that improvements in the transport infrastructure affect the allocation of workers across cities, but do so in a different way depending on the type of workers. Further, the welfare gains depend on the mobility of different skill groups. Insofar as low-skilled workers face greater barriers to inter-regional mobility (and are therefore less likely to migrate), improvements in the transport infrastructure will yield greater benefits to high-skilled workers and amplify existing welfare inequality.

## Chapter 2: Medieval Markets and Persistence

One of the objectives of economic geography is to understand what determines the spatial distribution of economic activity. Three main theories have emerged. One class of models puts the emphasis on locational fundamentals, also referred to as “first-nature” characteristics. According to these theories, variation in natural endowments, such as suitability for growing food, or access to international markets are responsible for the spatial divergence in development (see, for instance, Rappaport and Sachs, 2003 or Henderson, Squires, Storeygard, and Weil, 2018). The distribution of economic activity can evolve only if these first-nature characteristics change or their economic relevance becomes obsolete. Temporary shocks, irrespective of their magnitude, are inconsequential insofar as locations with better fundamentals experience faster recovery. A second class of models shows that a distribution of locations of different sizes can result from stochastic processes (Simon, 1955; Gabaix, 1999). Even temporary shocks have persistent effects and the population distribution follows a random walk. Finally, a third class of models advances an explanation based on “second-nature” characteristics. These are endogenous to growth and are the result of agglomeration economies (Krugman, 1991a,b). The specificity of these models is the possibility of multiple equilibria. A shock can have permanent effects if it shifts the economy from one equilibrium into another. Increasing returns theories also highlight the potential for path dependence in accounting for spatial divergence; an early start may explain why economic activity concentrated in some locations and failed to do so in others.

The second chapter of this dissertation speaks to this literature and studies growth over many centuries in England and Wales. The framework adopted in this study presents several advantages

over existing work. By focusing on a relatively homogeneous area, one can rule out “deep” factors like biodiversity, institutions, technology, ancestry or genetic distance as the main determinants of spatial inequality (for a review of this literature, see Spolaore and Wacziarg, 2013). Further, the proliferation of medieval markets predates most of the events highlighted in the literature as having had a positive contribution to England’s rise to riches, such as the opening to Atlantic trade (Acemoglu, Johnson, and Robinson, 2005) or the Industrial Revolution (Mokyr, 2005). Comparing regional development today with medieval patterns of growth has the potential to uncover remarkable persistence over time, despite the many negative shocks (famines, pandemics, wars) and technological innovations that separate the two periods.

In order to estimate the degree of persistence over time, this study exploits both medieval and contemporary data. I utilize the Gazetteer of markets and fairs from c. 900 to 1516 (Letters, Fernandes, Keene, and Myhill, 2004) to construct a data set of medieval markets. For every location, I observe the year its market was established, the assessed value in the 1334 lay subsidy and whether the market was still functioning in the sixteenth century. Overall, I identify more than 2,000 local markets founded in the late middle ages. I also use data from the Office for National Statistics to measure contemporary development at the regional level. The use of these data raises, nonetheless, concerns about the endogeneity of administrative boundaries. To address them, I divide England and Wales into a grid of 5-by-5-kilometer cells. Because output or population data is not available at this level, I follow Henderson, Storeygard, and Weil (2012) and use the average nighttime light intensity as a proxy for local development. The quantitative analysis then proceeds in three steps.

A relative peace, good weather and a growing money supply in the twelfth and thirteenth centuries provided auspicious conditions for commercial expansion (Langdon and Masschaele, 2006). The number of licensed markets exploded during this period, leading historians to conclude that the English economy was undergoing a process of swift commercialization (Britnell, 1996). I empirically validate this assertion using tax valuations in the 1334 lay subsidy as a measure of agricultural output. Consistent with the historical argument, I find a positive correlation between market establishment and agricultural productivity; more markets were established in counties with a higher valuation per square mile. To further the argument, I exploit the availability of tax assessments at the city level and estimate growth rates prior to 1334. The results are striking. Places with a market that survived into the sixteenth century grew at an annual rate of 0.3 – 0.4% whereas locations with a failing market stagnated.

In contrast to the expansion of commerce of the preceding centuries, the fourteenth century marked a severe downturn, with famines, wars and disease decimating England’s population. In a context of falling demand, many of the newly established markets disappeared. The second step of my analysis seeks to understand the determinants of a market’s success. I consider the effect of both first-nature (i.e. geographic characteristics and access to transportation infrastructure) and second-nature variables (i.e. distance to nearest major urban center) as well as of institutional characteristics on a market’s success. Surprisingly, I find that most first-nature characteristics are not correlated with the probability of survival. Only the terrain ruggedness index enters the

regressions with coefficients that are marginally significant. Second-nature characteristics, on the other hand, have a statistically significant impact on the survival of markets. Proximity to a major trade center is associated with a lower probability of survival, reflecting the effect of tougher spatial competition. Finally, institutional characteristics also played an important role in ensuring market success; markets located in wealthier urban locations were more likely to survive into the sixteenth century.

How do the regions with a higher number of successful medieval markets fare today? In the last step of my analysis, I show that contemporary regional population density and per capita gross value added correlate highly with the density of surviving markets. The correlation with the density of failed markets is negative but statistically insignificant. Moreover, using the grid partition of England and Wales, I show that both urban and rural cells with a successful medieval market emit, on average, 33% more light at night than similar cells with a failed market. The results are robust across a variety of specifications and the inclusion of local fixed effects.

While the results in this chapter rely mostly on OLS regressions and do not warrant a causal interpretation, there are several mechanisms that could account for a positive impact of local markets on subsequent growth. First, by providing regular trading venues, local markets could have reduced transaction costs and increased price transparency. It is perhaps not a coincidence that England, who developed a network of markets much earlier than its continental neighbors, exhibited less variation in wheat prices (and hence higher market integration) on the eve of the Industrial Revolution (Shiue and Keller, 2007). Second, markets could have increased competition, spurred innovation and facilitated the adoption of cost-saving technologies (Desmet, Greif, and Parente, 2019). As a consequence, historically sunk investments could have been larger in locations with a surviving market. Insofar as these investments have not fully depreciated, they could continue to have a positive impact on development nowadays. Thirdly, in models with multiple equilibria, there is an indeterminacy between locations that are similar in terms of locational fundamentals. Local markets could have acted as a coordination device, much like portage did in the US (Bleakley and Lin, 2012), cities founded by administrative fiat in Sweden (Cermeño and Enflo, 2019) or treaty ports in China (Jia, 2014).

The evidence presented in this chapter points toward high persistence in the regional distribution of economic activity over the last 800 years. How does this fit with the theories described above? The high degree of persistence is at odds with theories of random growth. Despite the numerous shocks that have affected Britain since the middle ages, none appears to have shifted the distribution of economic activity in a meaningful way: the most commercialized locations in the middle ages continue to emit more light today. This finding is consistent, on the other hand, with theories of locational fundamentals and increasing returns to scale. The lack of a significant relationship between first-nature characteristics and market survival raises nonetheless concerns about the ability of locational fundamentals to explain persistence. Furthermore, it is questionable whether their relevance was constant over time. Michaels and Rauch (2018), for instance, show that following the fall of the Roman Empire, the urban network in Britain reset and favored

locations with coastal access (either direct or through rivers) over access to Roman roads. Path dependence would appear as the most likely explanation for the patterns described in this study.

## **Chapter 3: Asylum Policies and International Tensions**

**co-author: Ludovic Panon**

Already in the 1980s, political scientists voiced their suspicion that “the granting or withholding of refugee status had become an instrument of the receiving state’s diplomacy toward the sending state” (Scheinman, 1983). In a similar vein, Teitelbaum (1984) argued that the admission of political refugees was often construed by host countries as a denunciation of flagrant human rights violations in the sending countries and used to discredit them. Further, receiving refugees could lead to the emergence of opposition movements in exile and deprive a rival country of part of its human capital. By a similar argument, a government should be reluctant to grant asylum to individuals fleeing friendly states. Such grants would have the potential to compromise good diplomatic relations with a partner. Domestic opposition groups could also present them as evidence of complicity with a regime that the government’s own bureaucracy considers oppressive.

History abounds of anecdotal evidence supporting this view. During the Cold War, the US gave preferential treatment to refugees fleeing the Communist Bloc, while showing greater reluctance to admit refugees from countries to which the US was providing military and police assistance, like Guatemala, El Salvador or Haiti (McBride, 1999; Salehyan and Rosenblum, 2008). In the late 1990s, Tanzania accepted more readily refugees from Burundi than from neighboring Rwanda. Jacobsen (2002) argues that this was due to Tanzania’s more cordial relationship with Rwanda than with Burundi. More recently, several studies have offered quantitative evidence of the importance of diplomatic considerations in shaping asylum policies, including Rosenblum and Salehyan (2004) and Jackson and Atkinson (2019).

Building on these intuitions and results, we estimate the relationship between several asylum policy outcomes and measures of interstate relations for 28 European countries receiving refugees from the rest of the world from 1999 to 2017. For each origin and destination pair, we observe the number of applications processed in a given year and the number of positive decisions. Using this information, we compute recognition rates. Recognition rates thus provide us with a measure of the generosity of a country’s refugee policy toward asylum seekers from a given origin. Concerning diplomatic relations, we first consider two measures widely used in the literature: an index of voting similarity in the United Nations (UN) General Assembly and an indicator variable that takes the value 1 if a free trade agreement exists between the origin and destination countries. We also use the occurrence of international incidents, whether disputes or agreements, as shocks to bilateral relations.

Our regression estimates confirm previous findings that asylum policies are sensitive to measures of international rivalry. While asylum seeker flows do not appear to correlate in a significant fashion with any of our bilateral measures of tensions, the number of admitted refugees declines with greater UN voting similarity and in the presence of a free trade agreement. An increase of ten percentage

points in the probability of voting along similar lines in the UN General Assembly is associated with a decline in recognition rates of 0.65 percentage points; free trade agreements further reduce this rate by approximately 2 percentage points. We also find that international disputes lead to higher approval rates. For each conflict, the recognition rate is estimated to increase by 0.4 percentage points. In contrast, admission rates are estimated to decrease by 0.1 with each episode of cooperation.

Several points should be made at this point. First, even though our analysis puts the emphasis on political economy considerations, we do not claim that humanitarian concerns are not an important determinant of asylum policies. In fact, we provide evidence that both refugee flows and recognition rates are correlated with measures of conflict and political terror in the asylees' country of origin. Rather, our argument is that, conditional on humanitarian conditions in the sending country, host countries are more likely to admit refugees from a rival than from a partner state. Second, our results are robust to the inclusion of country-pair fixed effects, meaning that our estimates are not confounded by time-invariant bilateral characteristics, such as cultural, historical or linguistic proximity. Third, we invite to caution when interpreting our results in a causal way and admit that the relationship between humanitarian crises, international tensions and asylum policies is more complex than modeled here. In many instances, refugee-producing events have a direct effect on bilateral tensions. For instance, after the 2016 failed coup d'état, Turkey proceeded to massive purges and arrests of human rights activists. This heightened tensions with Germany. Unsurprisingly, recognition rates also surged in the latter for Turkish asylum seekers. Such considerations, however, do not weaken our argument but highlight the strong relationship that exists between strategic interests and asylum policies.

The second part of the chapter stresses the importance of accounting for political economy factors when studying the effect of refugees, and migration more broadly, on international trade. An impressive number of articles document a positive contribution of migrants to international trade flows (see, for instance, Gould, 1994, Head and Ries, 1998 and Rauch and Trindade, 2002). Recently, a number of papers have used the random allocation of refugees as an instrumental variable for migrant stocks in order to estimate causal effects (Parsons and Vézina, 2018; Steingress, 2018).

In sharp contrast with these previous studies, we find a negative, robust and statistically significant correlation between asylum policies and aggregate imports into the European Union. A ten percentage point increase in recognition rates is associated with a decline in imports of roughly 0.5%. The effect, however, is not persistent and fades away after 2-3 years. Importantly, we do not find evidence of a contemporaneous response of export flows to changes in asylum policies.

The literature has identified two main channels through which migrant networks affect international trade flows. First, there is the preference channel. Migrants bring with them preferences that are biased towards goods produced in their countries of origin. Their desire to consume ethnic products will raise imports into the destination country. Second, the transaction cost channel assumes that migrant networks help disseminate information about specific market characteristics, assure better contract enforcement and reduce search costs. This channel is more relevant

for trade in differentiated goods, where search frictions are arguably higher (Rauch, 1999). Both mechanisms imply a positive contribution of migrants to international trade, although the effects are depend on the direction of trade (imports versus exports) and the type of goods (homogeneous versus differentiated). Our analysis shows that higher refugee admissions may also reflect interstate tensions, whose negative impact on trade is well-documented. The relationship between trade and asylum policies will correspond to the sum of these effects and its sign will depend on which effect is stronger.

In order to assess the relevance of these mechanisms, we separately estimate the gravity equation for different types of goods. We find a negative and statistically significant coefficient only for trade in homogeneous goods. We suggest that, for this type of products, the preference and transaction cost channels have only a limited scope. The point estimate will thus capture the negative effect of interstate rivalries.

International tensions have a negative impact on international trade flows (see Fuchs and Klann, 2013 or Michaels and Zhi, 2010). The underlying mechanisms explaining this effect are less well understood. Trade flows may decline as a result of a reduction in imports by state-owned enterprises (Davis, Fuchs, and Johnson, 2019). A climate of distrust may reduce the incentives of private firms to contract with foreign entities. Consumers may also boycott products from rival countries (Pandya and Venkatesan, 2016). While the available data do not allow us to distinguish between these alternative mechanisms, we provide tentative evidence by estimating the gravity equation at the industry level. We only find significant effects for trade in crude materials (SITC 2), animal and vegetables oils, fats and waxes (SITC 4) and manufactured goods (SITC 6). While caution is required in interpreting these results, it would seem that consumer boycott plays only a marginal role in explaining our findings.

To conclude, this chapter documents a robust and significant correlation between asylum policies and international tensions. It also emphasizes the possibility that the latter confound the relationship between migration and international trade. This suggests that using refugees as an instrumental variable for migration may not satisfy the exclusion restriction in more general setups.

# Résumé

Les recherches empiriques en géographie économique mettent en avant la répartition inégale de la richesse et du développement dans l'espace. Les dix pays les plus riches représentent plus des deux tiers du PIB mondial et la moitié de la population totale. Pourtant, ces mêmes dix pays occupent moins d'un tiers du total des terres de la planète (Banque mondiale, 2020). Outre des différences considérables entre États, des inégalités très élevées s'observent au sein des pays également. Aux États-Unis, les comtés situés à moins de 80 kilomètres d'un océan ou de la côte des Grands Lacs représentent 51 % de la population totale, 57 % des revenus mais seulement 13 % de la superficie du pays (Rappaport et Sachs, 2003). Cette thèse propose trois études qui analysent les déterminants de la répartition spatiale de l'activité économique et sa persistance dans le temps.

Le premier chapitre examine la concentration spatiale des travailleurs hautement qualifiés aux États-Unis. Au cours des dernières décennies, les zones urbaines qui comptaient au départ une proportion plus élevée de diplômés de l'enseignement supérieur ont vu leur population de diplômés augmenter davantage, tout en connaissant une plus forte croissance des salaires et des loyers. La sélection spatiale des travailleurs a eu des conséquences importantes en termes d'augmentation des inégalités (Moretti, 2013; Diamond, 2016) et pourrait avoir causé des pertes substantielles dans la mesure où la répartition géographique qui en a résulté était inefficace (Fajgelbaum et Gaubert, 2020). Il est donc essentiel de mieux comprendre comment des travailleurs hétérogènes choisissent leur résidence afin d'atténuer les inégalités territoriales et mettre en application des politiques régionales optimales.

La concentration géographique des travailleurs qualifiés est allée de pair avec une sélection plus forte des migrants internes. Comme le montre la fig. 4 ci-dessous, il existe une corrélation positive entre l'évolution de la part des résidents ayant un diplôme universitaire et la part des diplômés parmi les migrants internes. Autrement dit, les zones métropolitaines dont la population diplômée a augmenté plus vite de 1950 à 2000 ont attiré un nombre disproportionné de migrants hautement qualifiés. Cela suggère que la migration interne a joué un rôle important dans l'augmentation des inégalités dans la répartition spatiale des travailleurs qualifiés.<sup>3</sup>

Afin d'expliquer ces tendances, le premier chapitre établit une relation de causalité entre les améliorations de l'infrastructure routière et la sélection spatiale des migrants hautement qualifiés

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<sup>3</sup>Les différences dans la production locale des diplômés pourraient également expliquer ce phénomène. Cependant, je constate que l'évolution de la part des diplômés n'est que moyennement corrélée avec l'évolution des taux d'inscription à l'université.

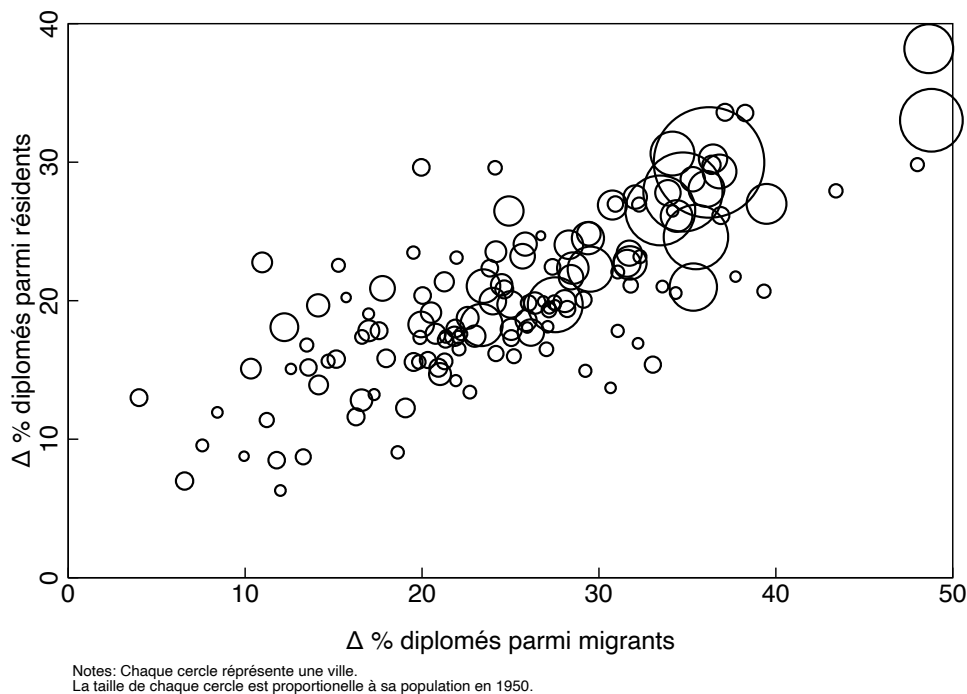


Figure 4: Concentration spatiale et migration des travailleurs qualifiés, 1950-2000

aux États-Unis. Duranton et Turner (2012) montrent que la construction du Système d'Autoroutes Inter-États (l'Interstate Highway System) a eu un impact positif sur la croissance urbaine. Une augmentation de 10 % du stock initial d'autoroutes d'une ville a entraîné une augmentation de l'emploi de 1,5 % au cours des 20 années suivantes. Je contribue à cette littérature en montrant que la construction des autoroutes inter-États a également affecté la composition des zones métropolitaines et, en particulier, la composition des flux migratoires internes.

Le deuxième chapitre traite de la persistance du développement régional pendant plusieurs siècles. Suite aux travaux de Davis et Weinstein (2002), plusieurs études ont montré que la répartition spatiale de l'activité économique résiste même à des chocs négatifs importants, comme des guerres ou des pandémies. Par exemple, le bombardement massif des villes japonaises pendant la Seconde Guerre Mondiale n'a pas eu d'effets à long terme sur la répartition de la population, la plupart des villes retrouvant les tendances de croissance d'avant-guerre dès 1965.

Ma contribution à cette littérature est de montrer que la répartition actuelle de l'activité économique en Angleterre et au Pays de Galles a des origines médiévales. De 950 à 1350, le commerce entre États s'est considérablement développé en Europe occidentale, ce qui a mené les historiens à évoquer une révolution commerciale (Lopez, 1976). Même si moins étudié par les économistes, le commerce interne a connu à la même époque une expansion considérable. La nécessité de gérer des volumes de transactions de plus en plus importants a conduit à l'émergence de nouvelles formes d'organisation. En Angleterre, l'innovation institutionnelle s'est matérialisée par la prolifération des marchés hebdomadaires qui réunissaient des communautés locales d'acheteurs,

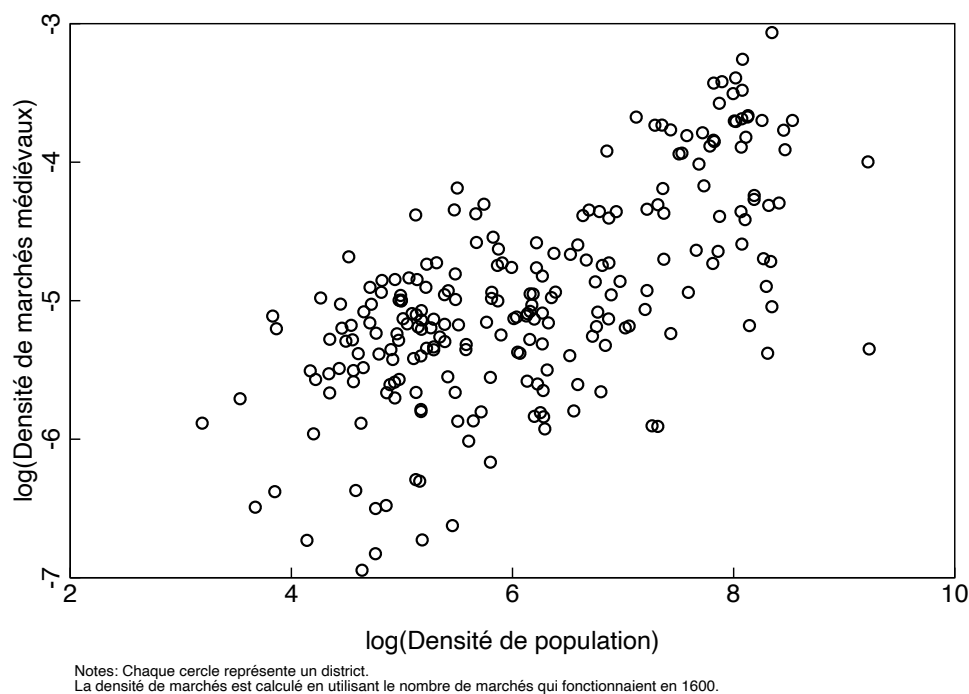


Figure 5: Marchés médiévaux et développement régional

d'agriculteurs, d'artisans et de commerçants (Britnell, 1996).

Les marchés fondés au Moyen Âge n'étaient pas tous voués à devenir de grands centres de commerce et beaucoup parmi eux n'ont pas survécu au déclin démographique du XIV<sup>e</sup> siècle. En 1600, seul un marché sur trois fonctionnait toujours. Ceci étant dit, l'héritage des marchés qui ont résisté aux vicissitudes du temps n'était pas moins durable. La Figure 5 montre une forte corrélation entre la densité de population aujourd'hui est le nombre de marchés médiévaux survivants.

Le troisième chapitre de cette thèse traite des facteurs déterminants d'un type spécifique de migration internationale, à savoir les flux de réfugiés, et des considérations d'économie politique qui façonnent les politiques d'admission dans les pays de l'Union européenne (UE). Celle-ci reste une des destinations principales pour les demandeurs d'asile. En 2008-10, les États membres de l'UE-15 ont reçu 25% du nombre total des demandes au monde (Chin et Cortes, 2015).<sup>4</sup> Le traitement des demandes varie cependant d'un État à l'autre, de sorte que la probabilité de se voir accorder le droit d'asile dépend du pays où la demande a été déposée, même pour des ressortissants d'un même pays d'origine.

À titre d'exemple, sur la Figure 6 sont représentés les taux d'admission pour les demandeurs d'asile russes dans trois pays européens : la France, l'Allemagne et le Royaume-Uni. Les taux d'admission correspondent à la part des demandes traitées qui ont abouti à une décision favorable. Bien qu'ils aient reçu un nombre similaire de demandes (environ 4300 par an), les taux d'admission

<sup>4</sup>L'UE-15 est composée de tous les États membres de l'UE avant l'élargissement de 2004 : Allemagne, Autriche, Belgique, Danemark, Espagne, Finlande, France, Grèce, Irlande, Italie, Luxembourg, Pays-Bas, Portugal, Royaume-Uni et Suède.

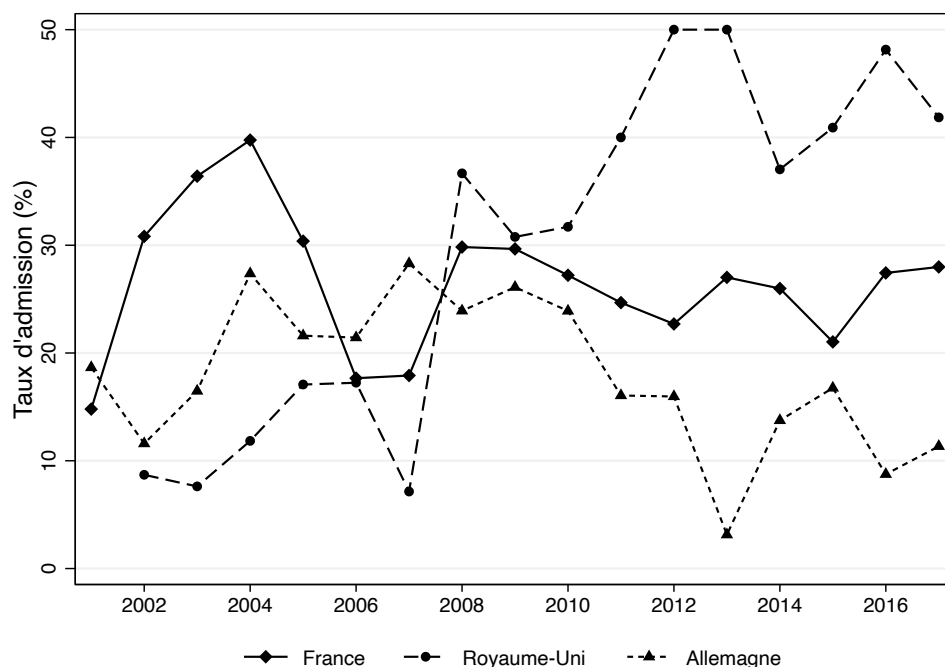


Figure 6: Taux d'admission pour les demandeurs d'asile russes dans trois pays de l'UE

en France ont été supérieurs de 8,5 points de pourcentage à ceux de l'Allemagne. Le Royaume-Uni a reçu beaucoup moins de demandes sur l'ensemble de la période (225 par an), mais ses taux d'admission ont été nettement plus bas de 2002 à 2007. En 2008, les taux d'admission y ont fait un bond et sont restés supérieurs à ceux de la France et de l'Allemagne pendant le reste de la période étudiée. Le traitement différent des ressortissants d'un même pays d'origine soulève la possibilité que des facteurs non-humanitaires, tels que des intérêts stratégiques ou de sécurité nationale, jouent un rôle important dans la conception des politiques d'asile.

Dans ce chapitre, co-écrit avec Ludovic Panon, nous suggérons que des considérations diplomatiques influent sur les politiques d'asile. Notre étude s'appuie sur des travaux dans les sciences politiques qui mettent en évidence la relation complexe qui existe entre l'accueil des réfugiés et les relations internationales. En bref, pour des niveaux similaires de conflit et de terreur politique dans le pays d'origine, les gouvernements sont plus susceptibles d'accueillir des réfugiés fuyant un pays rival que des réfugiés d'un pays partenaire. Le chapitre souligne également la possibilité que les tensions internationales biaisent l'estimation de la relation entre le commerce international et les flux migratoires.

## Chapitre 1 : Autoroutes et concentration spatiale des travailleurs

L'amélioration des infrastructures routières a des effets considérables sur la répartition spatiale de l'activité économique (voir Redding et Turner, 2015 pour un résumé de cette littérature). Des études

ont montré que la construction des autoroutes aux États-Unis avaient façonné les flux commerciaux interrégionaux (Duranton, Morrow et Turner, 2014), stimulé la croissance urbaine (Duranton et Turner, 2012), facilité la suburbanisation (Baum-Snow, 2007), conduit à une spécialisation industrielle (Chandra et Thompson, 2000), augmenté la demande pour les travailleurs qualifiés en zone rurale (Michaels, 2008) et encouragé l'innovation (Agrawal, Galasso et Oettl, 2017). Ce chapitre montre qu'une meilleure infrastructure routière peut également influencer sur la composition des populations résidant dans les zones urbaines.

Des travaux récents en économie spatiale ont souligné l'impact des coûts de transport sur la concentration de l'activité économique. Une meilleure infrastructure routière, en modifiant la géographie des coûts de transport et de migration, entraîne une redistribution de la population entre différentes régions. En utilisant un modèle spatial quantitatif, Redding (2016) démontre que dans les régions où les réductions des coûts de transport sont plus importantes (celles avec les meilleures connexions au réseau routier) la population augmente alors qu'elle décroît ailleurs. Ces effets ne sauraient pas pour autant être identiques à tous niveaux de compétences. Les travailleurs peuvent varier dans leur élasticité de migration, de sorte que des changements similaires dans les salaires réels entraînent des réponses migratoires différentes. Les coûts de migration peuvent également différer d'un groupe à un autre. En particulier, il se peut que les travailleurs peu qualifiés aient à payer des coûts plus élevés lorsqu'ils décident d'emménager dans une autre région. En conséquence, les améliorations des infrastructures peuvent induire des redistributions des populations qui varient avec le niveau de compétences. Dans ce cas, les effets sur le bien-être trouvés dans la littérature cacheraient des inégalités considérables.

La contribution principale de ce chapitre est de mettre en évidence les effets redistributifs des infrastructures routières. En particulier, j'identifie un effet causal des autoroutes inter-États sur la concentration spatiale des travailleurs hautement qualifiés. J'estime également les paramètres régissant les décisions de migration et, à l'aide d'un modèle spatial, quantifie les gains de bien-être pour différents types de travailleurs. Enfin, je suis Morten et Oliveira (2014) et décompose ces effets en composantes commerciale et migratoire. Cela me permet d'identifier les mécanismes conduisant à une augmentation des inégalités spatiales.

La première partie de ce chapitre estime l'effet causal des autoroutes sur la part des résidents urbains ayant obtenu un diplôme universitaire. À cette fin, je construis un échantillon de 307 villes pour lesquelles j'observe des statistiques éducationnelles, socio-économiques et d'infrastructure routière de 1950 à 2000. Sachant que l'attribution des autoroutes est probablement endogène aux marchés locaux du travail, j'utilise deux variables instrumentales. Le premier instrument, basé sur Baum-Snow (2007), correspond au nombre d'autoroutes prévues dans un plan de 1947 et qui seraient ouvertes à la circulation si les taux locaux de construction étaient égaux aux taux nationaux. Toutes les spécifications incluent des effets fixes spécifiques à chaque ville. L'identification des paramètres est basée sur la variation du nombre d'autoroutes au sein d'une zone métropolitaine au fil du temps. Sachant que la progression des travaux au niveau national est très probablement exogène aux évolutions des marchés locaux, la condition d'orthogonalité de l'instrument est satisfaite. Le

second instrument, basé sur Michaels (2008), utilise l'orientation géographique du réseau. Plus précisément, le système d'autoroutes suit une orientation nord-sud et est-ouest. De plus, il a été conçu pour relier les principaux centres urbains et industriels des années 1940. J'argue qu'une ville de plus petite taille orientée est-ouest ou nord-sud par rapport à une grande ville a plus de chances de se voir attribuer un nombre important d'autoroutes. Par conséquent, mon deuxième instrument correspond au stock agrégé d'autoroutes dans les deux grandes villes les plus proches qui sont situées sur des axes nord-sud et est-ouest. Comme j'ai davantage de variables instrumentales que de variables endogènes, je peux procéder à des tests standard de suridentification. Si mes spécifications passent le test, cela signifie soit que les deux instruments sont valides, soit qu'ils sont tous deux invalides et qu'il existe une corrélation systématique entre les instruments et les termes d'erreur. Étant donné que les instruments reposent sur des logiques différentes, ce dernier scénario semble très peu probable.

Des régressions linéaires mesurant l'effet des autoroutes sur la part des diplômés produisent des coefficients positifs et significatifs. Le paramètre estimé en moindres carrés ordinaires (MCO) est 0,4 et significatif à 1 %. Vu que ce coefficient est probablement biaisé, je présente également des résultats de régressions reposant sur des techniques des variables instrumentales (IV). Le paramètre estimé en IV est plus grand : une autoroute inter-États supplémentaire entraîne une augmentation de 0,6 point de la part des diplômés résidant dans une ville. Le fait que les effets estimés en IV sont plus importants que ceux estimés en MCO suggère l'existence d'un biais négatif. Cela concorde avec les résultats de Duranton et Turner (2012) selon lesquels les villes à croissance lente se sont vu attribuer un stock plus élevé d'infrastructure routière. Je trouve que la construction du réseau d'autoroutes inter-États a également conduit à une sélection des migrants. Pour chaque autoroute construite, la part des diplômés parmi les résidents nés dans un autre État a augmenté de 0,8 point de pourcentage. Enfin, les tests de suridentification produisent des valeurs-p supérieures à 0,1. Aussi je ne peux pas rejeter l'hypothèse nulle selon laquelle mes instruments sont valides.

Afin de déterminer les gains de bien-être dus à la construction du système d'autoroutes inter-États, j'introduis une extension d'un modèle spatial quantitatif classique. Plus particulièrement, le modèle admet l'existence de deux catégories de travailleurs, identifiés par le niveau de compétences. Les travailleurs hautement qualifiés diffèrent de ceux peu qualifiés selon deux dimensions. D'abord, même si les travailleurs sont mobiles géographiquement, chaque individu apprécie la qualité de vie dans une ville de manière différente. Le modèle suppose que la moyenne et la dispersion de ces préférences individuelles sont spécifiques à chaque niveau de compétence, ce qui implique des élasticités de migration différentes. Ensuite, lorsque les travailleurs décident d'emménager, ils payent un coût de migration. Suivant Monte, Redding et Rossi-Hansberg (2018) et Morten et Oliveira (2014), ces coûts prennent la forme d'iceberg et sont exprimés en termes d'utilité. Ils incluent non seulement les coûts monétaires du déménagement et des visites de retour ultérieures, mais aussi les coûts psychologiques dus au fait de vivre loin de sa famille et de ses amis. Plus important encore, ces coûts dépendent de l'infrastructure routière existante et varient avec le niveau de compétences.

L'estimation du modèle nécessite une paramétrisation des coûts de transport et de migration. Je suppose que les coûts bilatéraux sont une fonction de la distance géographique dont l'élasticité dépend du nombre d'autoroutes reliant les villes d'origine et de destination au réseau national. Les paramètres régissant les décisions de migration sont ensuite estimés à partir des données sur les flux migratoires inter-métropolitains dans le recensement de 2000. J'utilise également le modèle quantitatif pour récupérer les niveaux locaux de productivité et d'attractivité qui expliquent la répartition spatiale de l'activité économique. Une fois le modèle estimé, je réalise plusieurs expériences contre-factuelles.

La première expérience cherche à valider le modèle théorique. À cette fin, j'utilise des estimations de l'évolution des coûts de migration et de transport de 1950 à 2000 pour trouver la distribution de la population qui satisfait les conditions d'équilibre du modèle. Cela me permet de construire un échantillon de populations contrefactuelles et d'estimer l'effet des autoroutes sur la part des résidents diplômés prédit par mon modèle. Je trouve un coefficient d'un même ordre de grandeur que celui obtenu en utilisant des données réelles. En effet, le modèle arrive à reproduire 60 % de l'effet observé.

Le deuxième exercice envisage une suppression hypothétique du système d'autoroutes inter-États et présente des estimations de la baisse du bien-être qui en résulterait. Je constate que les travailleurs hautement qualifiés verraient leur utilité moyenne diminuer de 12,5 %, tandis que les travailleurs peu qualifiés perdraient 11,75 %. Bien que ces effets soient considérables, ils sont dans la lignée des résultats de Morten et Oliveira (2014) ou Fajgelbaum et Redding (2014). La décomposition des pertes en composantes commerciale et migratoires révèle des mécanismes intéressants. Des coûts de transport plus élevés entraînent des pertes similaires. Cela est dû au fait que tous les travailleurs dépensent la même part de leurs revenus sur des biens échangeables. Par conséquent, une hausse des prix les affecte de la même façon. En revanche, la hausse des coûts de migration a un impact plus important sur le bien-être des travailleurs hautement qualifiés. La probabilité de migration est plus élevée pour ceux-ci, ce qui implique qu'ils payent les coûts de migration plus souvent. Mes résultats confirment également la conclusion de Morten et Oliveira (2014) selon laquelle la composante commerciale représente la plus grande part des effets sur le bien-être découlant d'une amélioration des infrastructures routières.

En résumé, ce chapitre montre que les améliorations des infrastructures de transport influent sur la répartition spatiale des travailleurs, mais de manière différente selon leur niveau de compétences. En outre, les effets sur le bien-être dépendent du degré de mobilité des travailleurs. Dans la mesure où les travailleurs peu qualifiés sont confrontés à des coûts de migration plus importants (et sont donc moins susceptibles d'emménager dans une autre région), un meilleur réseau routier risque de profiter davantage aux travailleurs qualifiés et d'amplifier ainsi les inégalités spatiales.

## Chapitre 2 : Marchés médiévaux et persistance du développement

L'un des objectifs en géographie économique est d'identifier les déterminants de la localisation des activités économiques. Trois théories ont été avancées. Une première classe de modèles met l'accent sur des caractéristiques fondamentales, aussi appelées de "première nature". Selon ces théories, les différences de dotation en ressources naturelles (par exemple, des conditions propices à l'agriculture) ou de capacité d'échange (par exemple, l'accès aux côtes ou rivières navigables) seraient responsables de la répartition inégale des activités économiques (voir Rappaport et Sachs, 2003 ou Henderson, Squires, Storeygard et Weil, 2018). Celle-ci ne peut évoluer que dans la mesure où les caractéristiques fondamentales changent ou leur intérêt économique diminue. Un choc temporaire, quelque soit son ampleur, n'a pas de conséquences à long-terme : les régions avec des meilleurs fondamentaux connaîtront une reprise plus rapide. D'autres modèles expliquent que l'existence des villes de différentes tailles est le résultat des processus stochastiques (Simon, 1955; Gabaix, 1999). Dans ce cas, mêmes des chocs temporaires ont des effets permanents et la distribution de la population suit une marche aléatoire. Enfin, une troisième classe de modèles propose une explication basée sur des causes de "seconde-nature". Celles-ci sont endogènes au développement et reposent sur des effets d'agglomération (Krugman, 1991a,b). La spécificité de ces théories est la possibilité d'obtenir une multiplicité d'équilibres. Un choc, même temporaire, peut avoir des effets permanents s'il fait passer l'économie d'un équilibre à un autre. De plus, ces modèles soulignent l'importance de la dépendance au sentier : un démarrage précoce peut expliquer pourquoi l'activité économique tend à se concentrer dans certaines régions et pas dans d'autres.

Le deuxième chapitre de cette thèse puise ses fondements théoriques dans cette littérature et examine la persistance des inégalités spatiales en Angleterre et au Pays de Galles. Plus particulièrement, cette étude montre une forte corrélation entre l'essor des marchés au Moyen Âge et le développement contemporain. La méthodologie employée dans cette étude présente plusieurs avantages par rapport aux travaux existants. En se concentrant sur un pays relativement homogène, il est peu probable que la localisation des activités productives soit le résultat des déterminants "profonds", tels que la biodiversité, les institutions, la technologie ou la distance génétique (pour un résumé de cette littérature, voir Spolaore et Wacziarg, 2013). La prolifération des marchés médiévaux précède également la plupart des processus historiques ayant contribué à l'enrichissement de l'Angleterre, tels que l'ouverture au commerce atlantique (Acemoglu, Johnson et Robinson, 2005) ou la révolution industrielle (Mokyr, 2005). Ainsi, ce chapitre permet de mettre en évidence une remarquable continuité dans la localisation des activités économiques depuis le Moyen Âge et jusqu'à nos jours et cela en dépit de nombreux chocs (famines, pandémies, guerres) et innovations technologiques qui séparent les deux périodes.

Cette étude utilise à la fois des données médiévales et contemporaines. Tout d'abord, je me sers de la Gazette des marchés et des foires de 900 à 1516 (Letters, Fernandes, Keene et Myhill, 2004) pour construire un échantillon de marchés médiévaux. Pour chaque localité, j'observe l'année où son marché a été établi, la valeur estimée de la production agricole dans l'impôt de 1334 et si le marché fonctionnait toujours au XVI<sup>e</sup> siècle. Cela me permet d'identifier plus de 2 000 marchés fondés au

Moyen Âge. J'utilise aussi des données officielles de l'Office des statistiques nationales sur la population et la valeur ajoutée pour mesurer le développement régional contemporain. L'utilisation de ces données soulève néanmoins des inquiétudes quant à l'endogénéité des frontières administratives. Pour y remédier, je divise l'Angleterre et le Pays de Galles en une grille dont chaque cellule mesure 5×5 kilomètres. Vu que des données statistiques ne sont pas disponibles à ce niveau géographique, je suis Henderson, Storeygard et Weil (2012) et utilise l'intensité lumineuse nocturne comme indicateur du développement local.

Une paix relative, un climat favorable à l'agriculture et une masse monétaire croissante ont permis une expansion du commerce interne aux XIIe et XIIIe siècles (Langdon et Masschaele, 2006). En effet, le nombre de marchés locaux octroyés par le pouvoir royal a augmenté considérablement pendant cette période, ce qui a conduit les historiens à conclure que l'économie anglaise connaissait un processus de forte "commercialisation" (Britnell, 1996). Je teste cette hypothèse en utilisant la valeur estimée de la production agricole dans l'impôt de 1334 comme mesure de développement au début du XIVe siècle. Je trouve une corrélation positive entre la densité de marchés médiévaux et la productivité régionale : le nombre de marchés récemment établis était plus élevé dans les comtés qui ont payé davantage d'impôt par kilomètre carré en 1334. Ensuite, j'utilise les estimations de la production agricole de chaque localité pour calculer des taux moyens de croissance avant 1334. Les résultats sont frappants : les communes dont le marché fonctionnait toujours au XVIe siècle ont connu une croissance annuelle de 0,3 - 0,4 %, tandis que les autres communes ont stagné.

Faisant suite à une longue période d'expansion économique, le XIVe siècle a été marqué par des crises récurrentes. Les famines, les guerres et les pandémies à répétition ont décimé la population de l'Angleterre. Dans un contexte de baisse généralisée de la demande, plus de deux tiers des marchés ont fait faillite et disparu avant 1600. La deuxième étape de mon analyse cherche à comprendre les déterminants de la survie des marchés médiévaux. J'étudie l'impact des caractéristiques de première nature (la localisation géographique et l'accès aux infrastructures de transport) et de seconde nature (la distance par rapport au centre urbain le plus proche) ainsi que la contribution des facteurs institutionnels à la probabilité de survie des marchés. Étonnamment, la plupart des caractéristiques de première nature ne sont pas corrélées avec le succès commercial des marchés. Seul l'indice de rugosité a un effet marginalement significatif. En revanche, les caractéristiques de seconde-nature ont un effet significatif sur la survie des marchés. Une plus grande proximité des grands centres urbains est associée à une probabilité de survie plus basse, reflétant une concurrence spatiale plus rude. Enfin, les déterminants institutionnels jouent un rôle aussi important dans le succès des marchés. Ceux qui étaient situés dans les zones urbaines les plus riches ont eu plus de chances de survivre au déclin démographique du XIVe siècle.

Comment se portent aujourd'hui les régions qui comptaient davantage de marchés au Moyen Âge ? Je montre que la densité de population et la valeur ajoutée par habitant sont fortement corrélées avec la densité des marchés fonctionnant au XVIe siècle. Par contre, la corrélation avec la densité de marchés défaillants est négative mais statistiquement non significative. De plus, je montre que les cellules urbaines et rurales ayant un marché médiéval prospère émettent, en moyenne, 33 % de

lumière en plus que des cellules similaires dont le marché a disparu avant 1600.

Bien que les résultats présentés dans ce chapitre reposent essentiellement sur des corrélations et ne justifient pas une interprétation causale, plusieurs mécanismes pourraient expliquer un impact positif des marchés médiévaux sur le développement à long-terme. Premièrement, en créant un cadre légal et régulier pour des échanges commerciaux, les marchés médiévaux ont pu réduire les coûts de transaction et accroître la transparence des prix. Ayant développé son réseau de marchés bien avant ses voisins continentaux, l'Angleterre montrait une plus faible variation des prix à la veille de la révolution industrielle (Shiue et Keller, 2007). Deuxièmement, les marchés ont pu promouvoir la concurrence, stimuler l'innovation et faciliter l'adoption de technologies nouvelles (Desmet, Greif et Parente, 2019). Ces deux mécanismes auraient pu conduire à une hausse des investissements dans les localités dotées d'un marché prospère. Dans la mesure où ces investissements ne se sont pas dépréciés, ils pourraient continuer à avoir un impact positif sur le développement contemporain. Troisièmement, dans les modèles avec équilibres multiples, il y a une indétermination entre des lieux similaires en termes de fondamentaux. Les marchés locaux auraient pu faciliter la coordination spatiale des agents, à l'image des sites de portage aux États-Unis (Bleakley et Lin, 2012), des villes fondées par décret royal en Suède (Cermeño et Enflo, 2019) ou des ports ouverts en Chine (Jia, 2014).

Ce chapitre monte en épingle une remarquable continuité dans la localisation des activités économiques au cours des 800 dernières années. Comment interpréter ces résultats à la lumière des théories mentionnées ci-dessus ? Avant tout, la persistance documentée dans cette étude est en conflit avec les prédictions des modèles de croissance aléatoire. Malgré les nombreux chocs qui ont affecté l'Angleterre et le Pays de Galles depuis le Moyen Âge, aucun ne semble avoir modifié la répartition de l'activité économique de manière significative : les localités avec une activité commerciale plus forte au XIV<sup>e</sup> siècle continuent de concentrer des populations plus importantes aujourd'hui. Ce constat concorde, en revanche, avec les théories basées sur des causes de première nature ou sur des économies d'agglomération. L'absence d'une relation significative entre les caractéristiques de première nature et la survie des marchés soulève néanmoins des doutes quant à leur capacité à expliquer la continuité du développement. De plus, pour que ces caractéristiques conduisent à une persistance dans le temps, il est nécessaire que leur intérêt économique ne diminue pas. Or, Michaels et Rauch (2018) montrent qu'après la chute de l'Empire romain le réseau urbain anglais s'est recomposé en favorisant les lieux dotés d'accès côtiers au détriment des anciennes villes romaines. Même si des recherches plus avancées sont nécessaires, la dépendance au sentier semble être l'explication la plus probable des résultats présentés dans ce chapitre.

## Chapitre 3 : Politiques d'asile et tensions internationales

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Dès les années 1980, des politologues ont exprimé leur suspicion que “l’octroi ou le refus de l’asile politique était devenu un instrument de la diplomatie des pays de destination envers les pays d’origine” (Scheinman, 1983). À la même époque, Teitelbaum (1984) estimait que l’admission

des réfugiés politiques était souvent utilisée par les pays d'accueil pour dénoncer des violations flagrantes des droits de l'homme dans les pays d'origine et, de cette façon, les discréditer sur la scène internationale. En outre, accueillir des réfugiés pourrait contribuer à l'émergence de mouvements d'opposition en exil et à priver un pays rival d'une partie de son capital humain. Un gouvernement devrait être réticent à accorder l'asile à des personnes fuyant des États partenaires sachant que de tels octrois pourraient compromettre de bonnes relations diplomatiques. Par ailleurs, des groupes d'opposition nationaux pourraient également les présenter comme des preuves de complicité avec un régime oppressif.

L'histoire regorge d'exemples probants. Pendant la Guerre froide, les États-Unis ont admis un nombre important de réfugiés issus du bloc communiste, tout en se montrant plus hésitants à accueillir des réfugiés provenant des pays auxquels ils apportaient une aide militaire ou policière, comme le Guatemala, le Salvador ou Haïti (McBride, 1999, Salehyan et Rosenblum, 2008). À la fin des années 1990, la Tanzanie a accepté davantage de réfugiés fuyant le Burundi que de réfugiés du Rwanda. Jacobsen (2002) soutient que cela est dû aux relations plus cordiales que la Tanzanie entretenait avec le Rwanda qu'avec le Burundi. Récemment, plusieurs études statistiques ont monté en épingle l'importance des considérations diplomatiques dans l'élaboration des politiques d'asile, notamment Rosenblum et Salehyan (2004) et Jackson et Atkinson (2019).

Sur la base de ces intuitions et résultats, ce chapitre présente des estimations du lien entre les politiques d'asile et les relations internationales pour 28 pays européens accueillant des réfugiés du reste du monde de 1999 à 2017. Pour chaque pays d'origine et de destination, nous observons le nombre de demandes traitées au cours d'une année ainsi que le nombre de décisions octroyant protection internationale. À partir de ces informations, nous calculons le taux d'admission qui nous fournit une mesure de la générosité des politiques d'asile envers les ressortissants d'un pays d'origine donné. Concernant les relations diplomatiques, nous employons deux mesures largement utilisées dans la littérature : un indice de similarité des votes à l'Assemblée Générale des Nations Unies et une variable binaire qui prend la valeur 1 si un accord de libre-échange existe entre les pays d'origine et de destination. Nous utilisons également le nombre d'événements internationaux, qu'il s'agisse de différends ou d'accords.

Nos résultats confirment la thèse selon laquelle les rivalités internationales influent sur les politiques d'asile. Alors que les flux de demandeurs d'asile ne semblent pas être corrélés d'une manière significative avec nos mesures bilatérales de tensions, le nombre de réfugiés admis diminue avec une plus grande similitude de votes aux Nations Unies et en présence d'un accord de libre-échange. Une augmentation de dix points de pourcentage de la probabilité de voter de la même façon à l'Assemblée Générale des Nations Unies est associée à une baisse des taux d'admission de 0,65 points de pourcentage ; les accords de libre-échange réduisent ces taux d'environ 2 points supplémentaires. Nous constatons également que les différends internationaux entraînent une augmentation des taux d'admission. Pour chaque conflit, nous estimons que les taux augmentent de 0,4 point de pourcentage. En revanche, nous trouvons que les taux d'admission diminuent de 0,1 à chaque épisode de coopération.

Plusieurs points importants doivent être soulignés à ce stade. Premièrement, même si notre étude met l'accent sur des considérations d'économie politique, nous ne prétendons pas que les critères humanitaires ne sont pas un déterminant important des politiques d'asile. En effet, nous montrons que les flux de demandeurs d'asile et les taux d'admissions sont fortement corrélés avec des mesures de conflit et de terreur politique dans les pays d'origine. Notre argument est plutôt que, pour des conditions similaires dans les pays de départ, les gouvernements sont plus susceptibles d'admettre des réfugiés provenant d'un rival que d'un pays partenaire. Deuxièmement, nous obtenons des résultats similaires si nous incluons des effets fixes bilatéraux, ce qui signifie que nos estimations ne sont pas biaisées par des caractéristiques bilatérales qui ne varient pas dans le temps, telles que la proximité culturelle, historique ou linguistique. Troisièmement, nos résultats ne reflètent pas forcément un lien causal et nous admettons volontiers que la relation entre les crises humanitaires, les tensions internationales et les politiques d'asile est plus complexe. Dans de nombreux cas, les événements produisant des flux de réfugiés ont un effet direct sur les tensions entre États. Par exemple, après l'échec du coup d'État de 2016, la Turquie a procédé à des purges et des arrestations massives de militants des droits de l'homme. Cela a conduit à une hausse des tensions avec l'Allemagne. Il ne serait donc pas surprenant de constater que les taux d'admission pour les demandeurs d'asile turcs y aient également augmenté. Cependant, de telles considérations n'affaiblissent pas notre argument mais soulignent la forte relation qui existe entre les intérêts stratégiques des États et les politiques d'asile qu'ils adoptent.

La deuxième partie de ce chapitre souligne l'importance des considérations d'économie politique lorsqu'on mesure l'effet des réfugiés, et plus généralement des migrants, sur le commerce international. Un nombre impressionnant d'articles démontrent une contribution positive des migrants aux flux commerciaux internationaux (voir Gould, 1994, Head et Ries, 1998 ou Rauch et Trindade, 2002). Récemment, plusieurs économistes ont utilisé la répartition aléatoire des réfugiés comme variable instrumentale pour les stocks de migrants afin d'estimer un effet causal sur le commerce international (Parsons et Vézina, 2018, Steingress, 2018).

Contrairement à ces études, nous trouvons une corrélation négative et statistiquement significative entre les politiques d'asile et les importations dans l'Union européenne. Une augmentation de dix points de pourcentage des taux d'admission est associée à une baisse des importations d'environ 0,5 %. L'effet, cependant, n'est pas persistant et s'estompe au bout de 2 à 3 ans. Il est important de noter que nous ne trouvons pas de corrélation entre les exportations et les politiques d'asile.

La littérature a identifié deux mécanismes pour expliquer l'effet positif des migrants sur les flux commerciaux. Tout d'abord, les migrants apportent avec eux des préférences biaisées en faveur des biens produits dans leur pays d'origine. Leur désir de consommer ces produits va augmenter les importations dans le pays de destination. Deuxièmement, les réseaux de migrants contribuent à assurer une meilleure exécution des contrats et à réduire les coûts liés à la recherche d'informations. Ce mécanisme est plus important pour les échanges de biens différenciés étant donné que les frictions de recherche sont sans doute plus élevées dans cette industrie (Rauch, 1999). Ces deux mécanismes promeuvent les échanges internationaux, bien que les effets soient hétérogènes

selon la direction des échanges (importations ou exportations) et le type de biens (homogènes ou différenciés). Notre analyse montre que des stock de réfugiés plus élevés peuvent également refléter des tensions grandissantes entre États, dont l'impact négatif sur le commerce est bien documenté dans la littérature. La corrélation entre politiques d'asile et commerce international correspond donc à la somme de ces trois effets et le signe dépend du mécanisme dominant.

Afin d'évaluer la pertinence de ces considérations, nous estimons séparément l'équation de gravité pour différents types de biens. Nous trouvons un coefficient négatif et statistiquement significatif uniquement pour les échanges de biens homogènes. Nous suggérons que, pour ce type de produits, les mécanismes reposant sur les préférences biaisées des consommateurs ou sur la réduction des coûts de transaction n'ont qu'une portée limitée. L'effet dominant pour cette catégorie de bien est celui mettant en avant les rivalités entre États.

Les tensions internationales ont un impact négatif sur les flux commerciaux (voir Fuchs et Klann, 2013 ou Michaels et Zhi, 2010). Les raisons sous-jacentes de cet effet restent néanmoins peu connues. Les flux commerciaux peuvent diminuer en raison d'une réduction des importations par les entreprises d'État (Davis, Fuchs et Johnson, 2019). Un climat de méfiance peut également rendre des entreprises privées réticentes à passer des contrats avec des entités étrangères. Enfin, les consommateurs peuvent choisir de boycotter les produits de pays rivaux (Pandya et Venkatesan, 2016). Bien que les données disponibles ne nous permettent pas d'évaluer chacune de ces alternatives, nous présentons des résultats au niveau des industries. Nous ne trouvons d'effets significatifs que pour le commerce des matières brutes (CTCI 2), des huiles, graisses et cires d'origine animale ou végétale (CTCI 4) et des produits manufacturés classés principalement d'après la matière première (CTCI 6). Même s'il faut rester prudent en interprétant ces résultats, il semblerait que le boycott des consommateurs ne joue qu'un rôle marginal.

En conclusion, ce chapitre montre une corrélation significative entre les politiques d'asile et les tensions internationales. Il souligne également la possibilité que ces dernières biaisent les estimations de l'effet des migrants sur le commerce international. Cela suggère que la condition d'orthogonalité n'est pas forcément satisfaite lorsqu'on utilise le nombre de réfugiés comme variable instrumentale pour les stocks des migrants.

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# Chapter 1

## Roads, Migration and the Spatial Sorting of US High-Skilled Workers

### Abstract

This paper estimates the impact of a large transport infrastructure project, the construction of the Interstate Highway System, on the skill composition of US cities. To address the endogeneity of its construction, I instrument the local highway infrastructure with the number of planned interstates that would be open to traffic if construction rates were uniformly distributed across cities. I find that the fraction of residents with a college degree increased by 0.6 percentage points with each additional highway. To rationalize these reduced-form effects, I make use of a static quantitative trade model in which workers differ in terms of migration elasticities and migration costs. I estimate the parameters governing workers' migration decisions using data on inter-metropolitan worker flows and calibrate the model to match the distribution of population and wages in 2000. Simulating the US economy from 1950 to 2000, I find that the quantitative model is able to replicate 60% of the reduced form-effects documented previously. Finally, I find that a counterfactual removal of the Interstate Highway System would lead to large welfare losses for both types of workers. Assuming identical expenditure shares on housing, the welfare effects are stronger for high-skilled workers, the difference being driven by a higher impact of migration costs on the latter's welfare.

**JEL codes:** R41, O18, O51, J24, R23

**Keywords:** Transport infrastructure, skill, internal migration, trade, local labor markets



## 1.1 Introduction

This paper considers the relationship between transport infrastructure and the spatial distribution of skilled workers in the US. By altering the geography of trade and migration costs, investments in the transport infrastructure bring about consequential redistributions of economic activity. These effects, however, need not be homogeneous across skill groups. Workers may differ in their migration elasticities, such that similar changes in labor demand or migration costs will lead to asymmetric population reallocations.<sup>1</sup> Migration costs may also be skill-specific, with low-skilled individuals facing potentially higher barriers to spatial mobility.<sup>2</sup> These considerations raise the possibility that the welfare effects associated with improved infrastructure mask significant heterogeneity, both across space and skill groups.

In order to study this issue, I examine the impact of a large transport infrastructure project, the construction of the Interstate Highway System (IHS), on the location choices of US college graduates.<sup>3</sup> Understanding how road improvements affect the skill composition of local labor markets is crucial for designing optimal spatial policies. Infrastructure investments account for a large share of public spending. In 2017, the US spent a total of \$177 billion on highways, amounting to 1% of GDP (CBO, 2018). In addition to being costly, these investments are highly persistent. The interstate network, whose construction began in 1956 and was almost complete by 1980, continues to play a key role in managing travel flows. Despite representing only 1% of road mileage, the IHS accommodates 25.4% of total traffic (FHA, 2018). It is therefore not surprising that the literature has identified large and long-lasting effects of the IHS on economic activity (i.e. Duranton and Turner, 2012).

The evidence on the distributional consequences of transport infrastructure, however, is scarcer. The main contribution of this paper is to establish a causal relationship between the construction of the interstate highway network and the geographic sorting of high-skilled workers. The increased spatial concentration of college graduates is well documented in the literature and has been linked to raising inequality both across cities (Moretti, 2013; Diamond, 2016) and within cities (Couture, Gaubert, Handbury, and Hurst, 2019). I complement these studies and show that differences in market access, as mediated through better highway connections, were an equally important factor driving geographic sorting.

The second contribution of this paper is to quantify the welfare effects of better transport infrastructure for different types of workers and decompose them into trade and migration components.<sup>4</sup>

<sup>1</sup>For instance, Bound and Holzer (2000) find that college graduates have a higher elasticity of migration with respect to real wages as compared to non-graduates, who are rather inelastic.

<sup>2</sup>Topel (1986) argues that localized labor demand shocks cause asymmetric wage and employment adjustments when migration costs are heterogeneous. In particular, the impact is higher for the least mobile workers.

<sup>3</sup>Throughout this paper, high-skilled workers are defined as college graduates, with the remainder of workers being considered low-skilled. Cities correspond to metropolitan statistical areas (MSAs).

<sup>4</sup>Allen and Arkolakis (2014, 2019) compute welfare effects under counterfactual experiments in which the IHS is either removed or further expanded. Morten and Oliveira (2016) estimate welfare losses associated with a removal of Brazil's highways and decompose them into trade and migration components. None of these studies, however, discriminates between different worker types.

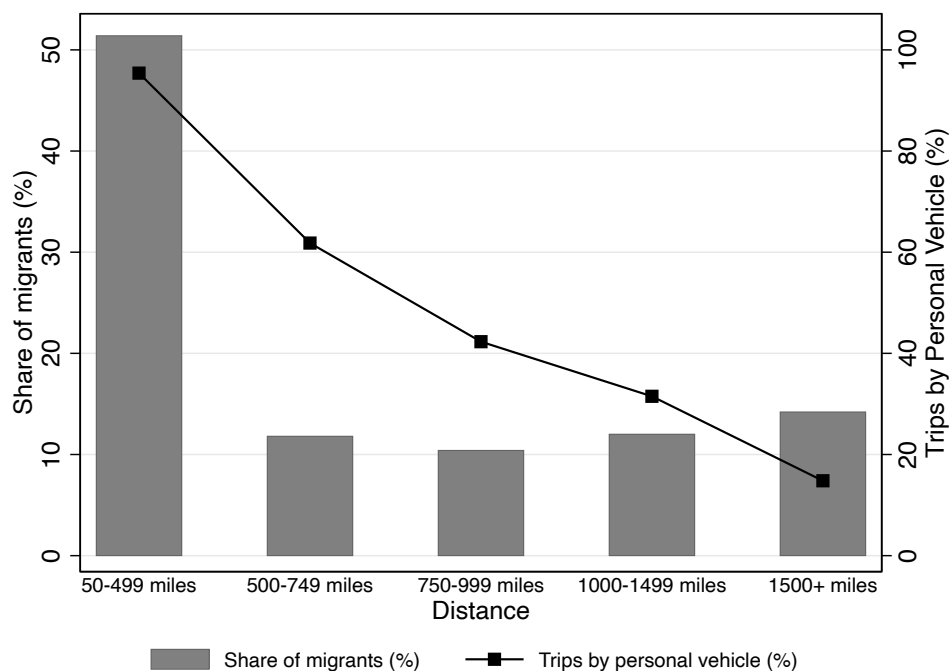


Figure 1.1: Migration by Distance and Mode of Transportation

Notes: The gray bars show the share of observed inter-metropolitan migrations that occurred within a given distance interval. The black square dots show the share of long-distance trips that were taken by personal vehicle. Source: author's calculation based on migration data from the 2000 IPUMS sample; National Household Travel Survey, long-distance file, 2001.

While there is ample evidence of the impact of transport infrastructure on trade flows (Duranton, Morrow, and Turner, 2014; Donaldson, 2018), the relationship between roads and migration has received far less attention. Yet, as Figure 1.1 illustrates, more than half of the US workers who move to another city choose a destination that is less than 500 miles away from their city of origin. Survey data reveals that for trips within this distance band, almost 90% are done by private vehicle. The existence of an adequate road network has the potential to affect the movement of people in addition to that of goods. This would imply that previous studies are likely to have understated the welfare gains due to improved transport infrastructure.

In the first part of this article, I estimate reduced-form effects of interstate highways on the share of graduates living in a city. To this aim, I construct a sample of 307 metropolitan areas. I observe educational, socio-economic and infrastructure outcomes for each city, in every decade, from 1950 to 2000. Using a fixed effect specification, I can identify the effect on the college share using within-city variation in the number of highways over time. Because I cannot rule out time-varying unobservable city characteristics that are correlated with the highway measure, I make use of two instrumental variables. First, I follow Baum-Snow (2007) and compute the number of rays in the 1947 plan that would be open to traffic in a given year if construction rates were uniformly distributed across cities. As national construction rates are plausibly orthogonal to local labor markets, the instrument will provide exogenous variation in the evolution of the number

of highways open to traffic in a city. Second, I build on Michaels (2008)’s observation that the interstate network follows a north-south and east-west orientation. Furthermore, inspection of interstate density maps suggests that construction proceeded radially, expanding from large urban centers to nearby counties. I argue that smaller cities were more likely to be connected to the interstate network at an earlier stage if they were located on east-west and north-south axis with major metropolitan areas where highway construction was more advanced. The instrument simply becomes the aggregate number of highways open to traffic in the two nearest major MSAs oriented east-west and north-south.<sup>5</sup> Using both instruments simultaneously allows me to perform standard over-identification tests and check their joint validity.

Regressions of the share of high-skilled workers on the number of interstate highways yield positive and highly significant coefficients. OLS estimates are about 0.40 and significant at 1%. IV regressions produce slightly bigger estimates: the college share increased by 0.55 percentage points for each additional highway open to traffic.<sup>6</sup> The effect was primarily driven by an increase in the number of college-educated residents. The impact on non-graduates was much smaller and oftentimes statistically not distinguishable from zero. The results are robust to using either instrument and I cannot reject the null hypothesis that they are jointly valid.

In the second part of the article, I quantify welfare effects arising from an improvement in the transport infrastructure. To this aim, I use a quantitative spatial model with heterogeneous workers. I assume two types of workers: high-skilled (college graduates) and low-skilled (non-graduates). Both types are mobile across locations, but have heterogeneous preferences for living in each city. As has become customary in the literature, I model these preferences as idiosyncratic utility shocks that are distributed Fréchet (Redding, 2016). The distribution of individual tastes can vary across skill levels, both in terms of average tastes and their dispersion. The model also incorporates bilateral migration costs, in a similar fashion to Monte, Redding, and Rossi-Hansberg (2018) and Morten and Oliveira (2016). Whenever workers decide to migrate to another city, they incur a one-time iceberg cost, expressed in terms of utility. This includes the monetary cost of both relocating and subsequent return visits to the location of origin. Importantly, I assume that migration costs are a function of the existing transport infrastructure and can vary across skill groups.

In order to estimate the model, I use data from 2000 on inter-metropolitan migration and trade flows. I parameterize the iceberg trade and migration costs as a function of geographic distance, with the elasticity being governed by the stock of highways in the cities of origin and destination.<sup>7</sup>

<sup>5</sup>My instrument differs from Michaels (2008) in two fundamental ways. First, I classify cities as being oriented east-west and north-south if they are located within a band of a given width relative to a major MSA. Second, the instrument is obtained by interacting the thus obtained orientation dummy variable with the stock of highways in the nearest major MSAs laying east-west or north-south.

<sup>6</sup>I consistently find that IV estimates are greater than their OLS counterparts. The downward bias of OLS coefficients is in line with results in other studies (Duranton and Turner, 2012; Agrawal, Galasso, and Oettl, 2017). To explain the direction of the bias, Duranton and Turner (2012) show that MSAs with sluggish growth had larger employment shares in road-building.

<sup>7</sup>As a robustness check, I also consider an alternative specification in which migration and trade costs are a function of travel times. The two procedures yield costs that are of the same order of magnitude and are highly correlated.

Estimating the Fréchet shape parameters and migration cost parameters proceeds in two steps. In the first step, I estimate the elasticity of migration with respect to distance. This allows me to obtain the product between the two parameters. The second step is guided by my quantitative framework: the destination-fixed effect from the gravity equation is a function of real wages in the city of destination. Regressing the predicted fixed effects on real wages delivers the Fréchet shape parameter. Using these estimates, as well as data on the distribution of population and wages, I can then invert the quantitative model and recover the level of local productivity and amenity.

I perform several counterfactual experiments. In the first exercise, I use predicted migration and trade costs from 1950 to 2000 to simulate the US economy under the assumption that the quantitative framework accurately describes it. This allows me to construct a sample of counterfactual college shares that I use to re-estimate reduced-form effects of highways. The coefficient on the number of highways is 0.33, which is of the same order of magnitude as estimates obtained for the actual data. To put it differently, the quantitative model is able to replicate 60% of the effect I estimated previously.

In a second set of counterfactual experiments, I consider a hypothetical removal of the IHS. This would translate into a significant increase in migration and trade costs. As a result, high-skilled workers would experience a fall in average welfare of 12.5%, while the low-skilled would lose 11.75%.<sup>8</sup> Decomposing the effects into trade and migration components, I find that higher trade costs generate similar losses for both types, in the range of 11%. This is a consequence of the assumption of homothetic preferences, with each type spending the same share of their income on tradable goods.<sup>9</sup> The increase in migration costs, on the other hand, has a greater impact on the high-skilled (2%) than on the low-skilled (0.75%). This is due to the former being more likely to migrate to begin with and hence pay the higher migration costs.

The analysis in this paper speaks to three main strands in the literature. First, I contribute to the quantitative spatial economics literature, reviewed in Redding and Rossi-Hansberg (2017). First-generation models build on the assumption that migration costs are driven entirely by preferences (Moretti, 2011; Allen and Arkolakis, 2014; Redding, 2016). More recent work has allowed for bilateral migration costs, but maintained the assumption of homogeneous workers (Monte et al., 2018; Morten and Oliveira, 2016; Caliendo, Dvorkin, and Parro, 2019; Tombe and Zhu, 2019). This article proposes an extension of a static quantitative model featuring heterogeneous workers that differ in the distribution of their idiosyncratic tastes and migration costs. In addition, using numerical simulations, I show under what conditions on the model's parameters an improvement in the transport infrastructure generates special sorting.

Second, this paper contributes to an ever-growing literature studying the impact of infrastructure on economic activity, as reviewed in Redding and Turner (2015). The Interstate Highway

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<sup>8</sup>The welfare losses are lower if migration and trade costs are defined as a function of travel times. Because the network of non-interstate highways is relatively dense and allows flows to travel at high speed levels, removing the IHS would generate small increases in travel times.

<sup>9</sup>Assuming that low-skilled workers spend a higher share of their income on the local, non-tradable good would lead to trade costs having a higher impact on the welfare of graduates.

System has encouraged inter-regional trade (Duranton et al., 2014), urban growth (Duranton and Turner, 2012), suburbanization (Baum-Snow, 2007), regional specialization (Chandra and Thompson, 2000; Michaels, 2008) and innovation (Agrawal et al., 2017).<sup>10</sup> My contribution is to document heterogeneous effects on the allocation of workers.

This study is closely related to concurrent and independent research by Fretz, Parchet, and Robert-Nicoud (2017) and Tsivanidis (2019).<sup>11</sup> The former study the impact of highways on geographic sorting in Switzerland, while the latter documents the effects Bogotá’s Rapid Bus System on the within-city allocation of heterogeneous workers. I depart from their analysis in three respects. First, the mechanisms driving geographic sorting in their studies rely on non-homothetic preferences. Specifically, richer households choose to live in more expensive locations and are more likely to commute by car. By contrast, sorting is driven here by heterogeneous migration elasticities and costs. Second, the focus in this paper is on migration patterns and not commuting. In particular, I study how infrastructure affects migrant flows between potentially distant labor markets. Third, both papers abstract from trade linkages. Instead, I incorporate them in my model and quantify their effect on the welfare of both types of workers.

Finally, I contribute to the literature studying the geographic sorting of US workers. Moretti (2013) and Diamond (2016) analyze the welfare implications of increased sorting by high-skilled workers, while Fajgelbaum and Gaubert (2020) document efficiency losses due to inefficient spatial allocation. Couture et al. (2019) report increased spatial sorting within cities and quantify its consequences on welfare inequality. Giannone (2019) studies the sorting of workers using a framework featuring skill-biased technical change and spatial diffusion of technology.<sup>12</sup> I complement these studies by shedding light on an additional source of inequality. Improvements in the transport infrastructure can amplify spatial disparities insofar as workers differ in their migration elasticities and costs.

The remainder of the paper proceeds as follows. Section 1.2 presents the data and reports summary statistics. In Section 1.3, I discuss the identification strategy employed to measure the impact of highways on the college share. Section 1.4 presents the main results. In Section 1.5, I describe the quantitative spatial model. Section 1.6 studies conditions on the model’s parameters for which an improvement in the transport infrastructure will generate geographic sorting. In

<sup>10</sup>The literature is not limited to developed countries. Volpe Martincus and Blyde (2013), Duranton (2015), Donaldson (2018) and Morten and Oliveira (2016) document trade effects in developing countries. Banerjee, Duflo, and Qian (2020), Faber (2014) and Baum-Snow, Henderson, Turner, Zhang, and Brandt (2018) study the impact of infrastructure on regional output in China. Datta (2012) and Ghani, Goswami, and Kerr (2015) document positive effects of the Quadrilateral Project on firm size and productivity in India. Appendix 1.10.2 provides a more detailed review of the literature.

<sup>11</sup>In an earlier paper, Candau and Dienesch (2015) study the geographic sorting of US workers in the context of increased market integration. Their independent variable is either the number of truck registrations or a market access measure derived from gravity equations. Their unit of analysis is at the state level. I depart from their analysis by considering the impact of roads on the college share. Using MSA data, I can also capture more of the significant within-state variation in educational attainment.

<sup>12</sup>Combes, Duranton, and Gobillon (2008) and De la Roca (2017) examine sorting of French and Spanish workers, respectively. Models of city specialization include Behrens, Duranton, and Robert-Nicoud (2014), Davis and Dingel (2020) and Eeckhout, Pinheiro, and Schmidheiny (2014). Combes, Duranton, Gobillon, Puga, and Roux (2012a) and Gaubert (2018) address the issue of spatial sorting for firms.

Section 1.7, I estimate migration and trade costs as well as the migration elasticities. I also invert the quantitative model to obtain average productivity and amenities in metropolitan areas. Section 1.8 conducts three sets of counterfactual experiments. Section 1.9 concludes. Appendix 1.10 provides additional material.

## 1.2 Data and Summary Statistics

My empirical analysis uses data on a series of economic outcomes at the MSA level. In what follows, I present these data sets and the methodology employed to construct the main variables of interest.<sup>13</sup> I conclude with a presentation of the changes in educational attainment and transport infrastructure from 1950 to 2000.

### 1.2.1 Data Sources

The data on educational attainment come from the County and City Data Books (CCDB). Published intermittently since 1944, these data sets contain a variety of socio-economic statistics at the state, county and city level. In particular, the CCDB provide the number of persons aged 25 or older who have graduated from high school and college in each county. In addition to educational attainment, the CCDB also contain demographic statistics (population, share of female and non-white residents, share of residents living in urban areas), high-school and college enrollment rates, as well as economic statistics (median wage, median rent and employment rates). I follow the US Office of Management and Budget's 1999 definition of metropolitan statistical areas in order to aggregate county data at the metropolitan level. This procedure yields 307 MSAs that I observe in every Census year from 1950 to 2000. Counties outside an MSA are treated as rural areas. I then group all rural counties within a state together to form additional geographic units.

I supplement the data from the CCDB with the 5 percent (1 percent for 1970) samples of the U.S. Census from the Integrated Public Use Microdata Series (IPUMS) (Ruggles, Flood, Goeken, Grover, Meyer, Pacas, and Sobek, 2018). Using information on the date of birth, I compute the number of migrants living in an MSA in a given year. Using information on the metropolitan area of residence 5 years prior to the survey, I construct inter-metropolitan migrant flows from 1980 to 2000 (this information is not available in previous samples). Unlike the CCDB, geographic coverage in the IPUMS data sets varies across time. The final samples consist of 282 MSAs, of which only 94 are observed in every Census year.

I also use the 2002 Commodity Flow Survey (CFS) to construct a bilateral matrix of inter-regional trade flows. The 2002 survey reports exports between 54 CFS regions, which are slightly larger units than the metropolitan areas in my sample. For each CFS region, I identify the central city and assign it to an MSA. The resulting data set consists of 2916 bilateral pairs which record both the value and the quantity of exports from each CFS region to all other regions, including itself.

The highway data are taken from Baum-Snow (2007). He combines Form PR-511, a federally kept database containing the opening dates of each highway segment, with a digital map of the US Interstate Highway System. This allows him to observe the number of radial highways open to traffic in each MSA during a given year. He also computes the number of highway miles open to traffic in all cities, which I use to compute a measure of local highway density.

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<sup>13</sup>I present the data sources in greater detail in Appendix 1.10.1.

The US Department of Transportation's Federal Highway Administration publishes annual geospatial data on the existing road infrastructure. I use the 2011 shapefile from the Highway Performance Monitoring System (HPMS) to create a digital map of the existing highway network.<sup>14</sup> I combine this data with information on maximum speed limits from the Insurance Institute for Highway Safety (IIHS). I then use a geographic information system (GIS) application to find the shortest route between all pairs of MSAs in the sample given a network of interstate highways and secondary roads.

I follow Diamond (2016) and generate a local amenity index using a principal component analysis (PCA) approach.<sup>15</sup> Because data on local amenities is not available for the year 1950, I only compute indices from 1960 onward. The number of apparel stores, eating and drinking establishments and movie theaters are all extracted from the County Business Patterns data sets from 1962 to 2000. Local expenditure, as well as the number of teachers, are identified through the Census of Local Governments. The number of students enrolled in PK-12 institutions in 1950 and 1960 is taken from the CCDB; data for 1970, 1980 and 1990 come from the Elementary and Secondary General Information System (ELSEGIS) data sets. For the year 2000, I use the Common Core of Data compiled by the National Center for Education Statistics (NCES). The Uniform Crime Reporting Program Data contains information on the number of violent and property crimes. All these statistics are provided at the county-level. I aggregate this data to obtain statistics at the MSA-level.

### 1.2.2 Sample Statistics and General Trends

The average share of residents with a college degree increased steadily, from 6.37% in 1950 to 23.40% in 2000.<sup>16</sup> The gains, however, were not uniformly distributed across cities. As Figure 1.2A illustrates, metropolitan areas with a college share above the 1950 median gained relatively more college graduates than cities below the median. The difference between the two groups was 3.37 percentage points in 1950. By the turn of the century, the gap reached 8.70 percentage points. Metropolitan areas below the median experienced an evolution that matched more closely that of rural counties.

Improvements in educational attainment were accompanied by significant increases in college attendance. In 1950, less than 2.25% of people aged 5 or older were enrolled in higher education. By 1990, the figure almost quadrupled, reaching 8.88%. College attendance slightly declined during the 1990s, but remained significantly higher than at the beginning of the period. Enrollment rates were consistently higher in MSAs above the 1950 median than elsewhere. The gap between MSAs above and below the median increased by 1.50 percentage points throughout the sample period. Changes in enrollment rates correlate only moderately with changes in the college share - the coefficient of correlation is 0.40.

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<sup>14</sup>In order to compute accurate travel times in 2000, I drop all interstate highways constructed after this date.

<sup>15</sup>Appendix 1.10.4 presents the methodology used to create the amenity index and the loadings on each component.

<sup>16</sup>Table 1.12 in the Appendix shows yearly summary statistics for all the variables in the final data set.

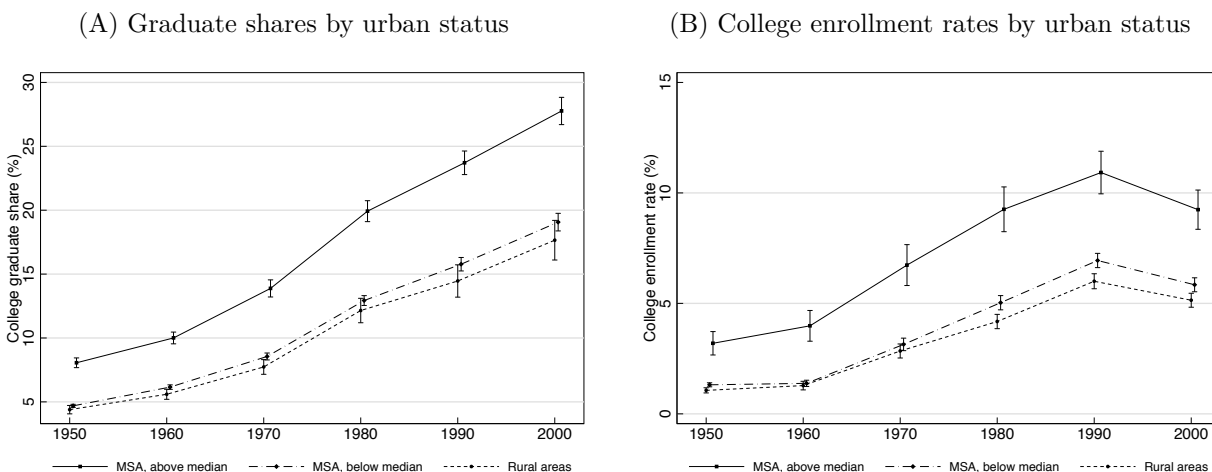


Figure 1.2: Educational Outcomes by Urban Status

Notes: Figure A shows the evolution of average college shares for MSAs below and above the 1940 median college share, and for rural counties aggregated at the state level. Figure B shows the evolution of average college enrollment rates. The college share is defined as the share of a city's residents, aged 25 or older, who graduated from a 4-year college program. The college enrollment rate is defined as the share of a city's residents, aged 5 or older, who were enrolled in a 4-year college program at the time of the survey. Source: County and City Data Books, 1947-2002.

The construction of the Interstate Highway System began in 1956 with the passage of the Federal Highway Act.<sup>17</sup> As a result, there are very few interstates that I observe in 1950. Only 10 MSAs are served by a highway, all of them being pre-existing state freeways that were later incorporated into the interstate system. By 1960, 123 MSAs were connected to the network, with an average of one highway per location. Most of the system was complete by the end of the 1970s. To this day, 43 metropolitan areas remain outside the interstate system. On average, a city is served by 3 highways, accounting for 76 miles.

<sup>17</sup>Appendix 1.10.3 provides an overview of the construction of the Interstate Highway System.

### 1.3 Identification Strategy

This section presents the methodology for estimating the causal impact of interstate highways on cities' skill composition. I first discuss the measure of highways I use and outline the baseline regression specification. I then describe the instrumental variable approach I adopt in order to address endogeneity concerns.

#### 1.3.1 Highway Measures and Baseline Specification

I follow Baum-Snow (2007) and use the number of highway rays crossing a metropolitan area as the preferred measure for interstate highways. A ray is defined as a limited access highway that connects an MSA to surrounding counties. A highway that passes through an MSA counts as two rays, while a highway that terminates in an MSA counts as one ray. Figure 1.3A exemplifies this definition for metropolitan areas in the state of Colorado. Denver, for instance, is served by 6 highway rays: Interstates 25 and 70 cross it from north to south and east to west, respectively, and are counted as two rays; Interstate 76 terminates in Denver and is counted as one ray; finally, Interstate 225 is an intra-metropolitan highway that connects Denver to Aurora and is counted as one ray. By comparison, Fort Collins is crossed from north to south by Interstate 25 and therefore is served by two rays only. As a robustness check, I also consider an alternative measure of highways: the highway density is defined as the number of highway miles open to traffic in an area of 100 square miles.<sup>18</sup>

I estimate the reduced-form impact of highways on MSA's college share using the following regression:

$$\% \text{ college}_{ist} = \alpha + \beta \text{ray}_{it} + \gamma X_{it} + \lambda_i + \delta_{st} + \epsilon_{it}, \quad (1.1)$$

where  $i$  indexes metropolitan areas,  $s$  denotes the state of MSA  $i$ 's central city and  $t$  is the year. The dependent variable,  $\% \text{ college}_{ist}$ , is the share of residents aged 25 or older in city  $i$  who have earned a 4-year college degree, expressed as a percentage.  $\text{ray}_{it}$  is the number of highway rays open to traffic in city  $i$  at time  $t$ .  $X_{it}$  is a vector of time-varying MSA-specific covariates, including educational, demographic, economic and amenity variables.  $\lambda_i$  is a time-invariant city-specific fixed effect that controls for local characteristics, such as history, climate or geographic location.  $\delta_{st}$  is a time effect that is common to all MSAs located in the same state.  $\epsilon_{it}$  is the time-varying location-specific residual. The coefficient of interest is  $\beta$  and measures the effect of within-city interstate highways on the share of college graduates.

Because of the fixed effect specification, the impact of highways on the college share is identified using within-city variation in the stock of interstates over time. Estimates of  $\beta$  will be unbiased if the number of highways is uncorrelated with the error term, conditional on covariates and the set of fixed effects:  $\text{cov}(\text{ray}_{it}, \epsilon_{it} \mid X_{it}, \lambda_i, \delta_{st}) = 0$ . This will not hold if there are time-varying unobservable characteristics that are correlated with the highway measure.

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<sup>18</sup>The highway density in MSA  $i$  at time  $t$  is simply  $\text{density}_{it} = \frac{\text{miles}_{it}}{\text{area}_{it}} \times 100$ , where  $\text{miles}_{it}$  is the number of interstate miles open to traffic and  $\text{area}_{it}$  is the city's area.

The direction of the bias could go both ways. For instance, cities that experienced negative employment shocks early in the construction process may have received more funding for infrastructure and, therefore, ended up with a higher stock of roads at an earlier stage. In this case, OLS estimates would understate the causal impact of highways on the college share. If, on the other hand, early infrastructure funding was allocated preferentially to growing cities, then OLS estimates would overstate their effect. Lastly, the causal relationship may also go in the opposite direction. Brinkman and Lin (2017) find that popular opposition to highways delayed construction and even led to certain planned segments be removed during the late 1960s. In particular, they report that better-educated neighborhoods were more successful in having interstates re-routed. To address these concerns, I exploit two instrumental variables that I discuss in detail the next section.

### 1.3.2 Instrumental Variable

The existing scholarship has relied on three types of instrumental variables when dealing with the endogeneity of transport infrastructure. First, planned routes oftentimes provide exogenous variation in the stock of highways (Baum-Snow, 2007; Hsu and Zhang, 2014). They typically serve clearly-defined purposes, such as national defense and are arguably orthogonal to local markets. A second class of instruments consists of historical routes, such as pre-modern roads, exploration routes or railway lines (Duranton and Turner, 2012; Garcia-López, Holl, and Viladecans-Marsal, 2015; Volpe Martincus, Carballo, and Cusolito, 2017). As these were motivated by considerations that have become obsolete, they provide exogenous variation in contemporary roads. The third class of instruments exploits the geographic location of smaller units relative to larger cities (Banerjee et al., 2020; Faber, 2014; Ghani et al., 2015). By considering peripheral nodes, the probability of being connected to the road network depends on whether a city is conveniently located between two larger entities or along a least-cost-path spanning tree.

The first instrument I consider uses a planned map of the interstate system from 1947. Figure 1.10A in the Appendix shows the interstate network as envisioned in 1947, while Figure 1.10B illustrates the approved network in 1958. Much of the initial plan did end up being constructed, the correlation between the number of highways in 2000 and the number of planned rays in 1947 being 0.78. Studies using the 1947 plan as an instrument argue that it was motivated primarily by economic and strategic considerations that were specific to the 1940s and are thus orthogonal to subsequent growth. Duranton and Turner (2012) and Agrawal et al. (2017), for instance, instrument the number of highway miles in 1983 with the number of interstate miles in the 1947 plan. My identification strategy departs from theirs in that what needs instrumenting in my case is not the aggregate stock of highways allocated to an MSA, but the within-city variation from one period to another. To this aim, I follow Baum-Snow (2007) and use national construction rates to compute the number of planned highways that would be open to traffic in city  $i$  at time  $t$  if construction

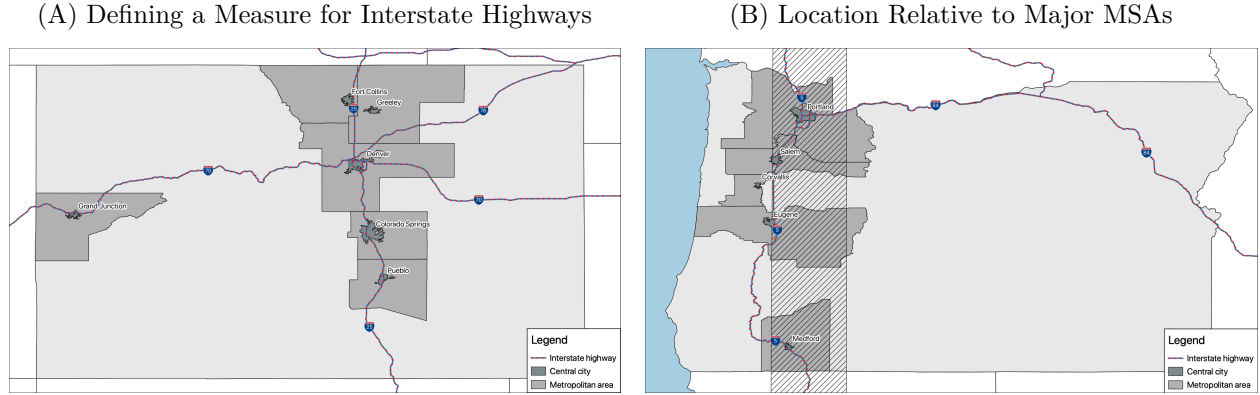


Figure 1.3: Constructing the Orientation-Based Instrument

Notes: Figure A exemplifies the measure for highways used throughout the article for metropolitan areas in the state of Colorado. A highway ray is defined as a segment of an interstate that connects an MSA with neighboring counties. A highway that passes through an MSA counts as two rays, while a highway that terminates in an MSA counts as one ray. Denver, for instance, is served by 6 rays: Interstates 25 and 70 cross it from north to south and east to west, respectively, Interstate 76 terminates in Denver, and Interstate 225 connects Denver to the bordering city of Aurora. Greeley is served by 4 rays, while Grand Junction, Fort Collins, Colorado Springs and Pueblo are each served by 2 rays. Figure B exemplifies the construction of the orientation-based instrument for metropolitan areas located in the state of Oregon. Salem, Eugene and Medford are all located within a 75-km east-west band relative to Portland. The city of Corvallis is located outside this band. While the first three cities are all served by Interstate 5, Corvallis remains unconnected to the interstate network.

rates were uniformly distributed across cities. Specifically, the instrument is:

$$\text{Planned rays}_{it} = (\text{Rays } 1947)_i \times (\text{Total rays}_t) / (\text{Total rays}_{2000}).$$

The instrument is highly correlated with the observed number of highways, mitigating concerns about weak instrumentation. By using national construction rates, it is also unlikely that it is correlated with time-varying unobservable city characteristics, ensuring that the exclusion restriction is not violated.

The second instrument I consider builds on previous work by Michaels (2008). He finds that rural counties were more likely to be served by an interstate if they laid to the east, west, north or south of a major city. I argue that this holds for smaller metropolitan areas as well. One of the stated objectives of the interstate system was to connect major urban and industrial centers “by routes as direct as practicable” (Federal Aid Highway Act of 1944). In line with this requirement, the interstate network exhibits a north-south, east-west orientation. Furthermore, inspection of highway maps from 1950 to 2000 reveals that the construction progressed radially, from large urban centers to nearby counties. Table 1.13 in the Appendix shows that MSAs whose population exceeded 500,000 residents in 1940 were better connected throughout the period to the network and were allocated a higher stock of highways at an earlier stage. I therefore conjecture that cities were more likely to have a higher number of interstates during a given year if the nearest major MSAs oriented east-west and north-south were better connected. Specifically, the instrument is given by:

$$\text{Rays in nearest major MSAs}_{it} = \text{rays\_closest\_EW}_{it} + \text{rays\_closest\_NS}_{it},$$

where  $\text{rays\_closest\_EW}_{it}$  and  $\text{rays\_closest\_NS}_{it}$  are the number of rays in the closest major MSAs oriented east-west and north-south, respectively.<sup>19</sup> For it to be a valid instrument, the number of rays in the nearest major MSAs has to correlated with the endogenous variable. While the coefficient of correlation is lower than for the number of planned rays, it remains positive. The instrument also needs to be orthogonal to the residual in the second stage equation. In order to mitigate such a risk, I restrict the sample of major MSAs to those not located in the same region as the current observation.

In order to obtain consistent estimates of  $\beta$ , I therefore estimate the following system of equations:

$$\% \text{ college}_{ist} = \alpha + \beta \text{ray}_{it} + \gamma X_{it} + \lambda_i + \delta_{st} + \epsilon_{it} \quad (1.2)$$

$$\text{ray}_{it} = \rho + \nu \text{Instrument}_{it} + \mu X_{it} + \eta_i + \zeta_{st} + \varepsilon_{it} \quad (1.3)$$

The validity of the approach depends on the following two conditions being satisfied:

$$\nu \neq 0 \quad (1.4)$$

$$\text{Cov}(\text{Instrument}_{it}, \epsilon_{it}) = 0 \quad (1.5)$$

Equation (1.4) is the relevance condition and requires the instrument to be correlated with the endogenous variable. Equation (1.5) is the exclusion restriction and requires the instrument to be orthogonal to the residual error.  $\text{Instrument}_{it}$  is either the number of planned rays, smoothed using national construction rates, or the number of highways in the nearest major MSAs oriented east-west and north-south. I also use both instruments simultaneously and report results from standard over-identification tests.

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<sup>19</sup>This strategy calls for two qualifications. First, I classify MSAs as major if their population exceeded 500,000 residents in 1940. 33 cities meet this requirement. As a robustness check, I consider alternative criteria, including employment in the manufacturing sector. Second, an MSA is defined as being oriented east-west or north-south if it is located within a band of given radius relative to a major city. In the baseline specification, the radius is set to 75 km. Figure 1.3B provides an example: the cities of Salem, Eugene and Medford are located within a 75 km-wide band relative to Portland, OR. They are all served by Interstate 5. The city of Corvallis is located outside this band and is not served by Interstate 5.

## 1.4 Reduced-Form Effects of Highways on the Skill Composition

This section provides reduced-form evidence of the impact of interstate highways on the skill composition of US metropolitan areas. I first discuss results from OLS regressions. As these estimates are likely to be biased, the second part presents coefficients from IV regressions. I also document that better highway connections lead to an increase in the number of residents born in a different state. Additional regressions show that suburbanization was not the main driver of this spatial concentration.

### 1.4.1 OLS Results

Table 1.1 presents ordinary least squares estimates of equation (1.1). In columns (1) through (3), the dependent variable is the share of a city's residents who have completed a 4-year college program, expressed as a percentage of population aged 25 or older. All specifications include educational, demographic and economic covariates, as well as time-invariant MSA-specific fixed effects. The regressions in columns (1) and (2) also include state-by-year fixed effects. In column (3), instead of state-by-year fixed effects, I control for the share of college graduates in rural counties, aggregated at the state level. Standard errors are clustered at the level of the state of an MSA's central city.

The coefficients on the number of rays are positive and highly significant across all specifications. The estimate in the baseline regression – column (1) – is 0.41 and significant at the 1% level. In column (2), I condition on the index of local amenities and restrict the sample to the 1960-2000 period. The OLS coefficient is now 0.45, and still significant. Finally, column (3) controls for the college share in rural counties and drops the state-by-year fixed effects. This produces an estimate of 0.37, which is in line with previous results. Because the college share is bounded by 0 and 100, columns (4) through (6) show estimates of equation (1.1) in which the dependent variable is the logit of the college share.<sup>20</sup> The coefficients on the number of rays are still positive and precisely estimated. Each additional highway ray is associated with an increase in the log odds of 0.01. The result is robust to including an index for local amenities and controlling for the log-odds share in rural counties instead of state-by-year fixed effects.

The other covariates have, by and large, the expected sign. College enrollment rates correlate positively with the share of high-skilled workers. An increase of one point in the fraction of residents attending college corresponds to a rise of 0.65 percentage points in the graduate share.<sup>21</sup> College graduates also sort into larger cities, confirming previous results in the literature (Glaeser and Resseger, 2010). A 10% increase in a city's population is associated with a college share that is bigger, on average, by 0.50 percentage points. The coefficient on the fraction of women is negative and significant at 10% in the baseline specification. While negative, the coefficients on the fraction

<sup>20</sup>Specifically, the dependent variable is  $\log(\% \text{ college}_{\text{ist}} / (100 - \% \text{ college}_{\text{ist}}))$ . This corresponds to the difference in the log-populations of high-skilled and low-skilled workers.

<sup>21</sup>While not conclusive, there is evidence that graduates are more likely to seek employment in the state where they went to college (Bound, Groen, Kezdi, and Turner, 2004; Groen, 2004). Abel and Deitz (2011) adopt an instrumental variable approach to measure the impact of the local production of degrees on a metropolitan area's college share. While IV techniques yield positive coefficients, they are not significant at conventional levels.

Table 1.1: OLS Regressions of the Determinants of MSA College Share, 1950 – 2000

	College Graduate Share			log(College Graduate Odds)		
	(1)	(2)	(3)	(4)	(5)	(6)
Number of highways	0.406*** (0.069)	0.454*** (0.095)	0.372*** (0.054)	0.010*** (0.003)	0.011*** (0.004)	0.012*** (0.003)
% enrolled in college	0.650*** (0.099)	0.574*** (0.126)	0.668*** (0.043)	0.013*** (0.005)	0.016*** (0.005)	0.021*** (0.003)
log(population)	4.730*** (1.476)	6.308*** (1.626)	2.626*** (0.761)	0.084* (0.044)	0.149*** (0.037)	0.069** (0.032)
% female	−0.287* (0.152)	−0.394* (0.184)	−0.534*** (0.136)	−0.019* (0.010)	−0.030*** (0.007)	−0.019** (0.009)
% non-white	−0.009 (0.034)	0.009 (0.040)	0.021 (0.027)	−0.005*** (0.001)	−0.004** (0.002)	−0.002* (0.001)
% urban	−0.026 (0.026)	−0.062*** (0.019)	−0.007 (0.025)	0.002 (0.002)	−0.002** (0.001)	0.001 (0.001)
Employment rate	0.385*** (0.081)	0.380*** (0.101)	0.325*** (0.034)	0.016*** (0.004)	0.016*** (0.004)	0.012*** (0.003)
Amenity index		0.072 (0.131)			0.008 (0.008)	
Rural college share			0.854*** (0.067)			0.896*** (0.026)
Adjusted R-squared	0.949	0.950	0.934	0.977	0.979	0.972
Within R-squared	0.372	0.328	0.919	0.136	0.186	0.967
Observations	1,824	1,520	1,842	1,824	1,520	1,842
Number of MSAs	304	304	307	304	304	307
Time Period	1950-2000	1960-2000	1950-2000	1950-2000	1960-2000	1950-2000
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes
State × Year FE	Yes	Yes	No	Yes	Yes	No

Notes: The data used in these regressions come from the County and City Data Books. The college share is computed as the percentage of a city's residents, aged 25 or older, who graduated from a four-year college program. The college graduate odds is the ratio between the college graduate share and the non-graduate share. The highway measure is the number of highway rays open to traffic in a given year. All specifications are estimated by ordinary least squares. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

of non-white residents and urbanization rates are small and not significant across all specifications. In contrast, employment rates correlate highly with the college share. The latter increases by 0.39 for each additional employment point. The coefficient on the amenity index is positive but not significant.<sup>22</sup> Finally, college shares in metropolitan areas correlate highly with the fraction of graduates residing in rural areas. The coefficient on the rural college share is 0.85 and significant

<sup>22</sup>The amenity index correlates negatively with the stock of both high-skilled and low-skilled workers, implying lower amenities in more densely populated areas. The point estimates are similar in magnitude for both types of workers, accounting for the lack of a strong relation between amenities and the college share.

at 1%. The sign of the covariates does not change when the dependent variable is the log-odds of the college share, albeit the coefficients on the share of non-white residents are now statistically significant.

In order to examine the population dynamics that underlie the observed geographic sorting of high-skilled workers, Panel A of Table 1.14 in the Appendix presents estimates of regressions in which the dependent variable is either the stock of college graduates – columns (1) through (3) –, or the stock of non-graduates – columns (4) through (6) –. The OLS coefficient on the number of rays is 0.02 for college-educated workers, and significant in all specifications. This result is robust to controlling for local amenities – column (2) –, or the stock of graduates in rural counties – column (3) –. The results for non-graduates are less clear-cut. In the baseline specification, the coefficient on the number of rays is 0.01, and significant at 10%. Controlling for local amenities reduces the point estimate, which becomes indistinguishable from zero. On the other hand, conditioning on the stock of college non-graduates in rural areas yields a larger effect, significant at 1%.

### 1.4.2 IV Results

The OLS coefficients reported in the previous section will be biased if the error term in equation (1.1),  $\epsilon_{it}$ , is correlated with the highway measure,  $\text{ray}_{it}$ . In order to address endogeneity concerns, I adopt an instrumental variable approach. Table 1.2 presents the results from IV regressions when the dependent variable is the college share and its logit transformation. In columns (1) through (4), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates.

The coefficient on the number of interstates in the baseline specification is 0.55 and significant at 1%. The effect is bigger than its OLS counterpart, suggesting that OLS estimates suffer from a downward bias. In column (2), instead of including state-by-year fixed effects, I condition on the share of college graduates in rural counties. At 0.47, the point estimates is now somewhat smaller, but remains highly significant and bigger than the corresponding OLS estimate. In column (3), I estimate the effect of highway on the college share only for metropolitan areas that were connected to the interstate network.<sup>23</sup> The coefficient is now 0.63 and highly significant. Column (4) conditions on the amenity index and, therefore, restricts the sample to the 1960-2000 period. The effect is bigger, approximately 0.84 percentage points for each additional highway, and significant at 1%.<sup>24</sup> In column (5), I instrument the number of highways with the aggregate stock of interstates in the two nearest major MSAs that are oriented east-west and north-south. As time-varying regional fixed effects absorb much of the variation in the instrument, I control for the rural college share instead. The coefficient on the number of rays is 0.52, which is in line with results using the number of planned rays. Finally, in column (6), I use both the number of planned rays and the stock of

<sup>23</sup>In 2000, 43 metropolitan areas were not served by any interstate. The 1947 plan did not allocate any highways to these cities, either.

<sup>24</sup>The larger point estimate does not appear to be driven by the inclusion of the amenity index, but rather by the shorter time frame. Estimating equation (1.1) over the 1960-2000 period without controlling for amenities produces a coefficient of 0.83.

Table 1.2: IV Regressions of the Determinants of MSA College Share, 1950 – 2000

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable: College Graduate Share						
Number of highways	0.552*** (0.150)	0.470*** (0.076)	0.630*** (0.145)	0.844*** (0.250)	0.519*** (0.147)	0.472*** (0.074)
Within R-squared	0.371	0.919	0.340	0.312	0.919	0.919
First-stage statistic	290.552	438.612	167.642	130.650	57.841	217.798
Over-id $p$ -value	—	—	—	—	—	0.762
Dependent Variable: log(College Graduate Odds)						
Number of highways	0.013* (0.006)	0.016*** (0.005)	0.016** (0.008)	0.027** (0.010)	0.037** (0.017)	0.016*** (0.005)
Within R-squared	0.140	0.967	0.112	0.176	0.965	0.967
First-stage statistic	290.552	386.056	167.642	130.650	37.945	217.798
Over-id $p$ -value	—	—	—	—	—	0.234
Educational controls	Yes	Yes	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes	Yes	Yes
Economic controls	Yes	Yes	Yes	Yes	Yes	Yes
Amenity controls	No	No	No	Yes	No	No
Rural college share	No	Yes	No	No	Yes	Yes
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	No	Yes	Yes	No	No

Notes: The data used in these regressions come from the County and City Data Books. The college share is computed as the percentage of a city's residents, aged 25 or older, who graduated from a four-year college program. The college graduate odds is the ratio between the college graduate share and the non-graduate share. The highway measure is the number of highway rays open to traffic in a given year. All specifications are estimated by two-stage least squares. In columns (1) through (4), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates: (rays in 1947 plan)  $\times$  (rays completed nationally in year  $t$ ) / (total number of rays in 2000). In column (5), the instrument is the aggregate number of highways open to traffic in the two nearest major MSAs oriented east-west and north-south. Column (6) uses both instruments. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

highways in the nearest major MSAs as instruments. The point estimate is 0.47 and significant at 1%. Moreover, the  $p$ -value of the over-identification test is 0.76, meaning that I fail to reject the over-identifying restrictions. Because the Sargan-Hansen test is a test of joint exogeneity, jointly endogenous instruments may still pass it if they induce biases of similar size. Given the different rationale of my two instruments, this seems improbable.

The results are robust to using the logit transformation of the college share as the dependent variable. The IV coefficient in the baseline specification is 0.013 and barely fails the significance test at 5%. It is also slightly larger than its OLS counterpart. Conditioning on the rural college share or restricting the sample to metropolitan areas connected to the interstate network lead to point estimates of 0.016. As was the case previously, controlling for local amenities and estimating the effect over the period from 1960 to 2000 inflates the highway effect on the college share. Instrumenting the number of rays with the stock of highways in the nearest major MSAs leads to a coefficient of 0.037, significant at 1%. Finally, using both instruments produces a coefficient of 0.016, which is in the range of previous estimates. I also fail to reject the null hypothesis that the

instruments are valid.

In all specifications, the first-stage F-statistic is well above Stock and Yogo's critical value, ensuring that weak instruments are not a problem here. Moreover, the sign on the instruments accords with expectations. Table 1.15 in the Appendix shows estimates of the first-stage equation. In the baseline specification, the coefficient on the number of planned rays is 1.14 and significant at 1%. This suggests that metropolitan areas were eventually allocated a higher number of interstates than initially planned. The coefficient on the stock of highways in the nearest major MSAs is also positive and highly significant: an additional highway in a major MSAs increases the stock of local highway by 0.15. Using both instruments simultaneously, leads to positive and significant coefficients on both the number of planned rays and the number of rays in major MSAs, albeit the latter is smaller.

Instrumenting the number of highways yields higher coefficients than OLS, indicating that endogeneity leads to a downward bias. This is consistent with results in Duranton and Turner (2012) and Agrawal et al. (2017). In order to account for this difference, Duranton and Turner (2012) document that cities that experienced negative population shocks tended to have larger employment in road building sectors.

In Panels B and C of Table 1.14 in the Appendix, I show IV estimates of the effect of highways on the number of college graduates and non-graduates living in a metropolitan area. The effect on the former is positive and significant at 5%: the number of college graduates increased by 2.6% with each additional highway ray. When the stock of highways in the nearest major cities is used as the instrument, the estimated coefficient on the number of highways is smaller and statistically insignificant. Using both instruments, on the other hand, generates larger effects that are now significant at 1%. I also pass standard over-identification tests. The results for the stock of non-graduates are less clear-cut. The coefficient in the baseline specification is 0.11 and not significant. The effect becomes statistically significant only when I control for the stock of non-graduates in rural areas. Overall, these results suggest that the concentration of high-skilled workers in better connected locations was driven by an increase in the stock of college educated workers, growth in the population of non-graduates being moderate at best.

Further robustness checks are provided in Table 1.16 in the Appendix. In particular, I consider alternative methodologies to construct the orientation-based instrument. First, I use different criteria to classify MSAs as major or minor. In column (1), I define as major those MSAs whose population exceeded the regional 90th percentile in 1940. In column (2), I use employment in manufacturing to group MSAs into major and minor. The coefficient on the number of rays are only slightly larger than in the baseline specification. In columns (5) and (6), I use different widths to construct the instrument. The coefficients are now somewhat smaller, but still significant. In column (9), I use the number of highways in the nearest major MSAs that are oriented east-west and north-south as separate instruments. The effect is similarly smaller. I also consider different combinations of these instruments and the number of planned rays. The coefficients I obtain are in the range of previous estimates. I pass standard over-identification tests in all specifications.

Section 1.10.5.1 discusses these results in greater detail.

### 1.4.3 Migration Outcomes

In this section, I present reduced-form evidence of the impact of interstate highways on migration outcomes at the city level. To this aim, I use the IPUMS data sets to compute the number of migrants living in each city from 1950 to 2000, where migrants are defined as individuals residing in a different state than the one they were born in. While the IPUMS data sets are extremely rich, their use raises several concerns.

First, there is significant variation in geographic coverage across periods. While this improves over time, only 94 MSAs are observed in every Census year. The unbalanced sample consists of 271 cities that are identified in at least two years. On average, metropolitan areas in the IPUMS samples are bigger, more educated and more urbanized. Second, the 1950 sample provides information on educational attainment only for a quarter of respondents. In the absence of supplement information, I assume that non-reporting is uniformly distributed across skill levels. Third, because geographic coverage is incomplete, the rural college share is measured with error as non-identified cities are mechanically assigned to rural areas. I therefore use the college share at the state level to control for unobserved time-varying regional trends. Table 1.17 in the Appendix re-estimates the effect of highways on the college share using the IPUMS sample. The results are similar to those obtained using CCDB data. Section 1.10.5.2 provides a more in-depth discussion of these regressions.

Table 1.3 presents OLS and IV estimates of the impact of highways on a series of migration outcomes. All specifications include educational, demographic and economic covariates, as well as MSA-specific fixed effects. In Panel A, the dependent variable is the log of the number of migrants living in a metropolitan area. Panel B shows results for the share of migrants with a college degree.

The coefficient on the number of rays when the dependent variable is the number of migrants is 0.03 in the baseline specification and is significant at 5%. In column (2), instead of including state-by-year fixed effects, I condition on the number of migrants at the state level. The estimate is only slightly higher and is now significant at 1%. In column (3), I instrument the number of rays with the number of highways in the 1947 plan, smoothed using national construction rates. I find that the number of migrants increased by 7.5% with each new interstate. Controlling for the number of migrants at the state level reduces the estimate to 0.05, but does not alter its significance. Adding the orientation-based instrument yields a similar coefficient and I cannot reject the null hypothesis that two instruments are jointly valid.

In addition to increasing the stock of migrants in a city, interstate connections also changed their composition. OLS regressions of the share of college graduates among migrants on the number of highways produce positive and highly significant coefficients. In the baseline specification, the coefficient on the number of rays is 0.39. Instrumental variable regressions indicate higher effects. The share of college graduates among migrants increased by 0.78 percentage points for each additional highway. The result is robust to controlling for the share high-skilled migrants at the state level and including the orientation-based instrument. The evidence hence suggests a positive im-

Table 1.3: Regressions of the Impact of Highways on Migration, 1950 – 2000

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	IV	IV	IV
Dependent Variable: $\log(\text{Migrants})$					
Number of highways	0.026** (0.012)	0.032*** (0.007)	0.072*** (0.021)	0.050*** (0.011)	0.050*** (0.011)
Within R-squared	0.231	0.759	0.204	0.757	0.757
First-stage statistic	–	–	158.259	387.542	189.590
Over-id $p$ -value	–	–	–	–	0.275
Dependent Variable: Share of College Graduates among Migrants					
Number of highways	0.391*** (0.146)	0.555*** (0.099)	0.783* (0.445)	0.766*** (0.205)	0.766*** (0.202)
Within R-squared	0.146	0.866	0.136	0.865	0.865
First-stage statistic	–	–	152.794	271.728	134.891
Over-id $p$ -value	–	–	–	–	0.974
MSA FE	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	No	Yes	No	No
State Controls	No	Yes	No	Yes	Yes

Notes: The data used in these regressions come from the 1950-2000 IPUMS samples of the US Census. The number of migrants in a metropolitan area is computed as the number of individuals who were born in a different state than the one they are currently living in. The share of college graduates among migrants is the percentage of migrants who graduated from a four-year college program. The highway measure is the number of highway rays open to traffic in a given year. In columns (3) and (4), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates:  $(\text{rays in 1947 plan}) \times (\text{rays completed nationally in year } t) / (\text{total number of rays in 2000})$ . In column (5), the highway stock is instrumented using both the plan-based and the orientation-based instruments. All specifications include educational, demographic and economic covariates. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

pact of interstate highways on the number of migrants, the effect being bigger for better educated migrants.

#### 1.4.4 Sorting, Suburbanization and Other Robustness Checks

There is mounting evidence that improvements in the transport infrastructure affect the internal structure of cities. In a seminal paper, Baum-Snow (2007) documents that the population of central cities declined by 18% with each additional highway, despite population increasing in metropolitan areas as a whole. Similar evidence was produced for Spanish cities (García-López et al., 2015) and Chinese prefectures (Baum-Snow, Brandt, Henderson, Turner, and Zhang, 2017). In this section, I test whether the impact of highways on the college share is heterogeneous within metropolitan areas.

## 1.4. Reduced-Form Effects of Highways on the Skill Composition

Table 1.4: Impact of Highways on the College Share in Central Cities and their Suburbs

	Central Cities				Suburban Areas			
	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) OLS	(6) OLS	(7) IV	(8) IV
Number of highways	0.578*** (0.115)	0.736*** (0.105)	0.971*** (0.282)	0.890*** (0.205)	0.419*** (0.125)	0.390*** (0.087)	0.895*** (0.328)	0.624*** (0.158)
Within R-squared	0.304	0.866	0.298	0.867	0.198	0.875	0.185	0.874
First-stage statistic	—	—	113.476	114.028	—	—	113.476	114.028
Over-id $p$ -value	—	—	—	0.430	—	—	—	0.328
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	No	Yes	No	Yes	No	Yes	No
State Controls	No	Yes	No	Yes	No	Yes	No	Yes

Notes: The data used in these regressions come from the City and County Data Books. The dependent variable is the college share, computed as the percentage of residents, aged 25 or older, who graduated from a four-year college program. Central cities are identified as the most populous city in their MSA. The remaining areas are assigned to the suburbs. The highway measure is the number of highway rays open to traffic in a given year. In columns (3) and (7), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates:  $(\text{rays in 1947 plan}) \times (\text{rays completed nationally in year } t) / (\text{total number of rays in 2000})$ . In columns (4) and (8), the highway stock is instrumented using both the plan-based and the orientation-based instruments. All specifications include educational, demographic and economic covariates. I also control for the log of the ratio between the median income (rent) in the central city and the median income (rent) in the MSA as a whole. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

To this aim, I re-estimate equation (1.1) separately for central cities and their suburbs.<sup>25</sup> Because highway connections may impact the distribution of economic activity within metropolitan areas and affect the local housing market, I include as additional covariates the log of the ratio of the median income (rent) in central cities and in the MSA as a whole. According to the results presented in Table 1.4, the OLS coefficient on the number of rays is bigger in central cities than in suburban areas. Instrumental variable regressions do not significantly alter this result. An additional interstate highway increases the share of graduates by almost a percentage point in central cities and 0.90 percentage points in their suburbs. Therefore, I find limited evidence of heterogeneous effects of roads within metropolitan areas.

Finally, Table 1.18 in the Appendix provides additional robustness checks. First, I test whether my results are sensitive to my choice for the measure of interstate highways. In columns (1) through (4), I consider an alternative measure: the local density of highways. Both OLS and IV coefficients remain positive and significant. Adding 1 interstate mile in an area of 100 square miles increases the college share by 0.60 percentage points. Second, in columns (5) through (8), I test whether the effect is driven by outliers. Dropping metropolitan areas that experienced gains in their college share below the 5th percentile and above the 95th percentile does not change the results in a substantial way. Finally, columns (9) and (10) provide estimates of equation (1.1) in long-differences. At 0.80, the OLS coefficient is larger than in panel regressions. Instrumenting the change in the number of rays with the number of rays in the 1947 plans yields a similar coefficient (0.83), significant at 1%. These results are discussed in greater detail in Section 1.10.5.3.

<sup>25</sup>For each MSA, the central city is defined as the most populous city within its geographic borders. The suburbs consist of all areas in a metropolitan area that are located outside the central city.

## 1.5 The Theoretical Framework

In this section, I describe a quantitative spatial model that builds upon previous work by Monte et al. (2018) and Morten and Oliveira (2016) to accommodate for heterogeneous workers. The economy comprises many asymmetric regions, indexed by  $i \in \{1, \dots, N\}$ . These may differ in terms of their residential land endowment, average productivity, local amenities and geographic location. Shipping goods from one region to another is subject to bilateral iceberg trade costs. Workers are mobile between locations, but have heterogeneous preferences for living in each region. Moving from one location to another is subject to bilateral migration costs. These take the iceberg form and are expressed in terms of utility. I depart from the previous papers and assume that workers are heterogeneous. In particular, I allow for the distribution of workers' idiosyncratic preferences to vary across skill groups.<sup>26</sup> Moreover, migration costs are skill-specific, meaning that different types of workers may face different costs for the same origin-destination pair. Finally, trade and migration costs depend on the existing transport infrastructure.

### 1.5.1 Consumer preferences

The utility of consumer  $\omega$  endowed with skill  $s$  depends on their consumption of a composite good,  $C_n^s(\omega)$ , residential land,  $H_n^s(\omega)$ , the cost of migration from  $i$  to  $n$ ,  $\kappa_{in}^s$ , and an idiosyncratic preference shock,  $b_n^s(\omega)$ . The last term is a measure of worker  $\omega$ 's taste for location  $n$ .<sup>27</sup> I assume that utility is a Cobb-Douglas function. Consumer  $\omega$ , who migrates from location  $i$  to  $n$ , maximizes the following utility function:

$$U_{in}^s(\omega) = \frac{b_n^s(\omega)}{\kappa_{in}^s} \left( \frac{C_n^s(\omega)}{\alpha} \right)^\alpha \left( \frac{H_n^s(\omega)}{1 - \alpha} \right)^{(1-\alpha)}, \quad 0 < \alpha < 1, \quad (1.6)$$

subject to the budget constraint:

$$P_n C_n^s(\omega) + r_n H_n^s(\omega) \leq W_n^s.$$

$W_n^s$  is the wage of skill- $s$  workers living in location  $n$ ,  $P_n$  is the ideal price index and  $r_n$  is the residential land rent. Because the utility function is Cobb-Douglas, workers spend a constant share of their income on housing,  $1 - \alpha$ .<sup>28</sup>

The final consumption good,  $C_n^s$ , is a CES aggregate of both domestic and imported goods,

<sup>26</sup>In Section B10 of the online Appendix accompanying their paper, Monte et al. (2018) outline a quantitative spatial model in which the distribution of idiosyncratic preferences varies across worker types, in a similar fashion to the one presented in this article.

<sup>27</sup>Monte et al. (2018) and Fretz et al. (2017) assume that the amenities shock is bilateral, implying that workers are heterogeneous in their idiosyncratic valuation of each commute  $(i, n)$ . In contrast, I assume that the idiosyncratic component of utility is destination-specific. This captures the idea that, in a migration model, workers only derive utility from consuming amenities in the location where they reside.

<sup>28</sup>Fretz et al. (2017) and Tsivanidis (2019) assume non-homothetic Stone-Geary preferences. As a consequence, the fraction of income spent on housing varies across locations and skill groups. In particular, this share is higher in more expensive locations and is lower for higher-skilled workers than for their lower-skilled counterparts.

which are defined over a continuum  $j \in [0, 1]$ :

$$C_n^s = \left[ \int_0^1 c_n^s(j)^{\frac{\sigma-1}{\sigma}} dj \right]^{\frac{\sigma}{\sigma-1}}, \quad \sigma > 0,$$

where  $c_n^s(j)$  is individual consumption of good  $j$  by type- $s$  workers and  $\sigma$  is the elasticity of substitution between goods. The corresponding dual price index is given by:

$$P_n = \left[ \int_0^1 p_n(j)^{1-\sigma} dj \right]^{\frac{1}{1-\sigma}}, \quad (1.7)$$

where  $p_n(j)$  is the price of variety  $j$  in location  $n$ .

Much of the quantitative spatial economics literature assumes that the idiosyncratic preference shocks are identically distributed across workers. Instead, I allow for the taste distribution to vary with the type of workers. Specifically, I posit that preference shocks of type- $s$  workers,  $b_n^s(\omega)$ , are independently drawn from a Fréchet distribution with scale parameter  $B_n^s$  and shape parameter  $\epsilon^s$ :

$$G_n^s(b) = e^{-B_n^s b^{-\epsilon^s}}, \quad B_n^s > 0, \quad \epsilon^s > 1. \quad (1.8)$$

Higher values of  $B_n^s$  correspond to better average amenities, in the sense that higher draws are more likely.<sup>29</sup>  $\epsilon^s$  determines the dispersion of individual preferences, with higher values corresponding to less dispersion in idiosyncratic tastes.

Migration costs,  $\kappa_{in}^s \in [1, \infty)$ , take the iceberg form and are expressed in terms of utility. They are assumed to include not only the monetary costs of migrating and subsequent return visits, but also the psychological cost of not living in the location of origin (i.e. being away from one's family and friends). I assume that migration costs are symmetric, i.e.  $\kappa_{in}^s = \kappa_{ni}^s$ , and are a function of the existing transport infrastructure. More importantly, I allow for different types of workers to face different migration costs.

### 1.5.2 Residential choices

Substituting the optimal levels of goods and residential land consumption into equation (1.6) yields the following expression for consumer  $\omega$ 's indirect utility:

$$U_{in}^s(\omega) = \frac{b_n^s(\omega)}{\kappa_{in}^s} \frac{W_n^s}{P_n^\alpha r_n^{1-\alpha}}. \quad (1.9)$$

Because the idiosyncratic preference shock enters the utility function multiplicatively, the latter inherits the distribution of  $b_n(s)$ . Indirect utility is thus distributed Fréchet with scale parameter

<sup>29</sup>I assume average amenities to be exogenous. Specifically, I rule out endogenous changes into amenities due to agglomeration forces (i.e. congestion, pollution) or changes in cities' skill mix. When undertaking counterfactuals, I test the sensitivity of my results to incorporating externalities on local amenities.

$\psi_{in}^s$  and shape parameter  $\epsilon^s$ :

$$H_{in}^s(U) = e^{-\psi_{in}^s U^{-\epsilon^s}} \quad \text{where} \quad \psi_{in}^s = B_n^s \left( \kappa_{in}^s P_n^\alpha r_n^{1-\alpha} \right)^{-\epsilon^s} (W_n^s)^{\epsilon^s}.$$

Workers choose the location where they live optimally. This means that individuals from  $i$  will migrate to  $n$  if the utility they obtain in  $n$  is higher than elsewhere. Using the properties of the Fréchet distribution, the probability that a worker from  $i$  migrates to  $n$  is:

$$\lambda_{in}^s = \frac{B_n^s \left( \kappa_{in}^s P_n^\alpha r_n^{1-\alpha} \right)^{-\epsilon^s} (W_n^s)^{\epsilon^s}}{\sum_{k=1}^N B_k^s \left( \kappa_{ik}^s P_k^\alpha r_k^{1-\alpha} \right)^{-\epsilon^s} (W_k^s)^{\epsilon^s}} = \frac{\psi_{in}^s}{\sum_{k=1}^N \psi_{ik}^s}. \quad (1.10)$$

The numerator is equal to the migration cost-adjusted utility in location  $n$ , while the denominator is an origin-specific term that corresponds to location  $i$ 's worker market access (Morten and Oliveira, 2016). The worker market access captures workers' access to high-utility locations. It is greater in regions located closer (smaller migration costs  $\kappa_{ik}^s$ ) to high-utility areas (better local amenities or higher real wages). The Fréchet shape parameter  $\epsilon^s$  governs the elasticity of migrant flows with respect to real wages and migration costs. First, a higher  $\epsilon^s$  corresponds to larger responses to changes in real wages. Intuitively, a higher  $\epsilon^s$  entails less dispersion in idiosyncratic preferences, so that smaller real wages are required for workers to reallocate across locations. Second, a higher  $\epsilon^s$  implies a greater elasticity of migrant flows with respect to mobility costs.

For an initial allocation of labor,  $L_{i0}^s$ , equilibrium migration flows from  $i$  to  $n$  are given by  $L_{in}^s = \lambda_{in}^s L_{i0}^s$ . Substituting equation (1.10) into this expression yields the following gravity equation for migrant flows:

$$L_{in}^s = \Omega_n^s (\kappa_{in}^s)^{-\epsilon^s} (WMA_i^s)^{-1} L_{i0}^s, \quad (1.11)$$

where  $\Omega_n^s = B_n^s (W_n^s / P_n^\alpha r_n^{1-\alpha})^{\epsilon^s}$  is the common component of average utility in location  $n$  and  $WMA_i^s = \sum_{k=1}^N (\kappa_{ik}^s)^{-\epsilon^s} \Omega_k^s$  is location  $i$ 's worker market access.

The total number of type- $s$  workers living in location  $n$  is obtained by summing migrant flows from all locations of origin:

$$L_n^s = \sum_{i=1}^N L_{in}^s = \sum_{i=1}^N \lambda_{in}^s L_{i0}^s. \quad (1.12)$$

In models where workers choose both their location of residence and their workplace, the spatial no-arbitrage condition implies that expected utility is the same across all residence-workplace pairs, and equal to expected utility in the economy (Monte et al., 2018). Here, because there are bilateral mobility costs and workers are initially assigned to a location of origin, the no-arbitrage condition requires that expected utility be the same for all workers within the same origin  $i$ :

$$\mathbb{E}(U_{in}^s \mid \text{locate in } n) = \gamma \left[ \sum_{k=1}^N B_k^s \left( \kappa_{ik}^s P_k^\alpha r_k^{1-\alpha} \right)^{-\epsilon^s} (W_k^s)^{\epsilon^s} \right]^{1/\epsilon^s}.$$

where  $\gamma = \Gamma\left(\frac{\epsilon^s-1}{\epsilon^s}\right)$  and  $\Gamma(\cdot)$  is the gamma function. In order to obtain a finite value for expected

utility, I require that  $\epsilon^s > 1$ .

### 1.5.3 Production

I follow a common approach in the labor economics literature and model production as a CES function of high-skilled and low-skilled workers (Katz and Murphy, 1992; Card and Lemieux, 2001; Notowidigdo, 2011). Specifically, I assume that good  $j$  is produced in location  $i$  according to the production technology:

$$q_i(j) = z_i(j) \left[ \eta_i \left( l_i^H(j) \right)^{\frac{\mu-1}{\mu}} + (1 - \eta_i) \left( l_i^L(j) \right)^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}}, \quad \mu > 1, \quad (1.13)$$

where  $l_i^H(j)$  and  $l_i^L(j)$  denote the number of high-skilled and low-skilled workers employed in location  $i$  to produce variety  $j$ .  $\eta_i$  is the skill intensity in location  $i$ , and  $\mu$  is the elasticity of substitution between skill groups.<sup>30</sup>  $z_i(j)$  is location  $i$ 's idiosyncratic productivity at producing good  $j$ .

The optimal levels of employment are obtained from the cost minimization problem. Every firm producing variety  $j$  in location  $i$  solves:

$$\min_{l_i^H(j), l_i^L(j)} W_i^H l_i^H(j) + W_i^L l_i^L(j) \quad \text{s.t.} \quad z_i(j) \left[ \eta_i \left( l_i^H(j) \right)^{\frac{\mu-1}{\mu}} + (1 - \eta_i) \left( l_i^L(j) \right)^{\frac{\mu-1}{\mu}} \right]^{\frac{\mu}{\mu-1}} \geq q_i(j).$$

The first order conditions yield the following expressions for the optimal demand for high-skilled and low-skilled workers:

$$l_i^H(j) = \frac{q_i(j)}{z_i(j)} \left( \frac{\eta_i W_i}{W_i^H} \right)^\mu \quad \text{and} \quad l_i^L(j) = \frac{q_i(j)}{z_i(j)} \left( \frac{(1 - \eta_i) W_i}{W_i^L} \right)^\mu,$$

where  $W_i$  is the ideal labor cost index in region  $i$ :

$$W_i = \left[ \eta_i^\mu \left( W_i^H \right)^{1-\mu} + (1 - \eta_i)^\mu \left( W_i^L \right)^{1-\mu} \right]^{\frac{1}{1-\mu}}.$$

The optimal unit cost of variety  $j$  produced in location  $i$  is therefore:

$$c_i(j) = \frac{w_i^H l_i^H(j) + w_i^L l_i^L(j)}{q_i(j)} = \frac{W_i}{z_i(j)}.$$

The ratio of high-skilled to low-skilled workers is constant across all firms in location  $i$  and is equal to the aggregate ratio of high-skilled to low-skilled workers. Moreover, it is decreasing in the

<sup>30</sup>With this specification, I rule out endogenous agglomeration forces. Ahlfeldt, Redding, Sturm, and Wolf (2015) and Allen and Arkolakis (2014) model production externalities as a function of the local employment density. Diamond (2016) allows for the productivity of high-skilled and low-skilled workers to depend on the skill mix of cities. In recent work, Giannone (2019) incorporates spatial knowledge diffusion into the production function. In order to concentrate on trade and migration effects, I switch these channels off.

wage skill premium:

$$\frac{L_i^H}{L_i^L} = \left( \frac{\eta_i}{1 - \eta_i} \right)^\mu \left( \frac{W_i^H}{W_i^L} \right)^{-\mu}. \quad (1.14)$$

Goods are produced under conditions of perfect competition and bilateral trade costs take the iceberg form. Specifically,  $\tau_{ni} \geq 1$  units of a good have to be shipped from  $i$  in order for one unit to arrive in  $n$ .

The price of good  $j$  produced in location  $i$  and consumed in location  $n$  is therefore given by:

$$p_{ni}(j) = \tau_{ni} \frac{W_i}{z_i(j)}. \quad (1.15)$$

Following Eaton and Kortum (2002), the productivity shocks  $z_i(j)$  are independently and identically drawn from a Fréchet distribution with scale parameter  $A_i$  and shape parameter  $\theta$ :

$$F_i(z) = e^{-A_i z^{-\theta}}.$$

$A_i$  is a measure of the average productivity in location  $i$ , while  $\theta$  governs the dispersion of productivity shocks. Higher values of  $A_i$  increases the likelihood of higher productivity draws in  $i$ , while a higher  $\theta$  corresponds to less dispersion in these draws.

#### 1.5.4 Expenditure Shares

Consumers in location  $n$  source every variety  $j$  from the lowest-cost supplier. Because productivity shocks are distributed Fréchet, the share of location  $n$ 's expenditure on goods produced in  $i$  is given by:

$$\pi_{ni} = \frac{A_i (\tau_{ni} W_i)^{-\theta}}{\sum_{k=1}^N A_k (\tau_{nk} W_k)^{-\theta}}. \quad (1.16)$$

This implies the following gravity equation for bilateral trade flows:

$$X_{ni} = \Phi_i (\tau_{ni})^{-\theta} (CMA_n)^{-1} X_n, \quad (1.17)$$

where  $\Phi_i = A_i W_i^{-\theta}$  is an inverse measure of production costs in  $i$ ,  $CMA_n = \sum_{k=1}^N (\tau_{nk})^{-\theta} \Phi_k$  is location  $n$ 's consumer market access (Donaldson and Hornbeck, 2016) and  $X_n$  is location  $n$ 's aggregate expenditure on consumption goods. Location  $n$ 's consumer market access captures its access to cheap products and is bigger when location  $n$  is located closer (smaller trade costs  $\tau_{nk}$ ) to low-cost producers (higher  $\Phi_k$ ). The parameter  $\theta$ , which governs the dispersion of idiosyncratic productivity shocks, also corresponds to the elasticity of trade with respect to trade costs.

The price index in any location  $n$  can be expressed as a function of its consumer market access:

$$P_n^{-\theta} = \gamma^{-\theta} \left[ \sum_{k=1}^N A_k (\tau_{nk} W_k)^{-\theta} \right] = \gamma^{-\theta} CMA_n, \quad (1.18)$$

where  $\gamma = \left[ \Gamma \left( \frac{\theta - (\sigma - 1)}{\theta} \right) \right]^{\frac{1}{1 - \sigma}}$  and  $\Gamma(\cdot)$  denotes the Gamma function. In order for the price index to be finite,  $\theta$  needs to be bigger than  $\sigma - 1$ . Locations with a higher consumer market access can source products from cheaper suppliers, leading to smaller price indices.

### 1.5.5 Aggregate Labor Income

I follow Monte et al. (2018) and assume that housing is owned by immobile landlords who spend all of their income on consumption goods in the location where they reside. Total goods expenditure in location  $k$  is then  $X_k = \alpha (W_k^H L_k^H + W_k^L L_k^L) + (1 - \alpha) (W_k^H L_k^H + W_k^L L_k^L)$ , where the first term is the amount spent by workers and the second term is landlords' expenditure.<sup>31</sup>

Labor income in each region equals total expenditure on goods produced there. The expenditure of workers in region  $k$  on goods produced in  $i$  is simply the product of  $k$ 's expenditure share on goods from  $i$  and  $k$ 's total expenditure:  $X_{ki} = \pi_{ki} X_k = \pi_{ki} (W_k^H L_k^H + W_k^L L_k^L)$ . Total labor income in location  $i$  then has to equal the sum of  $i$ 's exports to all other location. This writes as:

$$W_i^H L_i^H + W_i^L L_i^L = \sum_{k=1}^N X_{ki} = \sum_{k=1}^N \pi_{ki} (W_k^H L_k^H + W_k^L L_k^L). \quad (1.19)$$

### 1.5.6 Housing Costs

In equilibrium, land income and expenditure must be equal. Because the utility function is Cobb-Douglas, the share of income spent on residential land is  $(1 - \alpha)$ . From the residential land market clearing condition, one can derive the following expression for land rents:

$$r_n = (1 - \alpha) \frac{(W_n^H L_n^H + W_n^L L_n^L)}{H_n}. \quad (1.20)$$

### 1.5.7 General Equilibrium

The general equilibrium of the model can be represented by the set of expenditure shares,  $(\pi_{ni})$ , migration rates,  $(\lambda_{in}^s)$ , residential population,  $(L_n^s)$ , wages,  $(W_n^s)$ , prices,  $(P_n)$ , and rents,  $(r_n)$ , given exogenous migration costs,  $\{\kappa_{in}^s\}$ , trade costs,  $\{\tau_{ni}\}$ , average amenities,  $\{B_n^s\}$ , average productivities,  $\{A_n\}$ , and an initial allocation of labor,  $\{L_{n0}^s\}$ . In equilibrium, these quantities are such that:

- a) expenditure shares are given by equation (1.16);
- b) migration shares for each skill level satisfy equation (1.10);
- c) given an initial allocation of labor, population in every location solves equation (1.12);
- d) wages are determined jointly by the labor market clearing condition in equation (1.19) and the skill premium condition in equation (1.14);

<sup>31</sup>By comparison, Redding (2016) assumes that residential rents are redistributed lump-sum to consumers in every location. This entails that total income,  $\nu_k$ , will equal the sum of both labor income and expenditure of residential rents:  $\nu_k L_k = w_k L_k + (1 - \alpha) \nu_k L_k = \frac{W_k L_k}{\alpha}$ . By assuming immobile landlords, I avoid further assumptions on how rents are redistributed across different skill groups.

- e) the price index is given by equation (1.18);
- f) rents are such that the residential land market clears, i.e. equation (1.20) holds.

**Proposition 1** *Given exogenous land areas,  $\{H_n\}$ , average productivity levels,  $\{A_n\}$ , average amenity levels,  $\{B_n^s\}$ , trade costs,  $\{\tau_{ni}\}$ , migration costs,  $\{\kappa_{in}^s\}$ , and an initial allocation of labor,  $\{L_n^s\}$ , there exists a unique set of equilibrium migrant shares,  $(\lambda_{in}^s)$ , residential populations,  $(L_n^s)$ , expenditure shares,  $(\pi_{ni})$ , wages,  $(W_n^s)$ , prices,  $(P_n)$ , and rents,  $(r_n)$ , that solve the previous system of equations.*

In order to test the existence and uniqueness of an equilibrium, I use numerical simulations. After generating data for a hypothetical economy, I search for the set of endogenous variables  $(\lambda_{in}^s, L_n^s, W_n^s, \pi_{in}, P_n, r_n)$  using an iterative algorithm. I replicate the procedure for different combinations of Fréchet shape parameters  $\{\epsilon^H, \epsilon^L\}$  and migration costs  $\{\kappa^H, \kappa^L\}$ . The algorithm converged to a fixed point in all simulations. Moreover, using different initial starting points, the algorithm always converged to the same equilibrium. Appendix 1.10.6 discusses this in greater detail.

## 1.6 Model Simulations

This section examines the conditions under which heterogeneous preference distributions and mobility costs lead to geographic sorting. To this aim, I generate a hypothetical economy in the manner of Redding (2016). I assume that migration and trade costs are a function of effective distance:  $\kappa_{in}^s = \text{dist}_{in}^{\phi^s}$  and  $\tau_{in} = \text{dist}_{in}^{\epsilon}$ .<sup>32</sup> I then consider an exogenous shock to the transportation infrastructure that reduces the instantaneous cost of passing through treated locations. Using an iterative algorithm, I search for the equilibrium distribution of high-skilled and low-skilled workers before and after treatment. Because roads are assigned randomly, their impact on cities' skill composition can be estimated using a difference-in-difference specification.<sup>33</sup> I replicate the procedure for many configurations of preference and migration cost parameters and illustrate average treatment effects as contour plots.

### 1.6.1 Heterogeneous Migration Elasticities

I first analyze geographic sorting under heterogeneous preference distributions. In order to focus on this channel, I assume that both types of workers have identical migration costs, i.e.  $\phi^H = \phi^L = \phi$ , and differ only in the dispersion of their idiosyncratic tastes, i.e.  $\epsilon^H \neq \epsilon^L$ . I consider all combinations  $(\epsilon^L, \epsilon^H)$ , with  $\epsilon^L$  and  $\epsilon^H$  ranging from 1 to 5. For each pair, I search for the equilibrium allocation of workers  $\{L_n^H, L_n^L\}$  before and after treatment, holding the other parameters  $\{\alpha, \sigma, \theta, \mu, \eta, \phi\}$  and location fundamentals  $\{A_n, B_n^H, B_n^L, H_n\}$  fixed. Figures 1.4A and 1.4B show the estimated effects on the college share for null and positive bilateral migration costs, respectively. Red colors correspond to positive effects, with warmer shades indicating larger values. Blue colors correspond to negative effects, with colder shades indicating smaller values.

Figure 1.4A illustrates treatment effects when migration costs are driven entirely by idiosyncratic preferences, i.e.  $\phi = 0$ . An improvement in the transport infrastructure will increase demand for labor in treated locations, as they experience the largest reductions in trade costs.<sup>34</sup> The impact on the college share will be positive if  $\epsilon^H > \epsilon^L$ . To understand this result, it should be noted that, in the absence of bilateral migration costs, the share of workers who choose to migrate to a given destination is the same across all origins.<sup>35</sup> Intuitively, if there are no bilateral migration costs, location decisions are informed exclusively by real wages and local amenities in the city of destination. The Fréchet shape parameter will only govern the migration elasticity with respect

<sup>32</sup>The hypothetical economy consists of 121 locations, displayed on a  $11 \times 11$  grid. For each location, I draw values for the average productivity,  $\{A_n\}$ , and average amenities,  $\{B_n^H, B_n^L\}$ , from standard log-normal distributions. The residential land area in each location,  $\{H_n\}$ , is set to 100. The effective distance between two locations is computed using a least-cost-path algorithm. Appendix 1.10.7 presents the methodology used to generate the economy.

<sup>33</sup>I estimate the equation  $\Delta \log(\text{skill.share})_{nt} = \nu + \beta \mathbb{1}_{nt} + \epsilon_{nt}$ , where  $\Delta \log(\text{skill.share})_{nt}$  is the change in the share of high-skilled workers in location  $n$  and  $\mathbb{1}_{nt}$  is a binary variable that is equal to 1 if city  $n$  is on the path of improved roads.  $\beta$  measures the reduced-form effect of better roads on locations' skill composition.

<sup>34</sup>Treated locations experience higher increases in nominal and real wages, in housing costs, and sharper declines in price indices.

<sup>35</sup>The probability that a worker from  $i$  migrates to  $n$  is the same in all origins:  $\lambda_n^s = \frac{B_n^s (W_n^s / P_n^\alpha r_n^{1-\alpha})^{\epsilon^s}}{\sum_{k=1}^N B_k^s (W_k^s / P_k^\alpha r_k^{1-\alpha})^{\epsilon^s}}$ . This corresponds to equation (10) in Redding (2016).

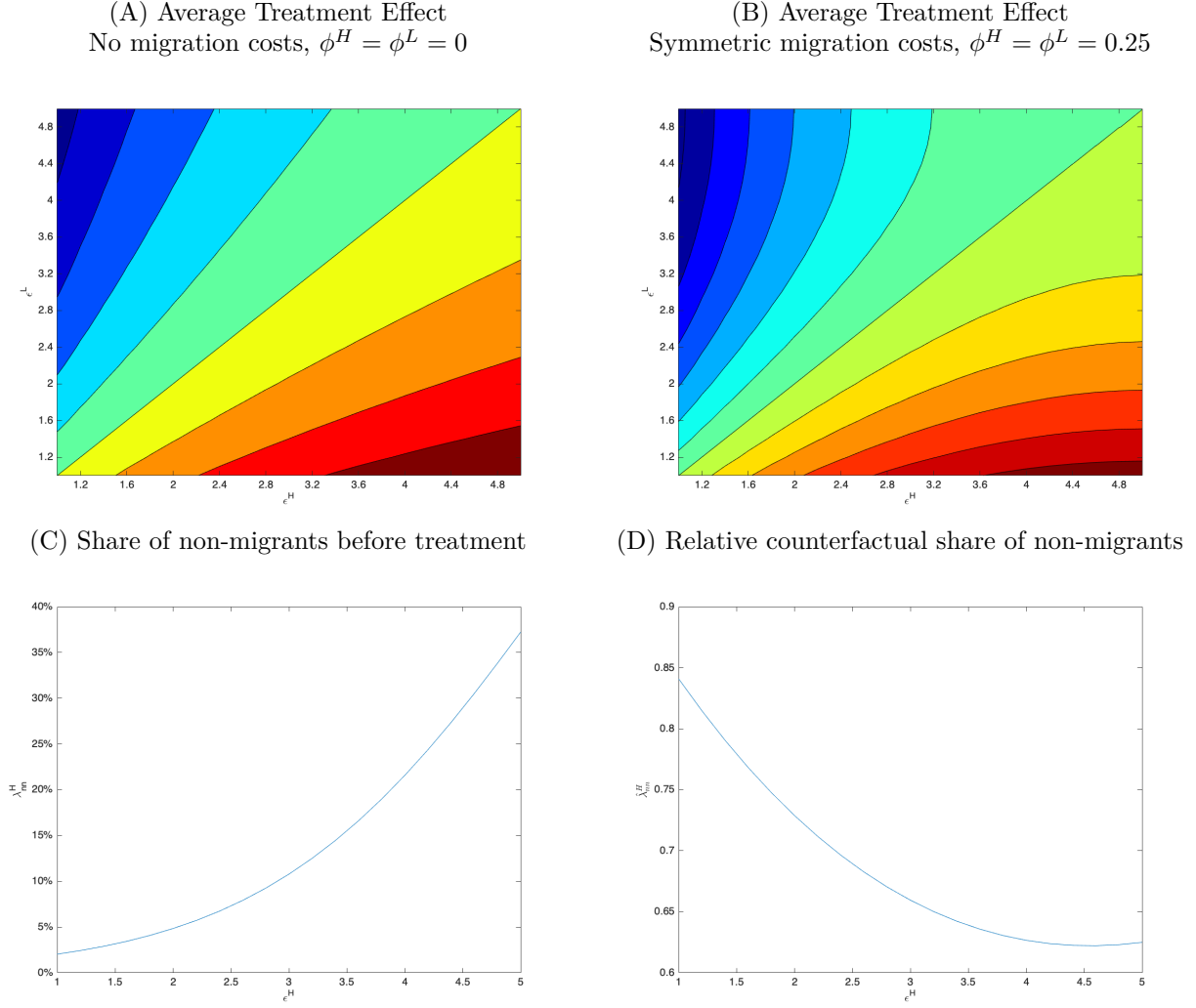


Figure 1.4: Treatment Effects under Heterogeneous Migration Elasticities

Notes: Figure A shows the average treatment effect of highway connections on the college share for different combinations  $\{\epsilon^L, \epsilon^H\}$  as a contour plot, assuming null bilateral migration costs ( $\phi^H = \phi^L = 0$ ). Figure B shows the average treatment effect for different combinations  $\{\epsilon^L, \epsilon^H\}$ , assuming positive and symmetric bilateral migration costs across skill groups ( $\phi^H = \phi^L = 0.25$ ). Colder (blue) colors indicate negative effects, while warmer (red) colors indicate positive effects. Figure C illustrates the average share of high-skilled non-migrants in the initial equilibrium as a function of the Fréchet shape parameter  $\epsilon^H$ . Figure D illustrates the change in the average share of high-skilled non-migrants after treatment as a function of  $\epsilon^H$ .

to real wages. A higher Fréchet shape parameter implies that there is less dispersion in individual preferences and smaller changes in real wages are required to induce workers to reallocate. In other words, the supply of workers with a higher Fréchet shape parameter is more elastic. By a similar argument, the effect on the skill share is negative if  $\epsilon^H < \epsilon^L$  and null if  $\epsilon^H = \epsilon^L$ .

Allowing for positive bilateral migration costs ( $\phi = 0.25$ ) complicates the analysis as the Fréchet shape parameter now governs the migration elasticity to migration costs. As it increases, location choices become more sensitive to migration costs. This translates into lower inter-regional mobility rates. To exemplify this, Figure 1.4C plots the share of high-skilled non-movers, i.e. individuals

from city  $i$  who reside in city  $i$ , as a function of  $\epsilon^H$ . The relationship is increasing. For  $\epsilon^H = 1$ , only 2% of high-skilled workers choose to stay in their location of origin; for  $\epsilon^H = 5$ , the share of non-movers reaches 37%.

In the context of a transport improvement, the Fréchet shape parameter determines the responsiveness of workers to a reduction in effective distance. Figure 1.4D expresses the change in the share of high-skilled non-movers following treatment as a function of  $\epsilon^H$ . The relationship is U-shaped. For small and intermediate Fréchet shape parameters, the change in the share of non-movers is decreasing in  $\epsilon^H$ , i.e. inter-regional mobility is greater for higher  $\epsilon^H$ . In this range of values, the higher sensitivity to a change in migration costs dominates the stronger elasticity to migration costs in absolute terms. When  $\epsilon^H$  is high, the relationship becomes increasing as workers are less likely to migrate altogether (i.e. migration decisions are overly sensitive to migration costs). It is noteworthy that the change in the share of non-movers is smaller than 1 for all values of  $\epsilon^H$ . A reduction in effective distance always leads to greater reallocations of workers.

What is the impact of better roads on the college share when bilateral migration costs are positive? Figure 1.4B shows the average treatment effects. As was the case when bilateral migration costs were null, the effect is positive if  $\epsilon^H > \epsilon^L$ . What changes, however, is the magnitude of the effect. For small and intermediate values of  $\epsilon^H$ , the effect is stronger in the presence of bilateral migration costs. High-skilled workers are not only more elastic to real wages, but they are also more responsive to a reduction in migration costs. For higher values of  $\epsilon^H$ , however, location choices are excessively sensitive to migration costs. This implies lower mobility rates for the high-skilled and, consequently, smaller effects on the college share.

The results presented thus far were obtained for a choice of  $\phi$  equal to 0.25. Figure 1.12 in the Appendix replicates the analysis for different values, ranging from 0 to 1. When  $\phi$  is small, the average treatment effect is positive whenever  $\epsilon^H > \epsilon^L$ . For  $\phi$  in this range, migration costs are small. This allows high-skilled workers to concentrate in treated locations even when their migration cost elasticity is big. For intermediate values of  $\phi$ , the effect is positive for  $\epsilon^H > \epsilon^L$  if  $\epsilon^H$  is not too big. As migration becomes more costly, a necessary condition for sorting is that high-skilled workers are not excessively elastic to migration costs. For large values of  $\phi$ , the average treatment effect is positive for  $\epsilon^H > \epsilon^L$  only when  $\epsilon^H$  is small. Migration costs being large, high-skilled migrants will concentrate in better connected locations only if their migration decisions are inelastic to migration costs.

### 1.6.2 Heterogeneous Migration Costs

In this section I study geographic sorting when workers only differ in their migration costs. In order to shed light on this mechanism, I assume that both types have the same Fréchet shape parameter, i.e.  $\epsilon^H = \epsilon^L = \epsilon$ , but face different migration costs, i.e.  $\phi^H \neq \phi^L$ . Consistent with estimates in Bryan and Morten (2019), I set  $\epsilon$  to 3 and conduct a grid search over values of  $\phi^H$  and  $\phi^L$  ranging from 0 to 1. For each pair  $(\phi^H, \phi^L)$ , I use an iterative algorithm to find the equilibrium allocation of workers  $\{L_n^L, L_n^H\}$  before and after treatment, holding the other parameters  $\{\alpha, \sigma, \theta, \mu, \eta, \epsilon\}$  and

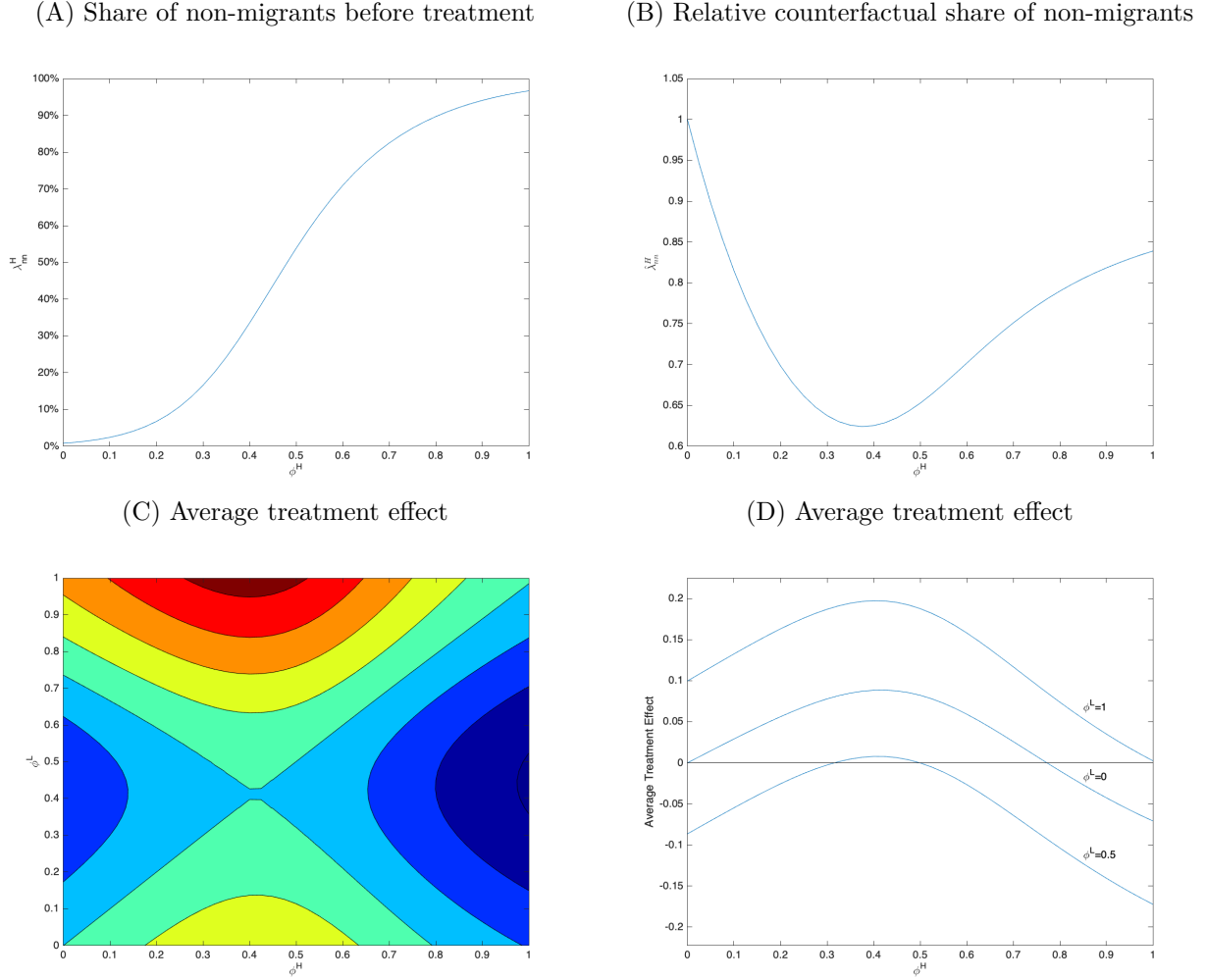


Figure 1.5: Treatment Effects under Heterogeneous Migration Costs

Notes: Figure A illustrates the average share of high-skilled non-migrants in the initial equilibrium as a function of the elasticity of migration costs with respect to distance  $\phi^H$ . Figure B illustrates the change in the average share of high-skilled non-migrants after treatment as a function of  $\phi^H$ . Figure C shows the average treatment effect of highway connections on the college share for different combinations  $\{\phi^L, \phi^H\}$  as a contour plot, assuming homogeneous migration elasticities ( $\epsilon^H = \epsilon^L = 3$ ). Colder (blue) colors indicate negative effects, while warmer (red) colors indicate positive effects. Figure D shows the average treatment effect on the college share as a function of  $\phi^H$  for different values of  $\phi^L$ .

location fundamentals  $\{A_n, B_n^H, B_n^L, H_n\}$  fixed.

The parameters  $\phi^H$  and  $\phi^L$  govern the elasticity of migration costs with respect to distance. Higher elasticities correspond to greater migration costs. Consequently, inter-regional worker flows are lower as  $\phi^H$  and  $\phi^L$  increase. Figure 1.5A shows that the share of high-skilled non-movers is an increasing function of  $\phi^H$ . For negligible migration costs ( $\phi^H \rightarrow 0$ ), less than 1% of high-skilled workers stay in their location of origin. For large migration costs ( $\phi^H \rightarrow 1$ ), the share of non-movers reaches 96%. Following a reduction in effective distance,  $\phi^H$  and  $\phi^L$  also determine the strength of migration responses. Figure 1.5B plots the change in the share of high-skilled non-movers after treatment as a function of  $\phi^H$ . The relationship is U-shaped. For smaller values of  $\phi^H$ , the change

in the share of non-movers is decreasing in  $\phi^H$ . In this region, the greater reductions in migration costs associated with a higher  $\phi^H$  are large enough to offset the effect of higher migration costs in absolute terms. For large values of  $\phi^H$ , mobility costs become prohibitive and prevent significant reallocations of workers, even after an improvement in the transport infrastructure.

What is the impact on the college share under heterogeneous migration costs? Figure 1.5C plots the effect of treatment on the share of high-skilled workers. Geographic sorting occurs when  $\phi^H$  is moderate and  $\phi^L$  is either small or large. For intermediate values of  $\phi^H$ , migration costs have not increased enough to prevent significant reallocations of high-skilled workers following treatment. By contrast, when  $\phi^L$  is small, low-skill migration costs are negligible, such that further reductions will not lead to consequential spatial reallocations. When  $\phi^H$  is large, low-skill mobility costs are prohibitive before and after treatment, such that an improvement in infrastructure generates relatively weaker migration responses.

Figure 1.5D exemplifies this dynamic by plotting the average treatment effect as a function of  $\phi^H$  for different values of  $\phi^L$ . If low-skill bilateral migration costs are null ( $\phi^L = 0$ ), the average treatment effect is positive if  $\phi^H$  is not too large and is maximized for moderate values. For values in this interval, the greater responsiveness to transport infrastructure dominates the negative effect of higher migration costs in absolute terms. When  $\phi^H$  is large, the effect becomes negative. Intuitively, relocating becomes more costly and migration probabilities decrease. This attenuates the effect on spatial reallocations. If low-skilled bilateral migration costs are moderate ( $\phi^L = 0.5$ ), the effect is positive if the bilateral costs of high-skilled workers are only slightly smaller than those of non-graduates. If the distance elasticity is too small, transport improvements generate too weak a migration response, while higher elasticities prevent reallocations altogether. If the low-skill migration costs are large ( $\phi^L = 1$ ), then the average treatment effect is positive for all values of  $\phi^H$ , and is maximized for intermediate values. As  $\phi^H$  approaches  $\phi^L$ , the average treatment effect decreases and vanishes when the two types have the same migration costs.

In Figure 1.13 in the Appendix, I replicate the exercise using different values for  $\epsilon$ . When  $\epsilon = 1$ , high-skilled workers concentrate in treated locations if  $\phi^H > \phi^L$ . When  $\epsilon$  is small, location choices are not too elastic to migration costs. This means that the stronger response to a reduction in migration costs due to a higher  $\phi^H$  dominates the negative effect of greater migration costs in absolute terms. For intermediate values of  $\epsilon$ , the impact on the college share is positive for intermediate values of  $\phi^H$ , and either low or high values for  $\phi^L$ . When  $\epsilon$  is large, high-skilled workers concentrate into treated locations when  $\phi^H$  is low, i.e. high-skilled workers face low mobility costs, and  $\phi^L$  is high, i.e. low-skilled workers face prohibitive mobility costs.

## 1.7 Estimating the Model

This section presents the methodology used to estimate the migration elasticity with respect to real wages for each skill group, as well as their migration and trade costs. I then use the structure of the quantitative model to recover the exogenous productivity and amenity levels that rationalize inter-metropolitan migrant and export flows in 2000.

### 1.7.1 Model's Parameters

I first choose values for the model's parameters from the existing empirical literature. Table 1.5 lists the parameter values used in this paper.  $(1 - \alpha)$  corresponds to the share of income spent on housing. Davis and Ortalo-Magné (2011) document that housing expenditure shares are stable across MSAs and over time, with an average of 0.24. Using data from the Consumer Expenditure Survey (CEX), Diamond (2016) finds that non-college households spend 39 percent of their income on housing, while college households 43 percent. In what follows, I set  $(1 - \alpha)$  to 25%, although I test the sensitivity of my results to using a higher expenditure share. The elasticity of substitution between goods,  $\sigma$ , is assigned a value of 4, which is consistent with estimates in Bernard, Eaton, Jensen, and Kortum (2003).

The Fréchet shape parameter  $\theta$  governs the dispersion in firm productivity. As apparent from equation (1.17), it also corresponds to the elasticity of exports with respect to trade costs. I assume a value of four for  $\theta$ , which is in the range of estimates in the literature (e.g. Simonovska and Waugh, 2014; Caliendo and Parro, 2015).

$\mu$  is the elasticity of substitution between high-skilled and low-skilled workers. I set  $\mu$  to 1.75, which is in the range of estimates in the literature (Docquier, Ozden, and Peri, 2013). Katz and Murphy (1992) estimate an elasticity of substitution of 1.41, while Diamond (2016) finds a value of 1.64. Farrokhi and Jenkins (2019) and Giannone (2019) obtain higher elasticities of substitution, 3.28 and 3.03, respectively.

Finally,  $\eta_i$  is the skill intensity of production in location  $i$  and is chosen to match the observed distribution of workers and wages in the 2000 IPUMS sample.

### 1.7.2 Parameterization of Migration and Trade Costs

#### 1.7.2.1 Migration costs

I model migration costs as a function of geographic distance, with the distance elasticity being governed by the stock of highways in the cities of origin and destination.<sup>36</sup> Specifically, I assume that migration costs between cities  $i$  and  $n$  in year  $t$  for  $s$ -type workers take the following form:

$$\kappa_{int}^s = \text{dist}_{in}^{\phi_0^s + \phi_1^s \text{ray}_{it} + \phi_2^s \text{ray}_{nt}}, \quad (1.21)$$

---

<sup>36</sup>The geographic distance between two metropolitan areas is computed using the Haversine formula based on the geographic coordinates of each MSA's central city. Internal distance is defined as two thirds of a city's radius.

Table 1.5: Parameter Values

Parameter	Description	Source	Value
$1 - \alpha$	Housing expenditure share	Davis and Ortalo-Magné (2011)	0.25
$\sigma$	Goods elasticity of substitution	Bernard et al. (2003)	4
$\theta$	Trade elasticity	Simonovska and Waugh (2014)	4
$\mu$	Labor elasticity of substitution	Docquier et al. (2013)	1.75

where  $\text{dist}_{in}$  is the distance between cities  $i$  and  $n$ .  $\text{ray}_{it}$  and  $\text{ray}_{nt}$  are the number of highways open to traffic in the MSAs of origin and destination.

Migration costs are increasing in geographic distance if  $\phi_0^s + \phi_1^s \text{ray}_{it} + \phi_2^s \text{ray}_{nt} > 0$  for any  $\text{ray}_{it}$  and  $\text{ray}_{nt}$ . For this inequality to hold, it must be that  $\phi_0^s > 0$ . If, in addition,  $\phi_1^s < 0$  and  $\phi_2^s < 0$ , migration costs are decreasing and convex in the number of rays.<sup>37</sup> This parameterization builds on the hypothesis that, as metropolitan areas gain better highway connections, geographic distance becomes less of an impediment to the movement of goods and people.<sup>38</sup> If these two conditions are satisfied, the following statements hold:

1. The marginal effect of an increase in the number of highways in an MSA is greater for locations that are geographically farther away:

$$\frac{\partial^2 \kappa_{int}^s}{\partial \text{dist}_{in} \partial \text{ray}_{it}} = \phi_1^s \frac{\kappa_{int}^s}{\text{dist}_{in}} [1 + \log(\text{dist}_{in}) (\phi_0^s + \phi_1^s \text{ray}_{it} + \phi_2^s \text{ray}_{nt})] < 0.$$

2. The marginal effect of an increase in the number of highways in the MSA of origin is lower if the MSA of destination is better connected, and vice versa:<sup>39</sup>

$$\frac{\partial^2 \kappa_{int}^s}{\partial \text{ray}_{nt} \partial \text{ray}_{it}} = 2\phi_1^s \phi_2^s \log(\text{dist}_{in}) \kappa_{int}^s > 0.$$

Substituting equation (1.21) into the gravity equation for migration, equation (1.11), yields:

$$L_{int}^s = \underbrace{\Omega_{nt}^s}_{\text{destination FE}} \text{dist}_{in}^{-\epsilon^s (\phi_0^s + \phi_1^s \text{ray}_{it} + \phi_2^s \text{ray}_{nt})} \underbrace{(WMA_{it}^s)^{-1} L_{it,0}^s}_{\text{origin FE}}. \quad (1.22)$$

It becomes apparent that the elasticity of migrant flows with respect to distance depends on both the Fréchet shape parameter for amenities  $\{\epsilon^s\}$  and the migration cost parameters  $\{\phi_0^s, \phi_1^s, \phi_2^s\}$ . Consequently, estimating the distance elasticity of migration does not allow to separately identify both sets of parameters.

<sup>37</sup>  $\frac{\partial \kappa_{int}^s}{\partial \text{ray}_{it}} = \phi_1^s \log(\text{dist}_{in}) \kappa_{int}^s < 0$  and  $\frac{\partial^2 \kappa_{int}^s}{\partial \text{ray}_{it}^2} = 2(\phi_1^s)^2 \log(\text{dist}_{in}) \kappa_{int}^s > 0$ .

<sup>38</sup> For instance, Duranton et al. (2014) find that inter-city trade is more sensitive to highway distance than to mere geographic distance.

<sup>39</sup> The main caveat of this specification is that pairs that are not connected to the network will not experience any change in their bilateral migration costs. In reality, bilateral costs between two unconnected cities may still decrease if the least cost path between them uses, at least partly, segments of other newly constructed highways.

Table 1.6: Migration and Trade Gravity Equations

	High-Skilled Migrant Flows		Low-Skilled Migrant Flows		Trade Flows	
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(\text{dist}_{in})$	-1.362*** (0.023)	-1.364*** (0.024)	-1.319*** (0.027)	-1.326*** (0.026)	-1.168*** (0.061)	-1.167*** (0.061)
$\log(\text{dist}_{in}) \times \text{Ray}_{it}$	0.018*** (0.005)	0.027*** (0.002)	-0.001 (0.005)	0.013*** (0.002)	0.013 (0.008)	0.018*** (0.004)
$\log(\text{dist}_{in}) \times \text{Ray}_{nt}$	0.037*** (0.005)	0.027*** (0.002)	0.028*** (0.005)	0.013*** (0.002)	0.024*** (0.007)	0.018*** (0.004)
$\mathbb{1}_{i \neq n}$	-3.289*** (0.070)	-3.274*** (0.075)	-3.853*** (0.083)	-3.812*** (0.083)	-0.688*** (0.189)	-0.688*** (0.189)
Symmetric costs	No	Yes	No	Yes	No	Yes
Origin $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	76,176	76,176	76,176	76,176	2,916	2,916

Notes: The migration data come from the 5% IPUMS sample of the 2000 Census. Migrant flows from MSA  $i$  to MSA  $n$  are constructed as the number of individuals who are currently residing in city  $n$  and who were living in city  $i$  five years ago. The final sample consists of 276 metropolitan areas. The trade data come from the 2002 Commodity Flow Survey. Trade flows are constructed as the total value of exports from MSA  $i$  to MSA  $n$ . The trade sample consists of 54 CFS regions. Both migration and trade costs are parameterized as a function of geographic distance, with the elasticity being governed by the stock of highways in the cities of origin and destination. All specifications are estimated by Poisson Pseudo-Maximum Likelihood. Specifications in columns (1), (3) and (5) allow for asymmetric bilateral migration and trade costs. Specifications in columns (2), (4) and (6) impose symmetry (i.e.  $\kappa_{in}^s = \kappa_{ni}^s$  and  $\tau_{in} = \tau_{ni}$ ). \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Equation (1.22) can be estimated using data on inter-metropolitan worker flows. To this aim, I use the 2000 IPUMS sample to construct a matrix of bilateral migrant flows. The IPUMS data set provides not only individuals' current metropolitan area, but also their city of residence five years prior to the survey. This allows me to observe migrant flows between 276 locations, totaling 76,176 bilateral flows.

One straightforward method to estimate the migrant gravity equation would be to log-linearize and then estimate it by OLS. However, this approach is known to generate biased estimates under heteroskedastic errors (Silva and Tenreyro, 2006) and does not account for zero flows. Instead, I use a Poisson Pseudo-Maximum Likelihood (PPML) estimator, which is robust to heteroskedasticity and allows for zero flows. In order to control for the amenity-adjusted real wages in the city of destination and the city of origin's worker market access, I include both origin and destination time-varying fixed effects. Standard errors are clustered at the city-pair level. Columns (1) through (4) of Table 1.6 report the main results.

Estimates in column (1) show that, in the absence of highways, the elasticity of high-skill flows with respect to distance is  $-1.36$ , the effect being significant at 1%. Adding a highway to the MSA of origin reduces this elasticity by 0.02, while an additional highway in the MSA of destination reduces it by 0.04. Both coefficients are highly significant. High-skilled workers also exhibit a strong home bias: within-MSA flows are more than 25 times larger than inter-metropolitan flows. Column (2) re-estimates equation (1.22), but imposes symmetry ( $\phi_1^H = \phi_2^H$ ). The distance elasticity in the absence of highways is still  $-1.36$ . Adding a highway in either the city of origin or destination

reduces this elasticity by 0.03, the effect being significant at 1%.<sup>40</sup>

Columns (3) and (4) replicate the analysis for low-skilled migrants. At  $-1.32$ , the distance elasticity when no highways are operating is similar to the one observed for graduate migrants. Surprisingly, each additional highway in the origin raises this elasticity, although the effect is marginal not significant. An additional highway in the city of destination, on the other hand, lowers the elasticity by 0.03. Low-skilled workers exhibit an even stronger home bias, within-MSA flows being 45 times larger than inter-metropolitan flows. Imposing symmetry leads to similar results. The distance elasticity when no highways are operating is  $-1.33$  and decreases by 0.01 with each additional highway in the cities of origin or destination.

### 1.7.2.2 Trade Costs

Trade costs are modeled in a similar fashion:

$$\tau_{int} = \text{dist}_{ni}^{\varepsilon_0 + \varepsilon_1 \text{ray}_{nt} + \varepsilon_2 \text{ray}_{it}}. \quad (1.23)$$

Trade costs are increasing with geographic distance if  $\varepsilon_0 + \varepsilon_1 \text{ray}_{nt} + \varepsilon_2 \text{ray}_{it} > 0$ . The distance elasticity of trade costs decreases with the number of rays in the city of origin and destination if  $\varepsilon_1 < 0$  and  $\varepsilon_2 < 0$ . Substituting equation (1.23) into equation (1.17) leads to the following trade gravity equation:

$$X_{nit} = \underbrace{\Phi_{it}}_{\text{origin FE}} \text{dist}_{ni}^{-\theta(\varepsilon_0 + \varepsilon_1 \text{ray}_{it} + \varepsilon_2 \text{ray}_{nt})} \underbrace{(CMA_{nt})^{-1} X_{nt}}_{\text{destination FE}}. \quad (1.24)$$

Given a choice for the Fréchet shape parameter  $\theta$ , trade cost parameters  $\{\varepsilon_0, \varepsilon_1, \varepsilon_2\}$  can be obtained after estimating the distance elasticity of trade flows. To this aim, I use the 2002 Commodity Flow Survey (CFS) to construct a matrix of trade flows. The CFS reports data on exports for 54 CFS regions, which correspond to the largest metropolitan areas in my sample. This leads to a matrix of 2,916 bilateral trade flows. Equation (1.24) is estimated by PPML. Destination and origin time-varying fixed effects control for the origin's productivity and the destination's consumer market access. Standard errors are clustered at the city-pair level.

Columns (5) and (6) of Table 1.6 report the results. The elasticity of exports with respect to geographic distance in the absence of highways is  $-1.17$ . An additional highway in the city of origin reduces it by 0.01 (not significant at conventional levels), while an additional interstate in the city of destination reduces it by 0.02 (significant at 1%). The home bias is lower than for high-skilled and low-skilled workers. Within-metropolitan trade flows are only twice as large as cross-city exports. As shown in column (6), imposing symmetry does not change the size of the distance elasticity in

<sup>40</sup>To address the potential endogeneity of highways, I instrument the number of highways with the number of planned rays. Because of the non-linearity of the PPML estimator, I use a control function approach (Petrin and Train, 2010). In the first stage, I regress the endogenous variables on the set of exogenous variables by OLS. In the second stage, I re-estimate equation (1.22) by PPML and add the residuals from the first stage as a control. The coefficient on the highways in the city of origin is only slightly higher, while the coefficient on the number of highways in the city of destination is lower. Imposing symmetry generates coefficients that are only slightly smaller than in the baseline specification.

the absence of highways. An additional highway in the city of destination or origin reduces it by 0.02, the effect being highly significant. Given these estimated distance elasticities and a value of four for  $\theta$ , I can recover the trade cost parameters  $\{\varepsilon_0, \varepsilon_1, \varepsilon_2\}$ . This allows me to predict trade costs for any allocation of interstate highways across cities.

### 1.7.2.3 Alternative Specification

As a robustness check, I follow Morten and Oliveira (2016) and model migration costs as a function of bilateral travel times:

$$\kappa_{int}^s = \text{time}_{int}^{\phi^s},$$

where  $\phi^s$  denotes the elasticity of migration costs to travel times for  $s$ -type workers. The migration gravity equation that needs to be estimated is now:

$$L_{int}^s = \underbrace{\Omega_{nt}^s}_{\text{destination FE}} \text{time}_{int}^{-\epsilon^s \phi^s} \underbrace{(WMA_{it}^s)^{-1} L_{it,0}^s}_{\text{origin FE}},$$

The elasticity of migration with respect to distance is  $-\epsilon^s \phi^s$ . As was the case in the baseline specification, the Fréchet shape parameter for amenities and the migration cost parameter are not separately identifiable from the estimated migration elasticity with respect to distance.

Trade costs are modeled in a similar fashion:

$$\tau_{nit} = \text{time}_{nit}^{\varepsilon},$$

where  $\varepsilon$  is the elasticity of trade costs with respect to travel times. The trade gravity equation thus becomes:

$$X_{nit} = \underbrace{\Phi_{it}}_{\text{origin FE}} \text{time}_{nit}^{-\theta \varepsilon} \underbrace{(CMA_{nt})^{-1} X_{nt}}_{\text{destination FE}}.$$

Both gravity equations are estimated by PPML. The results are reported in Table 1.19 in the Appendix. The elasticity of high-skilled migrant flows with respect to travel time is  $-1.12$  and significant at 1%. Low-skilled flows, on the other hand, exhibit a larger elasticity,  $-1.22$ . The two coefficients are significantly different, implying that travel times have a significantly larger effect on non-graduates than on graduates. Lastly, the elasticity of exports with respect to travel times is  $-0.94$  and significant at 1%.

### 1.7.3 Estimating the Migration Fréchet Shape Parameters

As mentioned before, the migration Fréchet parameters  $\{\epsilon^H, \epsilon^L\}$  cannot be directly estimated from the coefficients on distance. What is estimated is the product between the parameters and the elasticity of migration costs with respect to distance. In order to obtain  $\{\epsilon^H, \epsilon^L\}$ , I therefore use a two-step procedure.

In the first step, I estimate the migration gravity equation 1.11 by PPML and recover the

Table 1.7: Estimating the Fréchet Shape Parameters

	College Graduates			College Non-Graduates		
	OLS	IV Productivity	IV Bartik Shock	OLS	IV Productivity	IV Bartik Shock
Real wages	4.380*** (0.226)	5.715*** (0.274)	5.380*** (0.426)	3.198*** (0.245)	4.508*** (0.313)	4.409*** (0.702)
Constant	-7.385*** (0.335)	-9.351*** (0.406)	-8.858*** (0.628)	-3.805*** (0.243)	-5.094*** (0.310)	-4.997*** (0.692)
First-stage statistic		877.434	117.584		568.652	41.590

Notes: The dependent variable is the destination-specific fixed effect previously estimated from migrant gravity equations. The real wage is constructed using the observed hourly wage for employed workers, the price index that is consistent with the quantitative model and the estimated trade costs, and residential rents that satisfy the housing market clearing condition. The final sample consists of 276 observations for each skill group. Migration and trade costs are defined as a function of geographic distance, with the elasticity being governed by the stock of highways in the cities of origin and destination. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

predicted values for the destination fixed effects,  $\log(\hat{\Omega}_{nt}^s)$ .<sup>41</sup> According to the quantitative model, these should capture the product between local amenities and real wages raised to the power of  $\epsilon^s$ . I therefore regress in a second step the estimated destination-specific fixed effects on real wages.<sup>42</sup> Because of endogeneity concerns, I follow Monte et al. (2018) and instrument wages with productivity. As a robustness check, I also consider a shift-share instrument in the spirit of Bartik (1991). Specifically, I use national-level real wages for each industry to construct a location-specific shock based on that location's industry specialization. The Bartik instrument is:

$$\text{Bartik}_{it} = \sum_{\text{ind}} \omega_{\text{ind},-i} \frac{L_{\text{ind},i}}{L_i},$$

where ind indexed industries,  $\omega_{\text{ind},-i}$  is the average real wage in industry ind at the national level, excluding workers in location  $i$ ,  $L_{\text{ind},i}$  is the employment in industry ind in location  $i$  and  $L_i$  is total employment in location  $i$ .

Table 1.7 reports the main results of the second-step when the distance-based specification of migration costs is used. OLS yields a migration elasticity with respect to real wages equal to 4.38 for college graduates and 3.20 for non-graduates. Instrumenting real wages with productivity delivers higher estimates:  $\epsilon^H = 5.72$  and  $\epsilon^L = 4.51$ . Using the Bartik instrument yields similar results. The elasticity is now 5.38 for college graduates and 4.41 for non-graduates. In both cases, the first-state F-statistic is well-above the critical value, mitigating concerns about weak instrumentation. Finally, using both instruments simultaneously delivers estimates that are in line with those obtained using productivity as the unique instrument. Over-identification tests fail to reject the null hypothesis

<sup>41</sup>One of the advantages of using PPML over OLS is that the estimated fixed effects automatically satisfy the adding-up constraints of structural gravity, as shown by Fally (2015).

<sup>42</sup>I calculate real wages in the following way. I first use the estimated trade costs and data on the wage and population distribution to invert the quantitative model and recover the exogenous productivity,  $\{A_n\}$ . Equation (1.18) then delivers the local price index. Second, using the housing market clearing condition (1.20), I compute residential rents. The real wage in location  $i$  is simply  $W_i / (P_i^\alpha r_i^{1-\alpha})$ .

that the two instruments are jointly valid. Using the travel time specification of migration leads to higher estimates of the Fréchet shape parameters (see Table 1.20 in the Appendix). OLS implies  $\epsilon^H = 4.92$  and  $\epsilon^L = 3.51$ . Instrumenting real wages with productivity leads to  $\epsilon^H = 6.56$  and  $\epsilon^L = 5.04$ , while using the Bartik shock generates  $\epsilon^H = 6.36$  and  $\epsilon^L = 4.82$ .

These estimates are in the range of those found in the literature. Using data on Brazilian cross-state migrants, Morten and Oliveira (2016) find a migration elasticity of 1.91. Tombe and Zhu (2019)'s estimate for Chinese workers is 1.5, while Bryan and Morten (2019) report an elasticity of 3 for Indonesian migrants. Using historical data on US cross-state flows, Allen and Donaldson (2018) find a substantially larger elasticity of 11.75. Farrokhi and Jenkins (2019) estimate the dispersion in local preferences to be 13.8. However, these studies do not distinguish across skill groups. Using a quantitative model featuring endogenous amenities, Diamond (2016) estimates that, for a local expenditure share equal to 0.62 for both skill groups, the migration elasticity to wages is 2.12 for non-graduates and 4.03 for graduates. Allowing for different local expenditures, she finds a migration elasticity of 4.98 for graduates and 3.26 for non-graduates. Fan (2019) estimates an elasticity of 4.55 for Chinese high-skilled workers, and 4.80 for low-skilled workers. My results are in the range of estimates found in the literature. In what follows, I set  $\epsilon^H$  to 5.72 and  $\epsilon^L$  to 4.51.

#### 1.7.4 Inverting the Model

Given estimates of  $\{\epsilon^H, \epsilon^L\}$  and the distance elasticity, I can recover the parameters governing migration costs. I then use these to recover the exogenous amenity and productivity levels that rationalize the observed distribution of labor and wages in 2000. This is achieved in two steps.

First, I use data on the spatial distribution of high-skilled and low-skilled workers,  $\{L_n^H, L_n^L\}$ , and wages,  $\{W_n^H, W_n^L\}$ , from the 2000 IPUMS sample, as well as the previously estimated trade costs,  $\{\hat{\tau}_{ni}\}$ , to search for the unobserved local productivity levels,  $\{A_n\}$ . Specifically, equations (1.16) and (1.19) form a system of  $N^2 + N$  equations with  $N^2 + N$  unknowns. An iterative algorithm is used to obtain the unique values of  $\{A_n\}$  that, together with expenditure shares,  $\{\pi_{ni}\}$ , solve this system. Panel A of Figure 1.6 illustrates the distribution of local productivities when the distance-based specification of trade costs is employed. Darker shades of red correspond to higher average productivities. The most productive MSAs are located in the North East and in Southern California.<sup>43</sup> Using travel time-based trade costs delivers similar results, the two measures of productivity being highly correlated. The coefficient of correlation is 0.94.

In the second step, I recover the unobserved Fréchet scale parameters for amenities,  $\{B_n^H, B_n^L\}$ . Given average productivity levels,  $\{A_n\}$ , estimated trade costs,  $\{\hat{\tau}_{ni}\}$ , and wages,  $\{W_n^H, W_n^L\}$ , equation (1.16) delivers predicted expenditure shares,  $\{\hat{\pi}_{ni}\}$ . Equation (1.18) then delivers the price index in every city,  $\{\hat{P}_n\}$ . Equation (1.20) yields the equilibrium residential rents,  $\{r_n\}$ , given the observed stock of residential housing,  $\{H_n\}$ . Equations (1.10) and (1.12) then form a system

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<sup>43</sup>My results suggest that New York, San Francisco and San José are the most productive cities in the US. In contrast, Sumter, SC, Jacksonville, NC, and Sharon, PA, are the least productive.

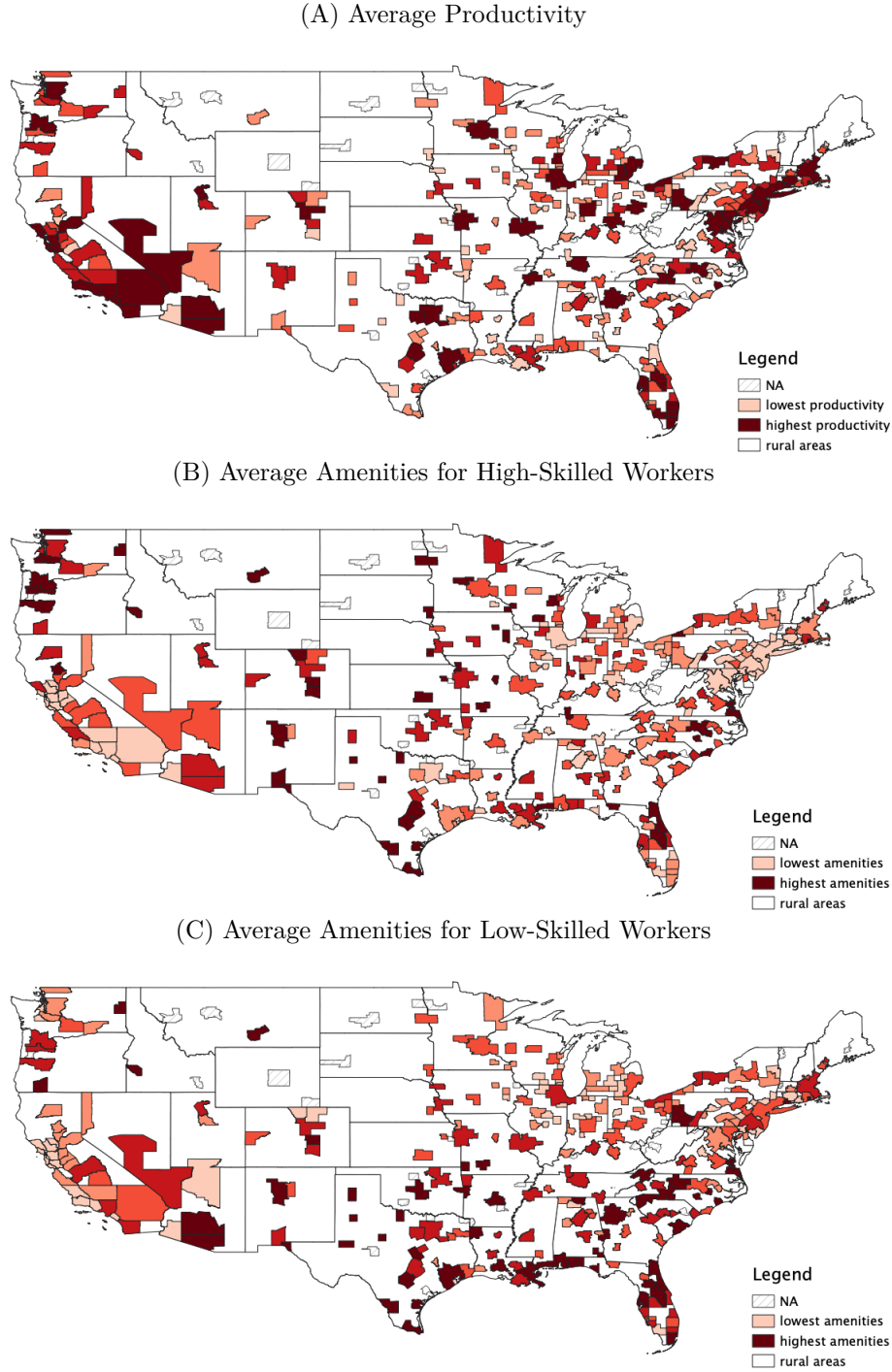


Figure 1.6: Distribution of Productivity and Amenities

Notes: Figures A through C show the average productivity and high(low)-skilled amenity levels for the 276 metropolitan areas in the 2000 IPUMS sample. Darker shades of red correspond to higher values. The amenity and productivity values were obtained after inverting the quantitative model using the ray-based specification of migration and trade costs.

of  $2(N^2 + N)$  equations with  $2(N^2 + N)$  unknowns. An iterative algorithm is used to obtain the unique values of  $\{B_n^H, B_n^L\}$  that, together with  $\{\lambda_{in}^H, \lambda_{in}^L\}$ , solve this system. Panels B and C of

Figure 1.6 show the results. The most attractive locations for high-skilled workers are in the North West and central US; the least attractive locations are located in the North East and the Midwest.<sup>44</sup> Low-skilled workers enjoy higher amenities in Southern California, Texas, Florida and the North East; the Midwest, on the other hand, offers them the lowest amenities.<sup>45</sup> Using travel times to estimate trade and migration costs produces similar results. Figure 1.14 in the Appendix shows the spatial distribution of productivity and amenities when travel times are used to estimate migration costs. The distance and travel time specifications produce highly correlated amenity values. The coefficient of correlation is 0.97 for high-skilled amenities and 0.99 for low-skilled amenities.

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<sup>44</sup>According to the model, Eugene, OR, Bellingham, WA, and Wichita Falls, TX, offer the best amenities to high-skilled workers. Trenton, NJ, Jackson, TN, and Yuma, AZ, have the lowest average amenities.

<sup>45</sup>McAllen, TX, El Paso and Miami have the highest low-skill amenities. Kenosha, WI, Iowa City, IA, Kokomo, IN, have the lowest low-skill amenities.

## 1.8 Counterfactual Experiments

In this section, I perform a series of counterfactual experiments. First, I test whether the quantitative model can reproduce the observed geographic sorting of high-skilled workers into better connected locations. Second, I compute welfare losses for both types of workers following a hypothetical removal of the Interstate Highway System. Furthermore, I decompose these effects into trade and migration components. Third, I examine the extent to which further reductions in migration and trade costs generate welfare gains. The section concludes with robustness checks.

### 1.8.1 Model Predicted Reduced-Form Effects on Skill Composition

As a first exercise, I test the ability of the quantitative model to replicate the reduced-form effects documented in Section 1.4. To this aim, I simulate the US economy from 1950 to 2000 using the following methodology. I first predict migration and trade costs for each of the periods in my sample given the observed number of highways in the cities of origin and destination. I then search for the allocation of high-skilled and low-skilled workers that satisfies the general equilibrium conditions of the model. This procedure allows me to construct a sample of counterfactual college shares from 1950 to 2000.<sup>46</sup> The impact on the college share is finally estimated by ordinary least squares using a fixed-effect specification. Table 1.8 reports the results.

Column (1) shows the effect of an additional highway on the college share when both migration and trade costs depend on the transport infrastructure. The point estimate is 0.33 and highly significant. Given the IV coefficients measured previously, the model is thus able to replicate almost 60% of the observed effect.<sup>47</sup> The model is also successful in delivering mobility rates that match those observed in the 2000 IPUMS sample. The average share of college graduates who, 5 years prior to the survey, were living in the same MSA as in 2000 was 82.80%. The average share of non-migrants was 91.45% for non-graduates. The model predicts that 75.79% of high-skilled workers and 87.78% of low-skilled workers would not out-migrate from their MSA of origin. Overall, the construction of the Interstate Highway System is predicted to have reduced the share of high-skilled and low-skilled non-migrants by 14.78 and 5.1 percentage points, respectively.

Column (2) replicates the procedure under the assumption that highways impact only trade costs, migration costs being fixed at their 1950 level. The model implies an effect of 0.32 percentage points on the college share, which is only marginally smaller than when both channels are operating. Inter-regional reallocations of workers, however, are now more modest. The predicted average share of non-migrants in 2000 is 88.30% for college graduates (a decrease of only 2.70 percentage points relative to 1950) and 92.62% for non-graduates (1.13 percentage points lower than in 1950). In column (3), I assume that highways impact only migration costs, trade costs being set at their

<sup>46</sup>In order to simulate the US economy, I make several assumptions. First, the initial allocation of workers is given by the population distribution in 1940. Second, the observed growth in the number of high-skilled and low-skilled workers is assumed to be uniformly distributed across cities:  $L_{i0,t} = L_{i,1940} \frac{L_t}{L_{1940}}$ . Third, average productivity and amenities do not change over time and are not affected by improvements in the transport infrastructure.

<sup>47</sup>The size of the effect depends on how population is assumed to be allocated at the beginning of every period. For instance, a uniform distribution of workers delivers significantly higher coefficients.

Table 1.8: Model-Predicted Effects of Highways on the College Share

	(1) Both Channels	(2) Only Trade	(3) Only Migration
Number of highways	0.328*** (0.049)	0.315*** (0.044)	0.268*** (0.050)
Avg. % HS non-migrants 1950	90.72%	90.72%	90.72%
Avg. % HS non-migrants 2000	75.79%	87.58%	75.21%
Avg. % LS non-migrants 1950	93.48%	93.48%	93.48%
Avg. % LS non-migrants 2000	87.78%	91.66%	87.37%

Notes: The dependent variable is the college share, computed as the percentage of college graduates in an MSA that is consistent with the quantitative model and the estimated migration and trade costs. Both migration and trade costs are parameterized as a function of distance, with the elasticity governed by the stock of highways in the cities of origin and destination. Trade and migration costs are predicted in each year using estimates of gravity equations from Table 1.6 and the observed number of highways. All specifications are estimated by ordinary least squares and include MSA-specific and year fixed effects. In column (1), both migration and trade costs are affected by highway interstates. In column (2), only trade costs are affected by highways, migration costs being held constant at their 1950 level. In column (3), only migration costs are affected by highways, trade costs being held constant at their 1950 level. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

1950 level. At 0.27, the effect on the college share is now smaller. The predicted average share of non-migrants, on the other hand, experiences slightly larger declines than in the first column: 15.24 for the high-skilled and 5.33 for the low-skilled.

### 1.8.2 Removing the Interstate Highway System

The second counterfactual seeks to quantify the welfare effects associated with a hypothetical removal of the IHS. To answer this question, I re-compute inter-metropolitan trade and migration costs under the assumption that MSAs are not served by any interstate. Given estimates from the previous section, I find that migration costs would increase by 27.09% for high-skilled workers and 18.52% for low-skilled workers. Trade costs would be 21.54% higher.<sup>48</sup> Table 1.9 reports the corresponding welfare effects.

A hypothetical removal of the Interstate Highway System would have large welfare effects for both types of workers. College graduates would experience an average decrease in welfare of 12.64%, whereas non-graduates would lose 11.75%. Even though these effects are somewhat larger than what other studies have found,<sup>49</sup> they are consistent with results in Morten and Oliveira (2016). They document welfare gains of 13.3% following the construction of Brazil's highway network,

<sup>48</sup>As a matter of comparison, Morten and Oliveira (2016) find that deleting all roads in Brazil would increase migration costs by 11% and trade costs by 28%.

<sup>49</sup>Allen and Arkolakis (2014) estimate that the construction of the IHS increased welfare by 1.1% to 1.4%. Balboni (2019) finds that road investments in Vietnam rose the net present value of aggregate welfare by 1.74%. Santamaria (2019) reports that reshaping the highway network by the German government in the aftermath of World War II increased real income by 0.60%.

Table 1.9: Average Welfare Impact of Removing the Interstate System

	(1) Both Channels	(2) Only Trade Costs	(3) Only Migration Costs
Relative change in HS welfare	0.8736	0.8904	0.9807
Relative change in LS welfare	0.8825	0.8890	0.9925

Notes: This tables shows the change in average expected utility if the Interstate Highway System was removed. Migration and trade costs are defined as a function of geographic distance, with the elasticity being governed by the number of highways in the cities of origin and destination. Migration and trade costs are assumed to be symmetric. Column (1) assumes that removing the IHS increases both migration and trade costs. Column (2) assumes that removing the IHS increases only trade costs, migration costs remaining fixed at their 2000 level. Column (3) assumes that removing the IHS increases only migration costs, trade costs remaining fixed at their 2000 level.

although they do not consider heterogeneity across skill groups. I follow their methodology and decompose the aggregate effect into trade and migration components. In column (2), I solve the model assuming that only trade costs are affected by the removal of the IHS. Under this scenario, high-skilled workers would lose 10.96% and low-skilled workers 11.00%. Higher trade costs imply bigger price indices which, in the presence of homothetic preferences, will impact both skill groups to a similar extent. In column (3), I assume that only migration costs change in the counterfactual. High-skill welfare would be 1.93% lower, whereas low-skill welfare would drop by 0.73%. The incidence of a removal of the IHS falls heavier on college graduates because they are more likely to migrate and incur the higher costs of relocating. These counterfactuals also show that the migration component accounts for a much smaller part of the total effects than the trade component: 15% for the high-skilled and 6% for the low-skilled.

The average welfare effects mask significant spatial variation. For instance, high-skilled and low-skilled workers from MSAs at the 25th percentile of the loss distribution see their welfare decrease by 11.57% and 10.24%, respectively. Workers from MSAs at the 75th percentile experience losses of 16.82% and 15.13%. Figure 1.8 illustrates the spatial distribution of these effects for the 276 metropolitan areas in my sample. Workers living in MSAs in the Middle Atlantic and East North Central would suffer the most. Workers in the Pacific and West South Central regions, on the other hand, are less exposed. The welfare losses tend to be smaller in regions that already had high average migration and trade costs, and larger in cities that exhibited bigger increases in these costs following the removal of the IHS.

Deleting the interstate network would have a direct consequence on travel times. Using road density maps and GIS tools, I find that a hypothetical removal of the interstates would increase travel times by approximately 20%. Using the estimates from the previous section, this would translate into trade costs that are 4.24% higher. Migration costs would increase by 3.03% for the high-skilled and 4.33% for the low-skilled. Table 1.21 in the Appendix summarizes the corresponding welfare effects. Both types of workers suffer welfare losses of approximately 2.70%. As was the case previously, the trade component accounts for the largest share of these effects and has a slightly higher incidence on the low-skilled. The increase in migration costs, on the other hand, has a higher incidence on the high-skilled. Relative to the distance-based specification, the spatial distribution

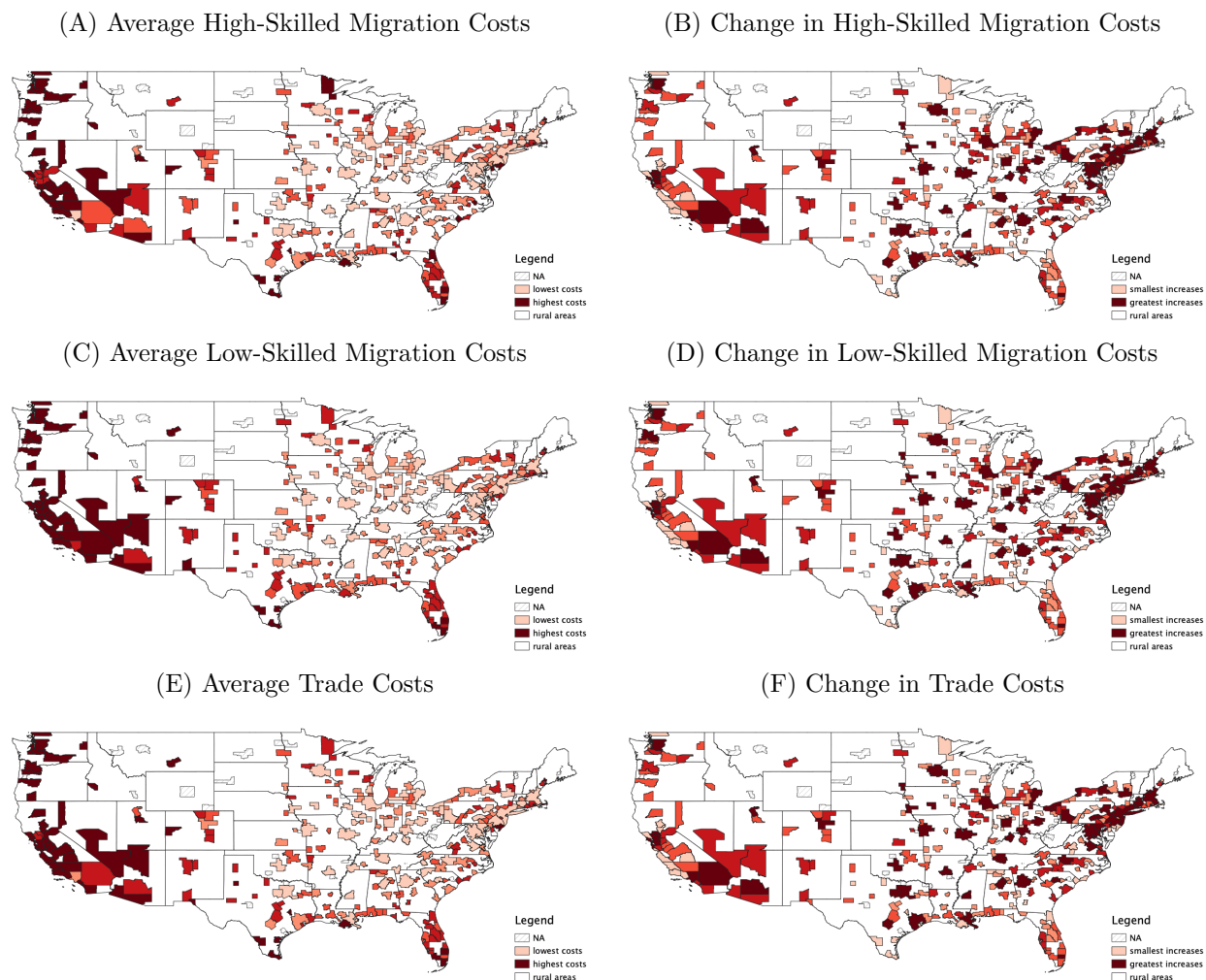


Figure 1.7: Migration and Trade Costs Based on Distance

Notes: Figures A, C and E show the average migration and trade costs to other destinations for each MSA in the 2000 IPUMS sample. Figures B, D and F show the increase in migration and trade costs in the case of a hypothetical removal of the Interstate Highway System. Darker shades of red correspond to higher values. Migration and trade costs are estimated as a function of geographic distance, with the distance elasticity being governed by the stock of highways in the city of origin and destination.

of welfare losses is significantly different when using travel times to parameterize migration and trade costs. As Figure 1.16 in the Appendix illustrates, MSAs located in the South-West experience the largest welfare declines, while MSAs in the North-East the smallest.

What can explain these differences? First, travel times may only capture a part of distance-related migration and trade costs. As such, the increase in travel times following the removal of the IHS would understate the actual increase in migration and trade costs and, therefore, generate smaller effects. Similarly, travel times in the counterfactual were computed under the assumption of no congestion and, as a result, may understate the actual effect of removing the IHS. Second, travel times also depend on the density of non-interstate highways. In particular, these exhibit an east-west gradient, with a much higher density in the East and a smaller density in the West.

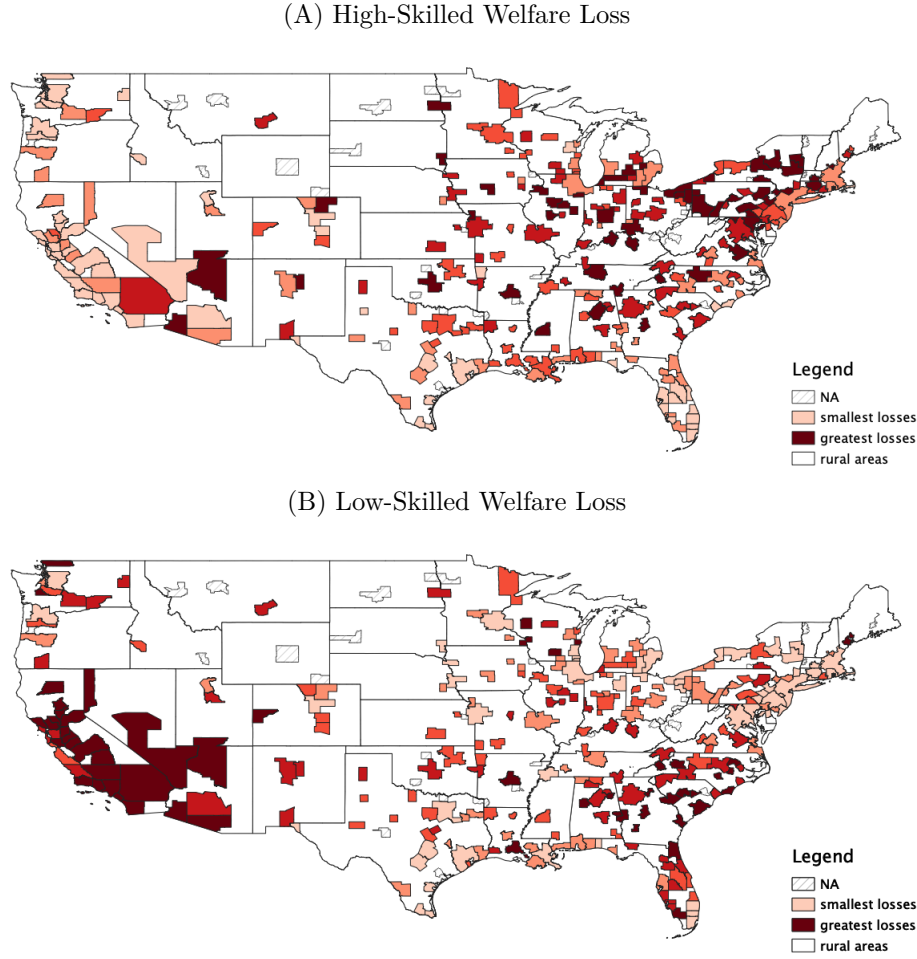


Figure 1.8: Distribution of Welfare Losses if IHS Is Removed

Notes: This figure shows the spatial distribution of welfare losses following a hypothetical removal of the Interstate Highway System. Darker shades of red correspond to greater losses. Migration and trade costs are estimated as a function of travel times.

Counterfactual travel times will thus increase by a larger margin in MSAs located on the West Coast, and be only marginally affected in the East. For example, MSAs in the North-East experience an increase in travel times of approximately 17.5%, while in cities in the Pacific region they raise by 24.5%. This is responsible for smaller welfare changes in the North-East and bigger effects in the West.

### 1.8.3 Reducing Migration and Trade Costs

I now examine how different configurations of Fréchet shape parameters and bilateral migration and trade costs affect the welfare of high-skilled and low-skilled workers. The results of these counterfactuals are reported in Table 1.10.<sup>50</sup>

In Panel A, I undertake counterfactuals in which I change the parameters governing the distri-

<sup>50</sup>The counterfactuals in this section use the distance specification for migration and trade costs. All the results are nonetheless robust to using the travel time parameterization. Table 1.22 in the Appendix shows the results.

Table 1.10: Welfare Effects under Different Counterfactuals

<i>Panel A: Changing Mobility Parameters for the Low-Skilled</i>			
	$\kappa_{in}^L = \kappa_{in}^H$	$\epsilon^L = \epsilon^H$	$\kappa_{in}^L = \kappa_{in}^H$ $\epsilon^L = \epsilon^H$
High-skilled workers	1.0005	1.0001	1.0015
Low-skilled workers	1.4037	0.9266	1.2175
<i>Panel B: Symmetric Reductions in Migration Costs</i>			
	10%	20%	40%
High-skilled workers	1.0179	1.0509	1.2184
Low-skilled workers	1.0086	1.0238	1.1049
<i>Panel C: Symmetric Reductions in Trade Costs</i>			
	10%	20%	40%
High-skilled workers	1.0563	1.1307	1.3652
Low-skilled workers	1.0586	1.1357	1.3756

Notes: This table shows the change in average expected utility for several counterfactuals. Panel A considers different configurations of Fréchet shape parameters and migration costs for low-skilled workers. Panel B considers symmetric reductions in inter-metropolitan migration costs for both skill groups, while holding trade costs fixed. Panel C considers symmetric reductions in inter-metropolitan trade costs, while holding migration costs fixed. Both migration and trade costs are estimated as a function of geographic distance, with the elasticity being governed by the stock of highways in the cities of origin and destination.

bution of location preferences and the migration costs of low-skilled workers. In the first column, their counterfactual migration costs are set to match those of high-skilled workers. Inter-regional mobility rates of non-graduates increase, the average share of non-migrants dropping from 90% to 50%. At the same time, their average expected utility increases by 40.37%. In the second column, I increase the Fréchet shape parameter to  $\epsilon^H = 5.72$  and hold migration costs fixed at their initial level. Increasing the Fréchet shape parameter entails both a stronger response to changes in real wages and a higher elasticity to migration costs. In this counterfactual, the second effect dominates and the average share of non-migrants increases by 8%. The average expected utility of low-skilled workers drops by 7.34%. In the third column, I set both the Fréchet shape parameter and the migration costs of non-graduates to match those of high-skilled workers. Under this scenario, low-skilled welfare would increase by 21.75%.

Panel B considers uniform reductions in inter-metropolitan migration costs, while holding trade costs constant at their 2000 level. Results are provided for reductions of 10%, 20% and 40%. High-skilled workers would see their utility increase by 1.72%, 4.71% and 19.26%, respectively. The low-skilled would gain, on average, 0.79%, 2.03% and 7.58%. The gains accrue mainly to college graduates as they are more likely to migrate. Are these effects reasonable? Monte et al. (2018) document a 12 percent increase in the ease of commuting from 1990 to 2010. Assuming a reduction in commuting costs equal to 12%, they compute an increase in welfare of approximately 3.3%. The effects I document are therefore consistent with their findings.

Finally, Panel C shows results for symmetric reductions in trade costs, while holding migration costs fixed at their 2000 level. In this case, reductions of 10%, 20% and 40% generate average increases in high-skill utility of 5.59%, 12.98% and 36.29%, respectively. Low-skilled workers gain 5.77%, 13.36% and 37.10%. Symmetric reductions in trade costs generate larger welfare gains than similar reductions in migration costs. These exercises suggest that, insofar as policy makers can only address one type of bilateral costs, focusing on lowering barriers to intra-national trade has the potential to generate greater welfare gains.

#### 1.8.4 Robustness Checks and Sensitivity Analysis

This section tests the sensitivity of the results presented in the previous sections to different parameter values. Table 1.23 in the Appendix summarizes the results from these robustness checks.

In the first three exercises, I consider different values for the Fréchet shape parameters. The first experiment uses Diamond (2016)'s migration elasticities from a model with endogenous amenities and fixed local expenditure shares. The second experiment uses Diamond (2016)'s estimates when local expenditure shares are allowed to vary across skill groups. The third experiment assumes identical Fréchet parameters that I estimate by regressing the difference in the destination-specific fixed effects from gravity equations on the difference in real wages. The model-predicted effect of an additional highway is approximately 0.31 in all exercises, only slightly smaller than in the baseline specification. The welfare losses associated with a hypothetical removal of the IHS are also consistent with previous results, ranging from 12.73 to 15.08 for high-skilled workers and 11.79 and 11.92 for low-skilled workers. In particular, higher Fréchet shape parameters correspond to smaller welfare losses. Symmetric reductions in migration costs benefit high-skilled workers to a greater extent, with the gains increasing with the Fréchet shape parameter. Symmetric reductions in trade costs generate greater welfare gains for both types and low-skilled skilled gain slightly more. As before, the effects are stronger for higher shape parameters.

The second set of exercises tests the sensitivity of my results to different values of the elasticity of substitution between high-skilled and low-skilled workers. Experiment 4 considers a value from the lower end of estimates found in the literature ( $\mu = 1.25$ ), whereas experiment 5 considers a higher elasticity of substitution ( $\mu = 3$ ). I find that the effect on the college share is larger for lower elasticities of substitution, but remains of the same order of magnitude. The welfare effects following a removal of the IHS or further reductions in trade and migration shocks do not change in a significant manner.

The third set of robustness checks considers different expenditure shares on housing. In experiment 6, both types of workers spend a higher share of their income on housing:  $1 - \alpha = 0.4$ . Relative to the benchmark specification, the model-implied effect on the college share is slightly smaller. Higher housing expenditure shares curtail significant population reallocations towards better connected cities, as these experience the largest increases in housing costs. The welfare effects of removing the IHS are also smaller. As workers spend a smaller share of their income on tradable goods, the incidence of higher price indices on welfare is lower. By a similar argument, symmetric

reductions in trade costs generate smaller welfare gains. Reducing migration costs has the same effect as in the baseline specification. Experiment 7 considers heterogeneous housing expenditure shares: low-skilled workers spend 30 percent of their income on housing, while high-skilled workers spend only 20 percent. Under this assumption, the model delivers a much higher effect on the college share: 0.36 percentage points for each additional highway. Relative to the baseline case, a hypothetical removal of the IHS has larger effects for high-skilled workers, as they spend a higher share of their income on tradable goods; the welfare losses of low-skilled workers are smaller. Further reductions in trade costs also generate larger welfare gains to high-skilled workers, while the size of the effects of reducing migration costs does not change.

Finally, experiment 8 relaxes the assumption of symmetric migration and trade costs, i.e.  $\kappa_{in}^s = \kappa_{ni}^s$  and  $\tau_{in} = \tau_{ni}$ . Specifically, I use the estimates from columns (1), (3) and (5) of Table 1.6 to construct bilateral migration and trade costs from 1950 to 2000. The model now predicts a slightly smaller effect on the college share. The welfare effects following a removal of the IHS or a reduction in migration and trade costs are similar to those obtained in the benchmark case.

## 1.9 Conclusion

Expenditure on transport infrastructure accounts for a significant share of US public spending. Highway investments are likely to increase in the upcoming decades, as a growing number of interstates will exceed their design life and handle heavier traffic than initially planned. It is therefore necessary to achieve a better understanding of how transport infrastructure shapes the spatial distribution of economic activity and impacts different types of workers. This paper answers this question in two steps. First, I estimate reduced-form effects of highways on the skill composition of US metropolitan areas from 1950 to 2000. Second, I use a quantitative spatial model with heterogeneous workers to measure welfare effects under different counterfactual road networks.

Infrastructure investments are likely to be endogenous to local skill levels. I therefore adopt an instrumental variable approach to measure the impact of interstate highways on cities' skill mix. Specifically, I use the number of planned routes, smoothed using national construction rates, and the stock of highways in the nearest major MSAs oriented east-west and north-south as instruments for the number of highways in a given metropolitan area. Regressions of the college share on the number of highways yield positive and highly significant coefficients. In particular, the share of a city's graduate population increased by more than half a percentage point for each additional interstate, with better connected MSAs attracting disproportionately more college-educated migrants.

The second contribution of this article is to quantify welfare effects for graduates and non-graduates. To this aim, I use an extension of the quantitative framework of Monte et al. (2018). Specifically, workers are allowed to differ in their migration elasticities and migration costs. I then parametrize bilateral trade and migration costs as functions of the transport infrastructure and estimate them using data on inter-metropolitan worker and export flows. I find that a hypothetical removal of the interstate network would reduce average high-skill and low-skill welfare by 13% and 12%, respectively. Additional counterfactual experiments show that further reductions in migration costs would generate limited welfare gains that accrue mostly to college graduates. Similar declines in trade costs would produce greater welfare effects that benefit non-graduates slightly more.

The results presented in this article raise several related questions. First, gravity regressions reveal that the distance elasticity decreases faster with better highways for high-skilled workers. What could explain this heterogeneity? Distance may correlate with unobserved costs, such as imperfect information or cultural differences, to which low-skilled workers may be more sensitive. Second, there is growing concern that the US economy exhibits too much spatial sorting, leading to efficiency losses. The findings in this article suggest that infrastructure investments in low college-share cities may shift the national distribution of skilled labor towards a more efficient allocation. This raises an important question. What is the optimal road network that would lead to an efficient allocation of high- and low-skilled workers? Finally, this paper addresses the issue of geographic sorting driven by market access in a developed country, with no formal barriers to the mobility of workers and goods. The mechanisms described here may nonetheless operate in other setups. The recent massive investments in transport infrastructure in developing countries, like India or China, provide ideal case studies. These exercises are left for future research.

## 1.10 Appendix

### 1.10.1 Data Description

Variable	Source	Sample	Notes
County-level demographic, economic and educational variables.	County and City Data Books. (U.S. Department of Commerce, 1947–2002).	All counties in the US from 1940 to 2000.	Counties are aggregated at the MSA level as in Baum-Snow (2007). The final sample consists of 307 MSAs that I observe in every decade from 1950 to 2000.
Migration outcomes at the MSA level.	IPUMS samples of the Census. (Ruggles et al., 2018).	The unbalanced sample consists of 286 MSA and 48 rural geographic units, aggregated at the state level. Only 94 urban MSAs are observed in every year.	I aggregate counties at the MSA level using the same definition as in Baum-Snow (2007). I only use the Census provided MSA-codes when an MSA cannot be identified using the state and county FIPS codes.
Highway data.	Baum-Snow (2007).	I observe the number of highway rays and miles open to traffic in every MSA from 1950 to 2000.	The definition of a highway ray is the same as in Baum-Snow (2007). Out of the 307 MSAs in the sample, only 43 are not served by an interstate in 2000.
Highway maps.	U.S. Department of Transportation (2011).	The data set contains all highways identified as interstate, principal arterial, and lower roadways.	I supplement this data set with information on speed limits from the Insurance Institute for Highway Safety. In calculating travel times, I disregard minor highways.
Inter-regional Trade Flows.	Commodity Flow Survey. (U.S. Department of Commerce, 2002).	The data set contains exports between 54 CFS regions. It provides information on both the value and quantity of exports.	For each CFS region, I identify its central city and assign it to a metropolitan area. The final sample consists of 2916 bilateral trade flows.

Variable	Source	Sample	Notes
Apparel stores, eating and drinking places, movie theaters.	County Business Patterns. (U.S. Department of Commerce, 1962–2002b).	The data sets include all counties in the US and provide information on the number of establishments by industry.	In the 1962, 1970, 1980 and 1990, industries are identified by their SIC code, whereas in 2000 NAICS codes are used.
Number of teachers and employees in health care.	Census of Local Governments – Employment files. (U.S. Department of Commerce, 1962–2002a).	The data sets include all counties in the US from 1960 to 2000.	In the analysis, I use only full-time employees.
Local expenditure on health, education and welfare.	Census of Local Governments – Finance files. (U.S. Department of Commerce, 1962–2002a).	The data sets include all counties in the US from 1960 to 2000.	The data sets contain information on public expenditure at the county level.
Number of students enrolled in PK-12.	The number of pupils in 1960 and 1970 comes from the CCDB. The source for 1980 is ELSEGIS. (U.S. Department of Education, 1980). For 1990 and 2000, the number of pupils was taken from NCES's Common Core of Data (U.S. Department of Education, 1980).	The data sets include all counties in the US from 1960 to 2000.	The data sets provide information on enrollment in free public elementary and secondary educational institutions.
Crimes per capita	Program Data: Offenses Known and Clearances by Arrest. (U.S. Department of Justice, 1960–2000)	All counties in the US from 1960 to 2000.	Violent crimes include murder, rape and assault. Property crimes include burglary, robbery, larceny and motor vehicle theft.

### 1.10.2 Literature Review

A growing body of literature documents the substantial ways in which transport infrastructure fashions the spatial distribution of economic activity. One of the most common assumptions about an improved road network is that it reduces shipping and commuting costs, which facilitates inter-regional flows of goods and people. For instance, Volpe Martincus and Blyde (2013) use a natural experiment to assess the impact of transport infrastructure on trade flows. They find that in the wake of the earthquake that rocked Chile in 2010, exports that had to be rerouted due to road destruction exhibited growth rates that were 33.7% lower than unaffected exports. Using US data on bilateral trade flows between 66 regions from the Commodity Flow Survey, Duranton et al. (2014) estimate that a 10% increase in the stock of highways within a city caused a 5% increase in the weight of exports. The effect on value was smaller and statistically insignificant. In contrast, Duranton (2015)’s estimates show that the impact of roads on the value of trade in Colombian cities was slightly larger than the effect on weight. In his study on the impact of railways in colonial India, Donaldson (2018) reports significant reductions in trade costs with the advent of the railroad network, which led to increased inter-regional trade flows.<sup>51</sup> In addition to facilitating trade, Morten and Oliveira (2016) show that an improvement in the transport infrastructure also promotes inter-regional flows of people. They provide quantitative evidence that migration rates between states that were better connected to Brazil’s highway network grew relatively more. Using a quantitative spatial model, they estimate that removing the highway system would have translated into an increase in trade and migration costs of 28% and 11%, respectively. Heuermann and Schmieder (2018) show that the expansion of high-speed rail in Germany generated a decline in travel times of 9.5% along newly introduced connections. Moreover, a reduction of 1% in travel times generated an increase of 0.25% in the number of commuters, the effect being larger for college graduates. Baum-Snow, Nathaniel (2010) identifies a positive impact of US interstate highways on commuting in the suburbs. For each radial highway, the number of commutes within suburban regions grew by 25%. Commutes within central cities, on the other hand, sharply decreased.

The existing scholarship also highlights significant effects on regional output, albeit these may mask substantial heterogeneity. Banerjee et al. (2020) compare Chinese counties located near the lines connecting historical cities to “treaty ports” with areas located farther away. They find that the distance elasticity of per capita GDP is  $-0.07$ . Hence, proximity to transportation networks was beneficial to Chinese counties. The elasticity of annual per capita GDP growth is not statistically significant. Jedwab and Moradi (2016) study the impact of the railway system in Sub-Saharan Africa during colonial times. They identify a positive effect on cocoa production and on urban growth. These effects were extremely persistent, despite the deterioration of the network during the post-colonial period. In a related paper, Storeygard (2016) takes the infrastructure network as fixed and uses world oil price fluctuations as a source of exogenous variation in transport costs.

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<sup>51</sup>A better transport network need not, however, reduce road congestion. Duranton and Turner (2011) show that the elasticity of vehicle kilometers traveled to the stock of interstate highways is close to 1 in US metropolitan areas. Hsu and Zhang (2014) arrive at similar conclusions for Japan. They find that the elasticity of traffic to road capacity is in the range of  $1.24 - 1.34$ , suggesting limited effects of highway provision on congestion relief.

Given a quadrupling of oil prices, he finds that the economy of cities located in close proximity to their country's largest port was 7% bigger as compared to identical cities located 500 km farther away. Donaldson and Hornbeck (2016) estimate that a 1% increase in market access due to the construction of railway lines in late 19th century US led to a rise in agricultural land values of 0.51%. Had the railway network not been built, agricultural land values would have been 60% smaller. Analyzing the impact of high speed rail on regional output in Germany, Ahlfeldt and Feddersen (2017) find a cumulated effect of 8.5% on counties with intermediate stops. Surprisingly, Faber (2014)'s study of the impact of China's National Trunk Highway System on local development reaches the opposite conclusion. Peripheral locations along the path of the NTHS experienced reductions in industrial and total GDP as compared to non-connected peripheral locations. Qin (2017) finds a negative impact of high-speed rails on local output in China. GDP and per capita GDP in bypassed counties along the improved railway lines fell by 3 – 5%, the effect being driven by a reduction in fixed asset investments. Baum-Snow et al. (2018) provide a reassessment of the effects of the NTHS by distinguishing between primate and non-primare prefectures. They find negative effects on GDP in non-primare municipalities and positive effects in primate cities.

The effects of transport infrastructure on the spatial distribution of population are consequential and show significant persistence. Studying the expansion of the railway system in 278 counties in the Midwest from 1850 to 1860, Atack, Bateman, Haines, and Margo (2010) uncover a small, positive effect of rail access on population density and a much larger effect on urbanization. Hornung (2015) documents that urban population growth was 1 to 2 percentage points higher in Prussian cities that adopted railroads relative to non-adopting cities. Berger and Enflo (2017) show that railroad construction in Sweden implied large population gains for connected towns, albeit these came at the expense of nearby non-connected locations. Moreover, cities that were connected in the first wave of construction continued to grow faster in the 19th and 20th century, despite steady expansions of the railroad network. Duranton and Turner (2012) study the impact of US highways on metropolitan population growth. Using an instrumental variable approach, they find that an increase of 10% in a city's stock of highways led to an increase of 1.5% in its employment. Mayer and Trevien (2017) reach similar conclusions for the expansion of the public railway system in the Parisian region. For a reduction of 1 minute in travel times, employment increased by 6.1%. While transport improvements spurred urban growth, the process often went hand in hand with substantial decentralization. Baum-Snow (2007) shows that the population of central cities decreased by 18 percent with each interstate highway ray. Similar patterns were observed in Chinese cities, where central cities lost 4% of their population to neighboring regions for each radial highway, and 20% for ring roads (Baum-Snow et al., 2017). Garcia-López et al. (2015) replicate the analysis for Spanish cities and reach similar conclusions.

Equally important, an improvement in the transport infrastructure can shape firms' location decisions and their management of production. Studying the impact of the Golden Quadrilateral (GQ) program on the performance of Indian firms, Datta (2012) finds that firms in non-nodal cities along the GQ highways reduced their average stock of inputs, were more likely to change

their primary suppliers and reported lower transportation barriers to production. Similarly, Ghani et al. (2015) find higher entry rates and larger gains in plant productivity in districts that are located within 10 km of the GQ. Holl (2016) documents an elasticity of productivity with respect to highway access of 1.3% – 1.7% for Spanish firms. The effect is larger for firms located in urban areas and in close proximity to the new highways. Using administrative data at the electoral ward level for Great Britain, Gibbons, Lyytikäinen, Overman, and Sanchis-Guarner (2019) find a positive effect of road accessibility on employment and the number of establishments. While the effect on employment at the establishment level is null, the impact on labor productivity is positive and significant. Audretsch, Dohse, and dos Santos (2018) document a negative impact of highway tolls on the number of firms and employment in Portugal. Using data on highway construction in Italy, Percoco (2015) shows that proximity to highway exits increased both employment and the number of firms.

The effects of an improved road network need not, however, be symmetric across sectors and different types of workers. Chandra and Thompson (2000) identify positive average effects of US interstate highways on earnings in connected rural counties. In particular, earnings in the services and retail industries grew by 5 – 8%. The effect on untreated neighboring counties is negative but similar in absolute terms, implying that aggregate changes might be null. Michaels (2008) reports a positive impact of interstate highways on profits in the trucking and warehousing sector, in the range of 7% – 10%. Retail sales rose by 8 to 10 percentage points. He also finds a positive impact on the demand for skill in skill-abundant counties. Sanchis-Guarner (2013) uncovers a positive effect of road accessibility from work location on income, and no effect for accessibility from home. Fretz et al. (2017) find strong effects on the local skill and income composition of Swiss municipalities. On average, highway access rose the share of high-income residents by 23% and reduced the share of low-income residents by 7%.

My analysis is also related to a bulk of studies that deal with the increased geographic sorting of high-skilled workers. From 1980 to 2000, college graduates concentrated in metropolitan areas with an initial large share of graduates. Already more expensive in 1980, these locations experienced further growth in housing costs. As a consequence, real wage inequality over the period increased at a slower pace than nominal wage inequality. Moretti (2013) further argues that the geographic sorting of college graduates was driven by local shifts in the demand for skill, implying that growth in welfare inequality was smaller than previously thought. In a closely related article, Diamond (2016) estimates a structural spatial equilibrium model and finds that changes in relative demand were, indeed, the main factor shaping the location decisions of high-skilled and low-skilled workers. However, local amenities and productivity endogenously responded to changes in the skill composition of cities, such that locations with a higher share of graduates became more attractive. The estimated changes in welfare inequality were substantially larger than what the college wage gap would suggest.<sup>52</sup>

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<sup>52</sup>Combes et al. (2012a) and Gaubert (2018) address the spatial sorting of heterogeneous firms. Combes et al. (2012a) aim at distinguishing between selection and agglomeration effects in explaining higher firm productivity in larger cities. While selection left-truncates the distribution of firm productivity, agglomeration effects shifts

Brinkman (2014) estimates a spatial model with heterogeneous workers and firms. Preferences for amenities can vary across workers' types and changes in a location's productivity can be both industry-specific and skill-specific. His results are in line with previous research, demonstrating that shifts in the demand for skill were the driving force for the geographic sorting of workers. Concerning the supply of skilled labor, his findings indicate that high-skilled workers increasingly valued amenities in larger cities. Gyourko, Mayer, and Sinai (2013) argue that historical differences in housing costs can be rationalized by a combination of inelastic land supply in some locations and an overall increase in the number of wealthy households. As the number of high-income households grows, housing demand in a given location increases; if supply can not meet the increased demand, labor market clearing implies higher rents, which drive out lower-income families.

Another strand of the literature has sought to highlight how differences in skill composition and sorting can account for spatial income disparities. Combes et al. (2008) find that almost half of the spatial variation in wages was due to differences in the skill composition. In particular, workers with similar labor market outcomes exhibit a tendency to concentrate in the same locations. While this is consistent with positive selection of high-skilled migrants into denser areas and negative selection of low-skilled migrants in less dense areas, Combes, Duranton, Gobillon, and Roux (2012b) argue that migration played only a limited role in explaining spatial disparities. Using Spanish administrative data, De la Roca (2017) observes positive selection of migrants to bigger urban areas in terms of productivity and education. Migrants to smaller cities, however, do not appear to self-select along any observable characteristics. In a closely-related paper, De la Roca and Puga (2017) find that sorting based on unobservables plays a marginal role in explaining regional wage disparities in Spain. Workers in big cities are not significantly different from workers in smaller cities in terms of unobserved abilities.

On the theoretical front, Davis and Dingel (2020) introduce a model of city specialization based on agglomeration economies and comparative advantage. They assume that locations are initially homogeneous and divergence occurs as the result of heterogeneous workers making different residential choices. Each city consists of a continuum of locations that differ in their attractiveness. Agglomeration implies that locations within a larger city are more attractive than identical locations in smaller cities. Because of complementarity between income and location desirability, larger cities will attract proportionally more skilled individuals. By comparative advantage, these cities will also specialize in skill-intensive sectors. Behrens et al. (2014) propose an alternative model of city specialization that incorporates agglomeration economies, sorting of workers and selection of firms. They highlight the subtle complementarities between the three. More talented workers locate in larger cities, as the profits they can make as entrepreneurs are increasing with city size and productivity. This selection makes firms more productive in bigger cities as well, the two mechanisms mutually reinforcing each other.

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the distribution to the right. Using French establishment-level data, they find little evidence of selection effects, agglomeration being more likely to explain the productivity advantages of larger cities. In contrast, Gaubert (2018) introduces a model in which heterogeneous firms make different location choices. Using French firm-level data, she finds that sorting explains almost half of the productivity advantage of big cities.

### 1.10.3 Overview of the US Interstate Highways System

The US Interstate Highway System is one of the most impressive infrastructure projects in history. It cost more than 500 billion dollars to build and its construction spread over several decades. Its story begins in 1941, when President Franklin D. Roosevelt appointed a committee to examine the need and suitability of a national system of highways.<sup>53</sup> Following its recommendations, Congress adopted the Federal Aid Highway Act of 1944, which made provisions for the construction of 40,000 highway miles. The stated objective of the network was to connect by the shortest routes possible, major urban and industrial centers, address concerns related to national defense and join US roads with arteries of “continental importance” in Canada and Mexico. In 1947, the first plan of the system was adopted, although there were limited federal funding provided. Appropriations for interstate highways only became available in 1956 when, under the presidency of Dwight D. Eisenhower, a new Federal Aid Highway Act was passed. This bill established a Highway Trust Fund that covered 90% of construction costs, states being required to come up with the remaining 10%. The bill also expanded the initial mileage.

Prior to 1956, barely any interstates were open to traffic. The few that appear in my database are preexisting state freeways. For instance, the Pennsylvania Turnpike opened as early as 1940 and was eventually incorporated into the interstate network. As soon as federal funding became available, construction proceeded with haste. In 1970, more than half of the 1956 plan had been built and by the end of the 1980s, most of the system was complete. In 2000, the Interstate System had expanded to 46,667 miles. The total mileage in my sample of metropolitan areas is 23,343 miles.

Inspecting the maps detailing the progression of construction of the IHS, it becomes apparent that construction spread radially from major urban centers to adjacent counties. In 1960, several segments of interstate highways were already open to traffic in urban centers like Portland, Los Angeles, Dallas, Saint Louis, Chicago, Boston or New York. Data on mileage constructed confirm this pattern. Table 1.13 summarizes the stock of highways open to traffic every decade in MSAs whose population exceeded 500,000 residents in 1940 (“major” MSAs) and smaller-sized urban areas (“minor” MSAs). In 1960, 25% of the 2000 mileage was complete in major MSAs, as compared to only 16.35% in minor MSAs. While the gap closed in subsequent decades, total mileage remained substantially bigger in major urban areas than elsewhere. In 2000, major MSAs were served, on average, by 7 radial highways (amounting to 243 highway miles), while minor MSAs had an average stock of 2.5 radial highways (and only 57 highway miles).

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<sup>53</sup>Already in 1938, President Roosevelt had expressed to Thomas MacDonald, in charge of the Bureau of Public Roads, the desire to establish a system of transcontinental routes comprising three east-west and five north-south corridors.

### 1.10.4 Amenity Index

I follow Diamond (2016) and use a single index for the level of amenities in given location that captures retail development, the quality of school, crime, the job market, housing congestion and the quality of education. To generate a single amenity measure, I use principal component analysis. I first create an index for each of the amenity categories mentioned before, and then compute the overall amenity index. The Table on the following page shows the loadings on all amenities.

In order to create the retail index, I collect data on the number of apparel stores, eating and drinking places, and movie theaters per 1000 residents. All of these measures receive positive loadings.

For the school index, I use the local expenditure on PK12 education per student and the student-teacher ratio. The loading on the per-student expenditure is positive, while the loading on the student-teacher ratio is negative. These results are intuitive, as higher expenditure per student should reflect better school amenities, and higher student-teacher ratios worse school amenities.

I use the number of property crimes and violent crimes per 1000 residents to generate the crime index. Both variables receive a positive loading.

For the job index, I collect data on local expenditure on welfare per 1000 residents and the local employment rate. The employment rate receives a positive loading, meaning that better matching between employers and employees leads to higher job indices. The loading on the expenditure on welfare is negative, as higher values are likely to reflect more friction in the labor market.

I use the ratio of households to the number of housing units and that of housing units to area to generate the congestion index. The loading on both variables is positive.

The health index assigns a positive value to expenditure on healthcare per resident and the number of healthcare employees per 1000 residents. The loadings on both variables is positive.

I combine all these indices to generate an overall amenity index. I find positive loading on the retail, school and job indices. The loading on the crime index is negative, as is the congestion index. Surprisingly, the loading on the health index is negative. This might due to the fact that higher expenditure on healthcare might be the result of worse health outcomes for the population.

Table 1.11: Principal Component Analysis for Amenity Indices

A. Retail Index			B. School Index		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Apparel Stores per 1000 Residents	0.5668	0.508	Expenditure on Education per Student	0.7071	0.3426
Eating and Drinking Places per 1000 Residents	0.6352	0.3821	Student-Teacher Ratio	-0.7071	0.3426
Movie Theaters per 1000 Residents	0.5246	0.5785			
C. Crime Index			D. Job Index		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Property Crimes per 1000 Residents	0.7071	0.2181	Expenditure on Welfare per 1000 Residents	-0.7071	0.4434
Violent Crimes per 1000 Residents	0.7071	0.2181	Employment Rate	0.7071	0.4434
E. Congestion Index			F. Health Index		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Households - Housing Units Ratio	0.7071	0.4615	Expenditure on Healthcare per Resident	0.7071	0.05354
Housing - Area Ratio	0.7071	0.4615	Healthcare Employees - Population Ratio	0.7071	0.05354
E. Overall Amenity Index					
	Loading	Unexplained Variance			
Retail Index	0.6525	0.4262			
School Index	0.5546	0.5855			
Crime Index	-0.1460	0.9713			
Job Index	0.1848	0.954			
Congestion Index	-0.4394	0.7398			
Health Index	-0.1348	.9755			

Notes: All variables are standardized in every decade. Due to data limitations, I can only compute amenity indices from 1960 to 2000. I report in Panels A to F the weights used in the construction of each sub-index. In Panel G I report the weights on each component of the overall amenity index.

### 1.10.5 Robustness Checks

#### 1.10.5.1 Alternative Instruments

In this section, I present IV results from several specifications in which I vary the methodology used to create the orientation-based instrument. Table 1.16 summarizes the main findings. All regressions include MSA-specific fixed effects, as well as educational, demographic and economic covariates. In addition, I control for the college share in rural counties, which I aggregate at the state level.

In column (1), I define major MSAs as cities whose population exceeded either 500,000 residents or the regional 90th percentile in 1940. This procedure yields 41 major metropolitan areas that I use to construct the orientation-based instrument. The effect of highways on the college share is now 0.56. The coefficient on the instrument in the first stage is 0.17 and is significant at 1%. It is only marginally bigger than the coefficient on the original instrument. The first-stage F-statistic is 71.74, mitigating concerns about weak instruments.

In column (2), I consider an alternative definition of major cities. Specifically, I classify as major those cities whose employment in manufacturing or manufacturing share in total employment was above the national 90th percentile in 1940. There are 52 cities that satisfy this condition and, among them, there are 25 that also meet the population criterion. Using this definition, the second stage coefficient on the number of rays is 0.60. The coefficient on the instrument in the first stage is 0.18 and the corresponding F-statistic is 50.31.

Column (3) uses both instruments to estimate the impact of highways on the college share. The effect is now 0.57. In the first stage, the coefficient on the population-based instrument is 0.14 and highly significant. The coefficient on the manufacturing-based instrument, on the other hand, is smaller (0.05) and not significant. The F-statistic is above Stock and Yogo's critical value and I cannot reject the null hypothesis that the instruments are valid. In column (4), I include the number of planned rays as an additional instrument. The second-stage coefficient on the number of rays falls to 0.48, but remains statistically significant. The first-stage coefficients on the orientation-based instruments are now similar in size and are not individually significant. The first-stage F-statistic rules out weak instrumentation and the over-identification  $p$ -value is 0.80. These regressions suggest that the stock of interstates in the most populous cities are better predictors of the number of highways in smaller cities. However, when I include the number of planned rays, both instruments perform equally well and lead to similar estimates.

In columns (5) through (8), I test the sensitivity of my results to using different widths to construct the instrument. In column (5), I consider a more conservative width of 60 km. The impact of highways on the college share is 0.40 and significant at 5% only. The first-stage coefficient on the instrument is 0.13 and highly significant. Column (6) increases the width to 90 kilometers. The effect on the college share is now 0.48 and the coefficient on the instrument in the first stage is 0.15. In both specifications, the first-stage F-statistic passes the weak instrument test. In column (7), I use simultaneously the instruments constructed using a 60 km, 75 km and 90 km width. The

second-stage coefficient on the number of rays is now 0.50. In the first stage, only the coefficient on the instrument using the largest width is individually significant. The coefficient on the 60-km instrument is even negative, but extremely small ( $-0.005$ ). This suggests that instruments using a wider band are better predictors of highways than instruments using more conservative widths. In column (8), I add the number of planned rays as an additional excluded instrument. The effect of an additional interstate on the college share is 0.47. The first-stage F-statistic is large enough to pass the weak instrument test and I cannot reject the null hypothesis that the instruments are jointly valid.

The last two columns of Table 1.16 use the number of highways in the nearest major MSAs oriented east-west and north-south as separate instruments. The estimated effect on the number of rays is 0.40, which is similar in size to the OLS effect. The coefficient on the number of rays in the nearest major MSA oriented east-west is 0.19, while the coefficient on the number of rays in the nearest major MSA oriented north-south is 0.10. Both are significant at 1%. The first-stage F-statistic is large, and I cannot reject at 5% the null hypothesis that the instruments are jointly valid. Including the number of planned rays as an additional instrument produces a coefficient of 0.47. In this specification, only the coefficient on the number of rays in the nearest major MSA oriented east-west is significant. Weak instrumentation is not an issue, and I pass standard over-identification tests.

#### **1.10.5.2 CCDB vs. IPUMS Samples**

Because MSA coverage is not systematic in the IPUMS samples, estimates of the impact of highways on migration outcomes might suffer from selection bias. In order to test whether this is a reasonable concern, I re-estimate equation (1.1) using CCDB data, but restrict the sample to metropolitan areas that appear in the IPUMS data sets. Panel A of Table 1.17 presents the results.

In the baseline specification with the college share as the dependent variable, the OLS coefficient on the number of rays is 0.39. This is similar to the effect obtained for the entire sample (0.41). Controlling for the rural college share instead of state-by-year fixed effects produces an estimate of 0.43, which is somewhat bigger than the original estimate (0.37). As was the case previously, IV regressions deliver larger effects on the college share. In the baseline specification, the coefficient on the number of highways is 0.61. The effect for the entire sample was 0.55. Conditioning on the rural college share and adding the orientation-based instrument reduce the point estimates, but do not change their significance. In all regressions, the first-stage F-statistic is well above the critical values and I pass standard over-identification tests.

The results are similar when the dependent variable is either the number of high-skilled workers or the number of low-skilled workers. The OLS coefficient is 0.02 (significant at 1%) for college graduates and 0.01 (not significant) for non-graduates. The IV effect is approximately 4% for the former and 2% for the latter. These are only slightly larger than the coefficients reported for the entire sample. As was the case previously, controlling for the stock of graduates and non-graduates living in rural areas inflates the IV estimates.

In Panel B, I re-estimate the effect of highways on cities' skill mix using the IPUMS data sets. The OLS estimate when the dependent variable is the college share is 0.37 and is significant at 1%. Instrumenting the stock of highways with the number of planned rays yields a coefficient of 0.57, which is remarkably close to the one obtained for the CCDB sample. Dropping the state-by-year fixed effects and controlling instead for the college share in rural areas, I find that the college share increased by 0.48 percentage points with each additional highway. The effect on the number of college graduates and non-graduates are, nonetheless, slightly bigger than the ones presented in Table 1.14. The OLS coefficients in the baseline regression with state-by-year fixed effects are not significant for either type of workers. If I control for the number of residents in rural areas, I find coefficients of 0.33 and 0.24 for college graduates and non-graduates, respectively, both being significant at 1%. IV estimates are larger and are significant across all specifications. They are also stable across different specifications.

### 1.10.5.3 Other Robustness Checks

Table 1.18 presents additional robustness checks. In columns (1) through (4), I test whether the results are sensitive to the highway measure I use. The independent variable is here the highway density, defined as the number of highway miles open to traffic in an area of 100 square miles. All regressions include demographic, economic and educational covariates, as well as MSA-specific fixed effects. The regressions in columns (1) and (3) also include state-by-year fixed effects, while the regressions in columns (2) and (4) control for the college share in rural areas instead. OLS coefficients on the number of rays are positive and significant at 1% in both specifications. Moreover, the point estimates are quite similar: a one unit increase in the highway density is associated with a 0.28 – 0.30 increase in the share of high-skilled workers. The IV coefficient is 0.60 in the baseline specification and 0.52 when controlling for the rural college share. This confirms the downward bias of OLS estimates. A higher highway density also causes an increase in the number of high-skilled residents. In regressions with the log of the number of low-skilled workers as the dependent variable, both OLS and IV coefficients on the highway density are positive, but not significant across all specifications.

The average increase in the college share in urban areas was approximately 17% from 1950 to 2000. In mostly rural and agricultural metropolitan areas, such as Yuma (AZ), Merced (CA) or Visalia (CA), the growth in graduation rates was less than 7 percentage points; by contrast, cities like Raleigh (NC), Charlottesville (VA) or Corvallis (OR) have seen their college share increase by more than 30 percentage points. Columns (7) through (8) present results from regressions in which the metropolitan areas below the 5th percentile and above the 95th percentile in terms of growth in their college share are excluded. In the benchmark specification with state-by-year fixed effects, the OLS coefficient on the number of rays is 0.39 and significant at 1%. Controlling for the share of graduates in rural counties delivers a point estimate of 0.36, equally significant. At 0.60, the IV effect is larger and in line with estimates obtained for the entire sample. Controlling for the rural college share lowers it to 0.49. The impact on the stock of college graduates is positive and

significant (5.70% for an additional ray), while the effect on the stock of non-graduates is smaller (1.07%) and not significant.

In columns (7) and (8), I present OLS and IV results from long-difference regressions. The OLS coefficient on the number of rays is 0.80 and significant at 1%. This is twice the size of the effect obtained using panel regressions. In column (8), I instrument the change in the number of highways with the number of rays in the 1947 plan. The coefficient is very close to one obtained using OLS, 0.83, and is highly significant. Long-difference estimates also indicate a large and significant effect on the number of college graduates, and a much smaller and less precisely estimated effect on the number of low-skilled workers. These coefficients, however, are more in line with estimates from fixed-effects specifications (4.71% for college graduates and 2.12% for non-graduates).

### 1.10.6 Existence and Uniqueness of an Equilibrium

*Null bilateral migration costs and identically distributed preference shocks across worker types*

If bilateral migration costs are null, i.e.  $\phi^H = \phi^L = 0$ , and location tastes are identically distributed across skill levels, i.e.  $B_n^H = B_n^L = B_n$  and  $\epsilon^H = \epsilon^L = \epsilon$ , the share of workers who migrate to a given destination is the same for all origins:  $\lambda_{in}^s = \lambda_n^s, \forall i$ .

This implies that  $L_n^s = \lambda_n^s \bar{L}^s$ , where  $\bar{L}^s$  is the total number of  $s$ -skilled workers in the economy. Assuming  $\bar{L}^H = \bar{L}^L$ , it is straightforward to show that the populations of high-skilled and low-skilled workers are equal in all locations:  $L_n^H = L_n^L = L_n$ .<sup>54</sup> Consequently, the wage skill premium can be expressed as a function of the ratio of marginal productivities. The ideal wage index simplifies to a linear function of the wage of high-skilled (or low-skilled) workers:  $W_i = \frac{W_i^L}{1-\eta} = \frac{W_i^H}{\eta}$ . Using these results, the condition that labor income equals expenditure on goods produced in a location can be rewritten as  $W_i L_i = \sum_{k=1}^N \pi_{ki} W_k L_k$ .

The general equilibrium is therefore described by the triple  $\{L_n, W_n, \pi_{ni}\}$ , which solves three sets of equations: expenditure shares satisfy equation (1.16), labor income is equal to goods expenditure, and an equation describing residential choice probabilities.<sup>55</sup> This system is identical to the one in Section 2.5 in Redding (2016). The proof of existence and uniqueness of an equilibrium follows the same structure.

*Null bilateral migration costs, symmetric Fréchet shape parameters and asymmetric scale parameters across worker types*

Most of the results derived previously still apply if I allow for the average level of amenities to be skill-specific, i.e.  $B_n^H \neq B_n^L$ . Under these assumptions, the ratio of migration rates depends on the ratio of average amenities:  $\frac{\lambda_n^H}{\lambda_n^L} = c \left( \frac{B_n^H}{B_n^L} \right)^{\frac{\mu}{\mu+\epsilon}}$ , where  $c$  is a scalar.<sup>56</sup> Because there are no bilateral migration costs, the labor market clearing condition writes  $L_n^s = \lambda_n^s \bar{L}^s$ . However, the wage skill premium depends on both the ratio of marginal productivities and the ratio of average amenities. Given this, the ideal wage index can be expressed as a function of the scalar  $c$ , low-skilled wages,  $W_n^L$ , and the ratio of average amenities. The equilibrium of the model is fully characterized by the triple  $\{L_n^L, W_n^L, \pi_{ni}\}$ , which solve a system of equations similar to the one described previously. An equilibrium exists and is unique using the the same argument.

*Positive bilateral migration costs and identically distributed preference shocks across worker types*

An alternative model that I consider features identically distributed preference shocks for locations,  $B_n^H = B_n^L = B_n$  and  $\epsilon^H = \epsilon^L = \epsilon$ , but dispenses with the assumption of zero bilateral mobility costs. In order to simplify the analysis, I assume that both types face the same migration costs,  $\kappa_{in}^H = \kappa_{in}^L = \kappa_{in}$ , and that initial labor endowments are equal,  $L_{k0}^H = L_{k0}^L$ . Under

<sup>54</sup>In the general case where  $\bar{L}^H = \delta \bar{L}^L$ , it is straightforward to show that  $L_n^H = \delta L_n^L$ .

<sup>55</sup>Substituting  $P_n$  and  $r_n$  into the residential probability condition yields  $\frac{L_n}{\bar{L}} = \frac{B_n (A_n / \pi_{nn})^{\alpha\epsilon/\theta} (L_n / H_n)^{-\epsilon(1-\alpha)}}{\sum_{k=1}^N B_k (A_k / \pi_{kk})^{\alpha\epsilon/\theta} (L_k / H_k)^{-\epsilon(1-\alpha)}}$ .

This corresponds to equation (17) in Redding (2016).

<sup>56</sup>Specifically,  $c$  is given by  $c = \frac{\sum_{k=1}^N V_k^L}{\sum_{k=1}^N (B_k^H / B_k^L) (\lambda_k^H / \lambda_k^L)^{-\epsilon/\mu} V_k^L}$ , where  $V_k^L = B_k^L (W_k^L / P_k^\alpha r_k^{1-\alpha})^\epsilon$  is the average utility enjoyed by low-skilled workers in location  $k$ .

these assumptions, both high-skilled and low-skilled workers exhibit the same migration patterns,  $\lambda_{in}^H = \lambda_{in}^L$ , entailing identical high-skilled and low-skilled populations in a location,  $L_n^H = L_n^L = L_n$ . The wage skill premium collapses to the ratio of marginal productivities and the ideal wage index can be expressed as a linear function of the wage of only one type of workers.

The general equilibrium of the model is described by a vector of four variables  $\{L_n, W_n, P_n, r_n\}$ , the other endogenous variables being determined by this quadruple. The four sets of equations that must hold in equilibrium are: income equals goods expenditure, residential choice probabilities satisfy equation (1.10), the land market clearing condition determines residential rents, and price indices are a function of consumer market access. Showing that the system of equations admits a unique solution follows Monte et al. (2018).

*Asymmetric migration costs and preference shock distributions across worker types*

When both migration costs and the distribution of preference shocks are skill-specific, the system of equations cannot be further simplified. The general equilibrium cannot be rewritten in the form required to apply the results on existence and uniqueness from the literature. Instead, I use numerical simulations to show that the model admits a unique solution. Specifically, I generate a hypothetical economy by randomly drawing values for the fundamentals (average amenities and productivities, land endowments) and define a matrix of exogenous trade and migration costs (the details of this procedure are presented in Appendix 1.10.7). Values for the model's parameters are chosen from the existing empirical literature.

In order to test whether an equilibrium exists, I use an iterative algorithm to find a fixed point for different configurations of Fréchet shape parameters  $\{\epsilon^H, \epsilon^L\}$  and strictly positive migration costs  $\{\phi^H, \phi^L\}$ . The algorithm converges to a fixed point in all specifications and relatively fast. The average number of iterations is 121.

I assess whether this equilibrium is unique by considering different initial guesses for the endogenous variables. In 20% of cases, the algorithm fails to reach a fixed point within a reasonable number of iterations. In all likelihood, the initial guess was significantly off target, which prevented the algorithm from finding a solution. In the remaining 80% of simulations, the algorithm always converges to the same fixed point, confirming expectations of a unique solution.

Finally, I test whether the equilibrium is regular, in the sense of Allen and Arkolakis (2014). For this, I compute the minimum and maximum population shares for different shape parameters. The most populous location accounts for less than 9% of total population, while the least populated accounts for 0.25%. I find no evidence that economic activity is concentrated in a single location under any configuration of shape parameters and migration costs.

### 1.10.7 Generating The Hypothetical Economy

I generate a hypothetical economy that consists of 121 asymmetric locations, displayed on a  $11 \times 11$  grid. Following Redding (2016), the effective distance between two adjacent locations  $i$  and  $n$  is  $\text{dist}_{in} = (\delta_i + \delta_n)/2$  for orthogonal moves and  $\text{dist}_{in} = [2(\delta_i + \delta_n)^2]^{0.5}/2$  for diagonal moves, where  $\delta_i$  is the cost of passing through node  $i$ . For non-adjacent locations, I calculate distance using a least-cost-route algorithm. In this setup, the average distance to other locations is the lowest in the center of the grid, and increases radially in nodes closer to the edge.

I consider an exogenous shock to trade and migration costs that takes the form of an improvement in the existing transport infrastructure (i.e. construction of a highway). The red lines in Figure 1.11A indicate the path of the new roads. The cost of passing through a treated location drops from  $\delta = 7.9$  to  $\delta = 1$ .<sup>57</sup> Following the road upgrade, average distance to other locations decreases in all nodes. The largest reductions, however, occur in locations along the path of the newly constructed highways, as shown in Figure 1.11B. I assume that trade and migration costs are an increasing function of effective distance.<sup>58</sup>

The local average productivity,  $A_n$ , and amenity levels,  $B_n^H$  and  $B_n^L$ , are exogenous and do not change following the upgrade in the road network. For each node, I draw values for the Fréchet scale parameters from standard log-normal distributions. Draws are random across locations, but average amenities for the high-skilled and the low-skilled correlate positively ( $\rho = 0.8$ ) within a given location. I draw the realization for  $A_n$ ,  $B_n^H$  and  $B_n^L$  as contour plots in Figure 1.11C, Figure 1.11D and Figure 1.11E, respectively. Hot colors correspond to higher values, while cold colors correspond to lower values. I set the residential land area in every node to 100. Each location's initial high-skilled and low-skilled population (i.e. prior to any spatial reallocation) is 1.

Concerning the model's parameters, I choose values from the existing empirical literature. The share of income allocated to residential land,  $(1 - \alpha)$ , is set to 0.25, which is consistent with findings in Davis and Ortalo-Magné (2011). Following Bernard et al. (2003), I choose a value of four for the elasticity of goods substitution ( $\sigma$ ). The Fréchet shape parameter for productivity ( $\theta$ ) is equal to elasticity of trade flows with respect to trade costs. I set it to four, which is in the range of values commonly found in the literature (Simonovska and Waugh, 2014; Caliendo and Parro, 2015). I choose a value of 1.75 for the elasticity of substitution between high-skilled and low-skilled workers ( $\mu$ ), which is in line with results in Docquier et al. (2013) and Diamond (2016). The relative productivity of high-skilled workers ( $\eta$ ) is assumed to be 0.635, as in Aubry, Burzyński, and Docquier (2016). Finally, the elasticity of trade costs with respect to distance is set to  $\varepsilon = 1/4$ . This implies that the elasticity of trade flows with respect to distance is  $-\theta\varepsilon = -1$ , which is in line with results summarized in Head and Mayer (2014).

<sup>57</sup>This matches Donaldson (2018)'s estimated cost of road transport relative to rail.

<sup>58</sup>There is ample evidence that trade and migration flows are affected different measures of geographic proximity. Using data on trade in manufactured goods between US cities, Duranton et al. (2014) find that trade flows are more sensitive to highway distance than to Euclidean distance. Morten and Oliveira (2016) exploit the geographic location of Brazilian states relative to the country's planned capital, Brasilia, to identify plausibly exogenous variation in travel times. They find an elasticity of migrant flows with respect to travel time of  $-0.65$  and a trade elasticity of  $-4$ .

Since highways are randomly allocated, I can estimate the reduced-form causal impact of transport improvements on the share of high-skilled workers. Specifically, I estimate the following long-difference equation:<sup>59</sup>

$$\Delta \log(\text{skill\_share})_{nt} = \nu + \beta \mathbb{1}_{nt} + \epsilon_{nt}$$

where  $\Delta \log(\text{skill\_share})_{nt}$  is the change in the log of the share of high-skilled workers in location  $n$ ;  $\mathbb{1}_{nt}$  is a binary variable that takes the value one if location  $n$  was connected to the highway network;  $\nu$  is a constant and  $\epsilon_{nt}$  is an error term. Because this is a long-difference specification, location-specific fixed effects difference out and the change in the period fixed effects is absorbed by the constant  $\nu$ .  $\beta$  measures the causal impact of being connected to the highway on the skill composition. For positive values of  $\beta$ , high-skilled workers concentrate in treated locations.

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<sup>59</sup>As shown in Redding (2016), reduced-form regressions of this type conceal significant heterogeneity in the impact of treatment. In particular, transport improvements can indirectly benefit non-treated locations by facilitating the flow of goods and migrants along least-cost routes. Nonetheless, I compute average treatment effects for a simulated economy in order to shed light on how different values of the model's parameters can lead to endogenous spatial sorting of workers.

## 1.10.8 Additional Tables

Table 1.12: Summary Statistics by Year

	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
	Year 1950				Year 1960			
<i>Demographics</i>								
Population	346,843	951,709	4,286	$1.33 \times 10^7$	436,682	$1.13 \times 10^6$	12,594	$1.53 \times 10^7$
% Female	49.98	1.737	38.15	52.94	50.41	1.503	40.14	52.59
% Non-white	10.87	12.53	0	57.30	10.52	11.05	0.0994	46.80
% Urban	62.67	17.10	0	97.48	67.93	15.93	16.80	98.80
<i>Education</i>								
% High school degree	34.16	8.421	11.74	55.99	42.55	7.885	22.33	62.40
% College degree	6.369	2.452	2.356	19.10	8.073	2.916	3.616	21.77
% Enrolled in college	2.231	2.540	0.0865	16.38	2.649	3.382	0.121	20.69
<i>Highways</i>								
Rays	0.0554	0.324	0	3	1.029	1.472	0	8
Miles	0.632	3.493	0	28	14.18	27.79	0	281
Density	0.0277	0.174	0	1.814	0.731	1.261	0	6.204
<i>Economics</i>								
Employment rate	95.22	2.111	84.16	99.38	94.74	1.582	88.90	98.40
Median income	2,940	619.3	1,399	4,318	5,394	962.4	2,675	7,417
<i>Housing and amenities</i>								
Housing	105,634	293,254	2,178	$4.12 \times 10^6$	141,040	376,080	5,950	$5.17 \times 10^6$
Median rent	NA	NA	NA	NA	66.54	11.28	39	96
Amenity index	NA	NA	NA	NA	0.0163	1.172	-3.370	7.172
	Year 1970				Year 1980			
<i>Demographics</i>								
Population	511,017	$1.27 \times 10^6$	27,559	$1.71 \times 10^7$	566,018	$1.27 \times 10^6$	58,460	$1.64 \times 10^7$
% Female	51.06	1.581	38.30	53.26	51.21	1.260	40.52	53.56
% Non-white	10.37	9.782	0.144	42.37	13.86	10.14	0.692	45.33
% Urban	71.87	15.13	29.48	98.99	74.36	13.61	34.68	99.69
<i>Education</i>								
% High school degree	54.10	8.719	30.30	76.50	67.78	8.131	41.07	86.12
% College degree	11.21	4.177	5.073	30.80	16.42	5.342	7.744	38.56
% Enrolled in college	4.884	4.631	0.306	29.10	7.092	5.138	1.493	33.60
<i>Highways</i>								
Rays	2.446	2.150	0	13	2.765	2.209	0	15
Miles	51.96	64.36	0	457	67.81	79.93	0	574
Density	2.700	2.393	0	12.74	3.480	2.690	0	14.03
<i>Economics</i>								
Employment rate	95.41	1.528	87.90	98.00	93.32	2.165	85.13	97.88
Median income	9,101	1,482	1,420	12,858	16,511	2,342	11,154	23,518
<i>Housing and amenities</i>								
Housing	168,857	428,039	13,046	$5.76 \times 10^6$	218,139	484,198	24,139	$6.27 \times 10^6$
Median rent	100.7	18.75	57	158.0	231.9	30.83	165.2	358
Amenity index	0.0159	1.071	-2.707	4.864	-0.00811	1.181	-3.347	5.487

This table continues on the next page.

Table 1.12: Summary Statistics by Year (continued)

	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
	Year 1990				Year 2000			
<i>Demographics</i>								
Population	632,363	$1.35 \times 10^6$	56,735	$1.68 \times 10^7$	719,484	$1.49 \times 10^6$	57,813	$1.83 \times 10^7$
% Female	51.22	1.218	40.19	53.30	50.99	0.983	44.81	53.01
% Non-white	15.88	10.69	1.199	46.66	20.19	11.80	2.389	53.09
% Urban	75.91	13.06	39.57	99.82	79.24	12.22	44.14	99.86
<i>Education</i>								
% High school degree	76.33	6.753	46.60	90.60	81.68	6.208	50.45	93.66
% College degree	19.73	6.182	9.459	44.00	23.40	7.143	11.05	47.60
% Enrolled in college	8.880	4.902	3.022	35.26	7.497	4.486	2.364	32.10
<i>Highways</i>								
Rays	2.922	2.291	0	15	2.990	2.323	0	15
Miles	74.10	85.82	0	618	76.16	87.04	0	618
Density	3.832	2.763	0	14.36	3.968	2.812	0	14.36
<i>Economics</i>								
Employment rate	93.66	1.786	85.70	97.10	95.86	2.343	74.43	98.76
Median income	28,407	5,019	16,703	48,115	37,319	5,956	20,034	59,639
<i>Housing and amenities</i>								
Housing	255,397	528,608	25,694	$6.61 \times 10^6$	289,124	572,752	26,047	$7.06 \times 10^6$
Median rent	409.3	89.92	277.4	790	550.6	109.0	362.5	1,185
Amenity index	-0.00882	1.194	-3.784	6.832	-0.0153	1.162	-3.965	6.219

Notes: Demographic, educational, economic and housing statistics are calculated using data from the 1950 to 2000 City and County Data Books. The data on interstate highways come from Baum-Snow (2007). The amenity index is discussed in greater detail in Appendix 1.10.4. Metropolitan areas are constructed by aggregating counties using the U.S. Census Bureau's 1999 definition of metropolitan statistical areas. The final sample consists of 307 MSAs.

Table 1.13: Annual Average Mileage in Major and Minor MSAs

Year	Minor MSAs			Major MSAs		
	Highway rays	Highway miles	% complete	Highway rays	Highway miles	% complete
1950	0.04	0.41	0.72%	0.21	2.48	1.23%
1960	0.77	8.55	16.07%	3.15	60.94	26.00%
1970	2.01	37.77	67.19%	6.09	169.76	71.08%
1980	2.30	50.19	87.27%	6.61	214.09	89.55%
1990	2.42	54.84	96.58%	7.06	234.03	97.66%
2000	2.48	56.50	100.00%	7.24	239.39	100.00%

Notes: The interstate highway data come from Baum-Snow (2007). This table shows the average number of interstate highway rays and miles open to traffic at the end of every decade in major and minor metropolitan areas. MSAs are classified as major if their population exceeded 500,000 residents in 1940. The sample consists of 33 major MSAs and 274 minor MSAs.

Table 1.14: Regressions of the Impact of Highways on the Number of Workers

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: OLS Results</i>						
	log(College Graduates)			log(College Non-Graduates)		
Number of highways	0.020*** (0.007)	0.017** (0.006)	0.026*** (0.004)	0.009* (0.005)	0.003 (0.005)	0.018*** (0.005)
Within R-squared	0.259	0.173	0.957	0.264	0.238	0.823
Amenity	No	Yes	No	No	Yes	No
Rural controls	No	No	Yes	No	No	Yes
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	Yes	No	Yes	Yes	No
<i>Panel B: IV Results</i>						
	Dependent Variable: log(College Graduates)					
Number of highways	0.026** (0.012)	0.039*** (0.009)	0.028 (0.017)	0.041** (0.018)	0.017 (0.028)	0.039*** (0.008)
Within R-squared	0.261	0.957	0.247	0.164	0.957	0.957
Over-id $p$ -value	—	—	—	—	—	0.477
	Dependent Variable: log(College Non-Graduates)					
Number of highways	0.011 (0.008)	0.027*** (0.006)	0.010 (0.011)	0.010 (0.011)	0.009 (0.018)	0.027*** (0.006)
Within R-squared	0.268	0.823	0.262	0.242	0.823	0.823
Over-id $p$ -value	—	—	—	—	—	0.350
Amenity	No	No	No	Yes	No	No
Rural controls	No	Yes	No	No	Yes	Yes
First-stage statistic	290.552	438.612	167.642	130.650	57.841	217.798
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	No	Yes	Yes	No	No

Notes: The data used in these regressions come from the County and City Data Books. The number of college graduates is computed as the number of residents, 25 years or older, who have graduated from a four-year college program. The number of non-graduates is computed as the number of residents, 25 years or older, who have not graduated from a four-year college program. The highway measure is the number of highway rays open to traffic. Panel A presents results from ordinary least squares regressions. Panel B presents results from two-stage least squares regressions. In columns (1) through (4), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates: (rays in 1947 plan)  $\times$  (rays completed nationally in year  $t$ ) / (total number of rays in 2000). In column (5), the instrument is the aggregate number of highways open to traffic in the two nearest major MSAs oriented east-west and north-south. Column (6) uses both instruments. All specifications include educational, demographic and economic covariates. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.15: First Stage Results of IV Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
	Dependent Variable: Number of Highways					
Smoothed planned highways	1.142*** (0.067)	1.325*** (0.063)	1.008*** (0.078)	1.048*** (0.092)		1.289*** (0.065)
Rays in major MSAs					0.150*** (0.020)	0.032** (0.013)
% enrolled in college	-0.001 (0.024)	0.016 (0.016)	-0.013 (0.034)	0.037 (0.025)	0.069** (0.030)	0.012 (0.016)
log( population)	0.374 (0.243)	0.087 (0.164)	0.263 (0.254)	0.212 (0.328)	0.937*** (0.180)	0.099 (0.156)
% female	-0.039 (0.041)	0.040 (0.038)	-0.048 (0.050)	-0.029 (0.041)	0.144* (0.078)	0.028 (0.037)
% non-white	0.051** (0.020)	0.005 (0.008)	0.060** (0.025)	0.026* (0.016)	0.011 (0.012)	0.009 (0.008)
% urban	-0.007 (0.009)	0.003 (0.006)	-0.001 (0.009)	-0.005 (0.007)	-0.027*** (0.008)	0.002 (0.006)
Employment rate	0.008 (0.027)	-0.010 (0.010)	0.004 (0.030)	-0.021 (0.020)	-0.009 (0.017)	-0.007 (0.011)
Rural college share		0.015 (0.012)			0.071*** (0.018)	0.008 (0.011)
Adjusted R-squared	0.884	0.871	0.873	0.912	0.728	0.872
Within R-squared	0.506	0.756	0.401	0.326	0.486	0.758
Observations	1,824	1,842	1,554	1,520	1,842	1,842
Number of MSAs	304	307	259	304	307	307
Time Period	1950-2000	1950-2000	1950-2000	1960-2000	1950-2000	1950-2000
First-stage statistic	290.552	438.612	167.642	130.650	57.841	217.798
Stock-Yogo critical value (10% maximal IV size)	16.38	16.38	16.38	16.38	16.38	16.38
MSA FE	Yes	Yes	Yes	Yes	Yes	Yes
State $\times$ Year FE	Yes	No	Yes	Yes	No	No

Notes: The data used in these regressions come from the County and City Data Books. The dependent variable is the number of highways open to traffic in a given year. The number of smoothed planned rays is equal to the number of rays in the 1947 plan that would be open to traffic if construction rates were uniformly distributed across locations and equal to the national construction rate: (rays in 1947 plan)  $\times$  (rays completed nationally in year  $t$ ) / (rays completed nationally in 2000). The number of rays in major MSAs corresponds to the aggregate number of highways open to traffic in the two nearest major MSAs oriented east-west and north-south. All specifications are estimated by ordinary least squares. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.16: IV Regressions with Alternative Instruments

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Dependent Variable: College Share									
Number of highways	0.561*** (0.132)	0.599*** (0.176)	0.568*** (0.134)	0.476*** (0.073)	0.400** (0.191)	0.485*** (0.157)	0.496*** (0.153)	0.471*** (0.075)	0.401*** (0.151)	0.465*** (0.074)
First-stage statistic	71.742	50.309	38.547	145.068	47.348	47.348	20.664	122.538	33.114	146.894
Stock-Yogo critical values (10% maximal IV size)	16.38	16.38	19.93	22.30	16.38	16.38	22.30	24.58	19.93	22.30
Over-id <i>p</i> -value	–	–	0.741	0.798	–	–	0.373	0.571	0.058	0.166
Criterion	Pop. (%)	Mfg.	Pop. (%) & Mfg.	Pop. (%) & Mfg.	Pop.	Pop.	Pop.	Pop.	Pop.	Pop.
Instrument width	75 km	75 km	75 km	75 km	60 km	90 km	All	All	75 km	75 km
Orientation	EW + NS	EW + NS	EW + NS	EW + NS	EW + NS	EW + NS	EW + NS	EW + NS	EW & NS	EW & NS
Smoothed planned highways included	No	No	No	Yes	No	No	No	Yes	No	Yes

Notes: The data used in these regressions come from the County and City Data Books. The dependent variable is the college share, computed as the percentage of a city's residents, aged 25 or older, who graduated from a four-year college program. The highway measure is the number of highway rays open to traffic in a given year. All specifications are estimated by two-stage least squares. The instrument is the stock of highways open to traffic in the two nearest major MSAs oriented east-west and north-south. In column (1), major MSAs are defined as cities whose population exceeded the regional 90th percentile. In column (2), major MSAs are defined as cities with a manufacturing population above the national 90th percentile. Column (3) uses simultaneously the instruments constructed using the previously mentioned criteria. Column (4) adds the number of planned rays as an additional instrument. In column (5), the instrument follows the baseline definition but is constructed using a smaller radius (60 km). In column (6), the instrument is constructed using a larger radius (90 km). Column (7) uses simultaneously the instruments constructed using a 60 km, 75 km and 90 km radius. Column (8) adds the number of planned rays as an additional instrument. Column (9) uses the number of rays in the nearest major MSAs oriented east-west and north-south as separate instruments. Column (10) adds the number of planned rays as an additional instrument. All specifications include educational, demographic and economic covariates as well as MSA-specific fixed effects. I also control for the rural college share, aggregated at the state level. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.17: OLS and IV Results for Different Samples

	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	IV	IV	IV
<i>Panel A: CCDB sample</i>					
Dependent Variable: College Share					
Number of highways	0.388*** (0.077)	0.425*** (0.059)	0.607*** (0.190)	0.541*** (0.070)	0.543*** (0.070)
Dependent Variable: log(College Graduate Odds)					
Number of highways	0.010** (0.004)	0.012*** (0.004)	0.015* (0.008)	0.017*** (0.005)	0.017*** (0.005)
Dependent Variable: log(Graduates)					
Number of highways	0.019*** (0.007)	0.029*** (0.005)	0.038*** (0.014)	0.047*** (0.009)	0.047*** (0.009)
Dependent Variable: log(Non-graduates)					
Number of highways	0.007 (0.004)	0.016*** (0.004)	0.018* (0.010)	0.028*** (0.006)	0.027*** (0.006)
<i>Panel B: IPUMS sample</i>					
Dependent Variable: College share					
Number of highways	0.371*** (0.101)	0.417*** (0.061)	0.571** (0.240)	0.479*** (0.081)	0.478*** (0.081)
Dependent Variable: log(College Graduate Odds)					
Number of highways	0.001 (0.009)	0.007 (0.005)	0.001 (0.021)	0.004 (0.009)	0.004 (0.009)
Dependent Variable: log(Graduates)					
Number of highways	0.015 (0.012)	0.033*** (0.008)	0.048* (0.026)	0.050*** (0.012)	0.049*** (0.012)
Dependent Variable: log(Non-graduates)					
Number of highways	0.013 (0.008)	0.024*** (0.006)	0.043*** (0.013)	0.041*** (0.007)	0.041*** (0.007)

Notes: The data used in the regressions reported in Panel A come from the County and City Data Books. Panel A shows estimates of the impact of highways on the college share when the sample is restricted to MSAs that appear in the IPUMS data sets. The data used in the regressions reported in Panel B come from the IPUMS sample of the US census. The college share is computed as the percentage of a city's residents, aged 25 or older, who graduated from a four-year college program. The number of college graduates is computed as the number of a city's residents, 25 years or older, who have graduated from a four-year college program. The college graduate odds is the ratio between the college graduate share and the non-graduate share. The number of non-graduates is computed as the number of a city's residents, 25 years or older, who have not graduated from a four-year college program. The highway measure is the number of highway rays open to traffic. Specifications in columns (1) and (2) are estimated by ordinary least squares. Specifications in columns (3) through (6) are estimated by two-stage least squares. All specifications include educational, demographic and economic covariates as well as MSA-specific fixed effects. Regressions in columns (1) and (3) also include state-by-year fixed effects. Regressions in columns (2), (4) and (5) control for the rural counterpart of the dependent variable, aggregated at the state level. In columns (3) and (4), the instrument is the number of highways in the 1947 plan, smoothed using national construction rates: (rays in 1947 plan)  $\times$  (rays completed nationally in year  $t$ ) / (total number of rays in 2000). Column (5) adds the number of interstate highways in the two nearest major MSAs oriented east-west and north-south as an additional instrument. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.18: Additional Robustness Checks

	Highway Density			Dropping Outliers			Long-Difference			
	(1) OLS	(2) OLS	(3) IV	(4) IV	(5) OLS	(6) OLS	(7) IV	(8) IV	(9) OLS	(10) IV
Highways	0.282*** (0.066)	0.295*** (0.059)	0.603* (0.343)	0.515*** (0.139)	0.394*** (0.058)	0.359*** (0.052)	0.603*** (0.094)	0.494*** (0.070)	0.801*** (0.149)	0.828*** (0.240)
Within R-squared	0.368	0.919	0.334	0.917	0.351	0.932	0.324	0.931	0.517	0.517
First-stage statistic	—	—	11.302	33.772	—	—	254.696	207.480	—	225.959
Over-id <i>p</i> -value	—	—	—	0.765	—	—	—	0.859	—	—
Highways	0.008*** (0.002)	0.011*** (0.003)	0.022 (0.016)	0.027*** (0.009)	0.011*** (0.003)	0.013*** (0.003)	0.015*** (0.005)	0.017*** (0.005)	0.029*** (0.006)	0.024*** (0.010)
Within R-squared	0.141	0.967	0.114	0.965	0.093	0.977	0.083	0.969	0.248	0.247
First-stage statistic	—	—	11.302	26.789	—	—	254.696	182.385	—	225.959
Over-id <i>p</i> -value	—	—	—	0.731	—	—	—	0.313	—	—
Highways	0.013** (0.006)	0.015*** (0.005)	0.058*** (0.013)	0.048*** (0.009)	0.019** (0.008)	0.026*** (0.005)	0.027** (0.012)	0.039*** (0.008)	0.049*** (0.012)	0.046*** (0.013)
Within R-squared	0.259	0.957	0.168	0.954	0.269	0.959	0.262	0.959	0.438	0.438
First-stage statistic	—	—	12.712	33.517	—	—	268.361	206.459	—	238.170
Over-id <i>p</i> -value	—	—	—	0.060	—	—	—	0.439	—	—
Highways	0.004 (0.005)	0.010* (0.005)	0.033 (0.020)	0.025** (0.010)	0.007 (0.006)	0.017*** (0.005)	0.011 (0.009)	0.025*** (0.006)	0.020* (0.010)	0.021*** (0.009)
Within R-squared	0.266	0.822	0.209	0.817	0.271	0.824	0.270	0.824	0.393	0.393
First-stage statistic	—	—	12.712	61.267	—	—	268.361	281.734	—	238.170
Over-id <i>p</i> -value	—	—	—	0.084	—	—	—	0.337	—	—

Notes: The data used in these regressions come from the County and City Data Books. The college share is computed as the percentage of a city's residents, aged 25 or older, who graduated from a four-year college program. The college graduate odds is the ratio between the college graduate share and the non-graduate share. The number of college graduates is computed as the number of a city's residents, 25 years or older, who have graduated from a four-year college program. The number of non-graduates is computed as the number of a city's residents, 25 years or older, who have not graduated from a four-year college program. In columns (1) through (4), the highway measure is the highway density, defined as the number of highway miles open to traffic in an area of 100 square-miles. In columns (5) through (10), the highway measure is the number of interstate rays. In columns (3) and (7), the instrument is the stock of highways in the 1947 plan, smoothed using national construction rates. In columns (4) and (8), the stock of highways is instrumented using both the smoothed stock of planned highways and the stock of highways open to traffic in the two nearest major MSAs oriented east-west and north-south. In column (10), the instrument is the number of highways in the 1947 plan. The samples in columns (1) through (4) and (9) and (10) consist of all 307 metropolitan areas. The samples in columns (5) through (8) exclude MSAs with the 5% smallest and largest increases in their college shares. All specifications in columns (1) through (8) include educational, demographic and economic covariates as well as MSA-specific fixed effects. Specifications in columns (1), (3), (5) and (7) also include state-by-year fixed effects, while specifications in columns (2), (4), (6) and (8) control for the rural counterpart of the dependent variable. The long-difference specifications in columns (9) and (10) include educational, demographic and economic covariates as well as state fixed effects. Robust standard errors clustered at the state level are reported in parentheses. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.19: Migration and Trade Gravity Equations

	High-Skilled Migrant Flows	Low-Skilled Migrant Flows	Trade Flows
$\log(\text{Travel time}_{\text{int}})$	-1.118*** (0.021)	-1.217*** (0.024)	-0.942*** (0.049)
$\mathbb{I}_{i \neq n}$	-2.892*** (0.065)	-3.522*** (0.080)	-0.400** (-0.183)
Origin $\times$ Year FE	Yes	Yes	Yes
Destination $\times$ Year FE	Yes	Yes	Yes
Observations	76,176	76,176	2,916

Notes: The migration data come from the 5% IPUMS sample of the 2000 Census. Migrant flows from MSA  $i$  to MSA  $n$  are constructed as the number of individuals who are currently residing in city  $n$  and who were living in city  $i$  five years ago. The final sample consists of 276 metropolitan areas. The trade data come from the 2002 Commodity Flow Survey. Trade flows are constructed as the total value of exports from MSA  $i$  to MSA  $n$ . The trade sample consists of 54 CFS regions. Both migration and trade costs are parameterized as a function of travel times. All specifications are estimated by Poisson Pseudo-Maximum Likelihood. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.20: Estimating the Fréchet Shape Parameters

	College Graduates			College Non-Graduates		
	OLS	IV Productivity	IV Bartik Shock	OLS	IV Productivity	IV Bartik Shock
Real wages	4.924*** (0.234)	6.555*** (0.290)	6.362*** (0.446)	3.510*** (0.257)	5.039*** (0.329)	4.819*** (0.695)
Constant	-8.906*** (0.367)	-11.451*** (0.454)	-11.151*** (0.698)	-4.525*** (0.277)	-6.165*** (0.355)	-5.929*** (0.746)
First-stage statistic		875.601	123.294		590.256	47.643

Notes: The dependent variable is the destination-specific fixed effect previously estimated from migrant gravity equations. The real wage is constructed using the observed hourly wage for employed workers, the price index that is consistent with the quantitative model and the estimated trade costs, and residential rents that satisfy the housing market clearing condition. The final sample consists of 276 observations for each skill group. Migration and trade costs are defined as a function of travel times. \* indicates significant at the 10% level, \*\* indicates significant at the 5% level, \*\*\* indicates significant at the 1% level.

Table 1.21: Average Welfare Impact of Removing the Interstate System

	(1) Both Channels	(2) Only Trade Costs	(3) Only Migration Costs
Relative change in HS welfare	0.9728	0.9766	0.9961
Relative change in LS welfare	0.9724	0.9750	0.9973

Notes: This tables shows the change in average expected utility if the Interstate Highway System was removed. Migration and trade costs are defined as a function of travel times. Column (1) assumes that removing the IHS increases both migration and trade costs. Column (2) assumes that removing the IHS increases only trade costs, migration costs remaining fixed at their 2000 level. Column (3) assumes that removing the IHS increases only migration costs, trade costs remaining fixed at their 2000 level.

Table 1.22: Welfare Effects under Different Counterfactuals

<i>Panel A: Changing Mobility Parameters for the Low-Skilled</i>			
	$\kappa_{in}^L = \kappa_{in}^H$	$\epsilon^L = \epsilon^H$	$\kappa_{in}^L = \kappa_{in}^H$ $\epsilon^L = \epsilon^H$
High-skilled workers	0.9994	1.0001	1.0008
Low-skilled workers	1.3487	0.9197	1.1532
<i>Panel B: Symmetric Reductions in Migration Costs</i>			
	10%	20%	40%
High-skilled workers	1.0186	1.0541	1.2380
Low-skilled workers	1.0089	1.0253	1.1175
<i>Panel C: Symmetric Reductions in Trade Costs</i>			
	10%	20%	40%
High-skilled workers	1.0566	1.1313	1.3655
Low-skilled workers	1.0596	1.1374	1.3784

Notes: This table shows the change in average expected utility for several counterfactuals. Panel A considers different configurations of Fréchet shape parameters and migration costs for low-skilled workers. Panel B considers symmetric reductions in inter-metropolitan migration costs for both skill groups, while holding trade costs fixed. Panel C considers symmetric reductions in inter-metropolitan trade costs, while holding migration costs fixed. Both migration and trade costs are estimated as a function of travel times.

Table 1.23: Robustness Checks Counterfactuals

(1)		(2)	(3)	(4)
ATE		IHS removed	↓ Migration Costs	↓ Trade Costs
<u>Experiment 1: Heterogeneous Migration Elasticities (<math>\epsilon^H = 2.116</math> and <math>\epsilon^L = 4.026</math>)</u>				
Local expenditure share set to 0.62 for both skill groups (Diamond, 2016)				
0.309***	HS welfare	0.8492	1.0341	1.1243
(0.042)	LS welfare	0.8821	1.0224	1.1349
<u>Experiment 2: Heterogeneous Migration Elasticities (<math>\epsilon^H = 4.976</math> and <math>\epsilon^L = 3.261</math>)</u>				
Local expenditure shares vary across skill groups (Diamond, 2016)				
0.312***	HS welfare	0.8717	1.0471	1.1298
(0.052)	LS welfare	0.8808	1.0203	1.1336
<u>Experiment 3: Homogeneous Migration Elasticities (<math>\epsilon^H = \epsilon^L = 3.60</math>)</u>				
0.316***	HS welfare	0.8645	1.0411	1.1290
(0.047)	LS welfare	0.8811	1.0213	1.1347
<u>Experiment 4: Lower Elasticity of Substitution Between HS and LS Workers (<math>\mu = 1.25</math>)</u>				
0.342***	HS welfare	0.8737	1.0507	1.1303
(0.049)	LS welfare	0.8824	1.0239	1.1359
<u>Experiment 5: Higher Elasticity of Substitution Between HS and LS Workers (<math>\mu = 3</math>)</u>				
0.304***	HS welfare	0.8735	1.0511	1.1312
(0.052)	LS welfare	0.8825	1.0238	1.1355
<u>Experiment 6: Higher Housing Expenditure Share (<math>1 - \alpha = 0.4</math>)</u>				
0.315***	HS welfare	0.8938	1.0511	1.1035
(0.051)	LS welfare	0.9033	1.0238	1.1071
<u>Experiment 7: Heterogeneous Housing Expenditure Shares (<math>1 - \alpha^H = 0.2</math> and <math>1 - \alpha^L = 0.3</math>)</u>				
0.360***	HS welfare	0.8670	1.0508	1.1400
(0.047)	LS welfare	0.8893	1.0239	1.1261
<u>Experiment 8: Asymmetric Migration Costs (<math>\kappa_{int}^s \neq \kappa_{nit}^s</math>)</u>				
0.305***	HS welfare	0.8738	1.0511	1.1311
(0.050)	LS welfare	0.8833	1.0241	1.1368

Notes: This table summarizes results from several robustness checks. Column (1) reports the reduced-form effects of highways on the college share that is consistent with the quantitative model and the estimated trade and migration costs. Column (2) reports the change in the average expected welfare for high-skilled and low-skilled workers if the Interstate Highway System was removed. Column (3) shows the increase in average expected welfare for high-skilled and low-skilled workers in the case of a symmetric reduction in inter-metropolitan migration costs of 20%. Column (4) shows the increase in average expected welfare for high-skilled and low-skilled workers in the case of a symmetric reduction in inter-metropolitan trade costs of 20%. In all counterfactuals, migration and trade costs are parameterized as a function of geographic distance, with the elasticity being governed by the stock of highways in the cities of origin and destination.

## 1.10.9 Additional Figures

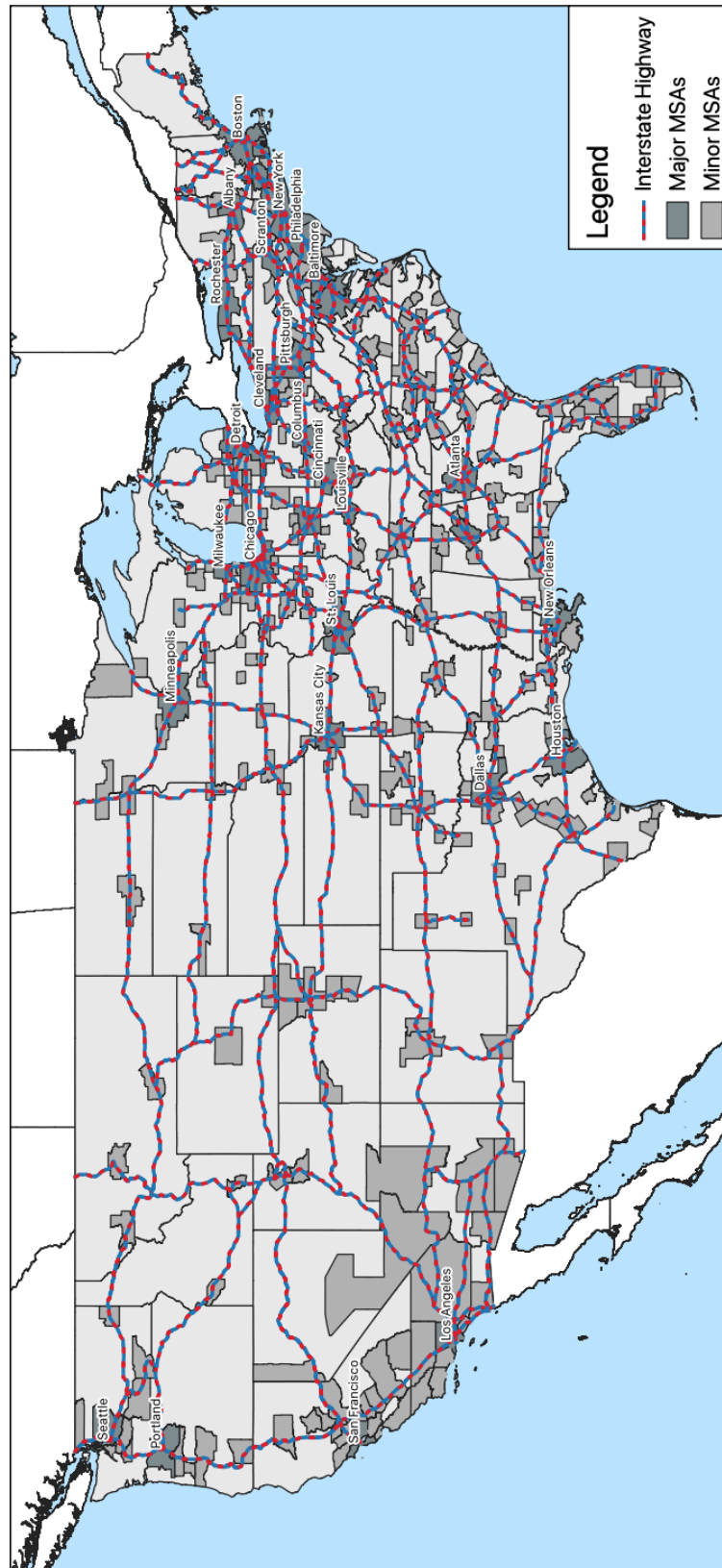
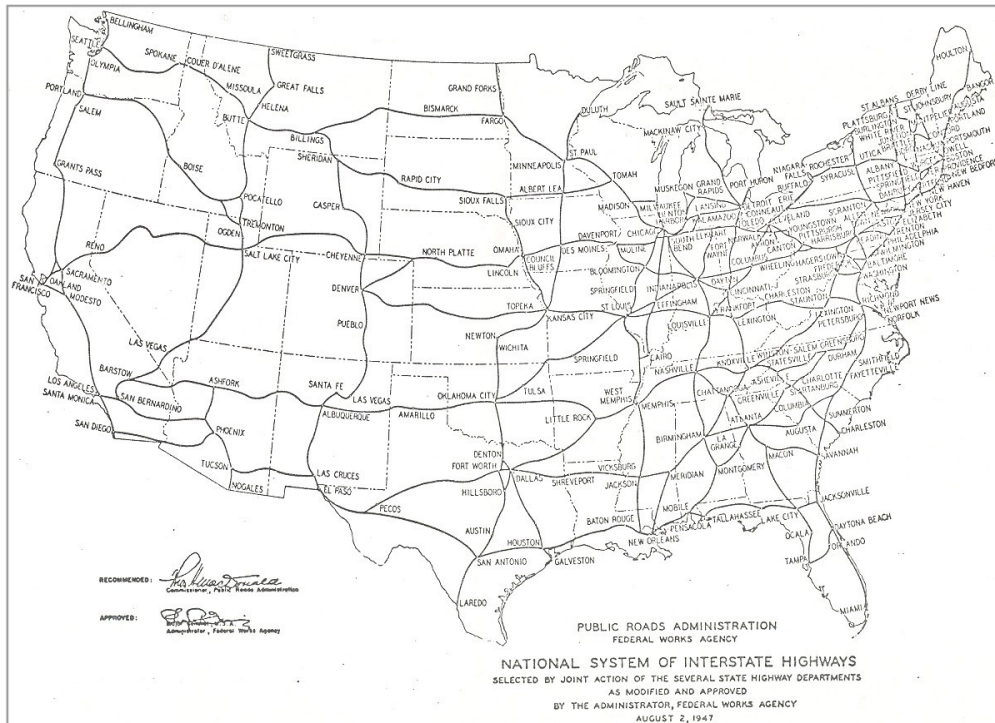


Figure 1.9: Primary Interstate Highways and Metropolitan Areas, 2000

(A) Planned Map in 1947



(B) Approved Map in 1958

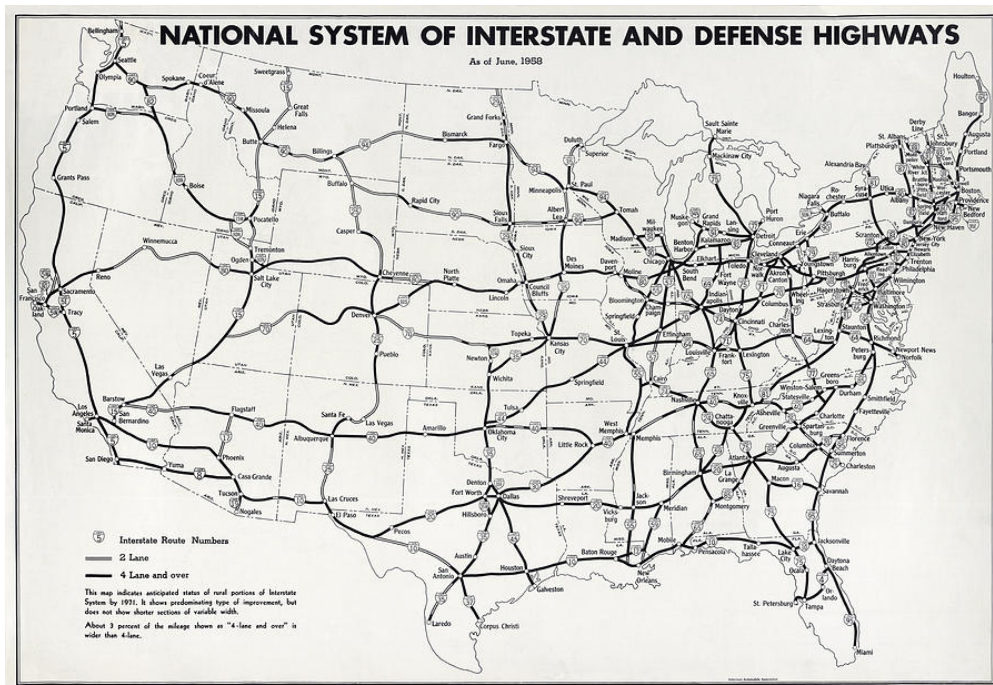


Figure 1.10: The Interstate Highway System

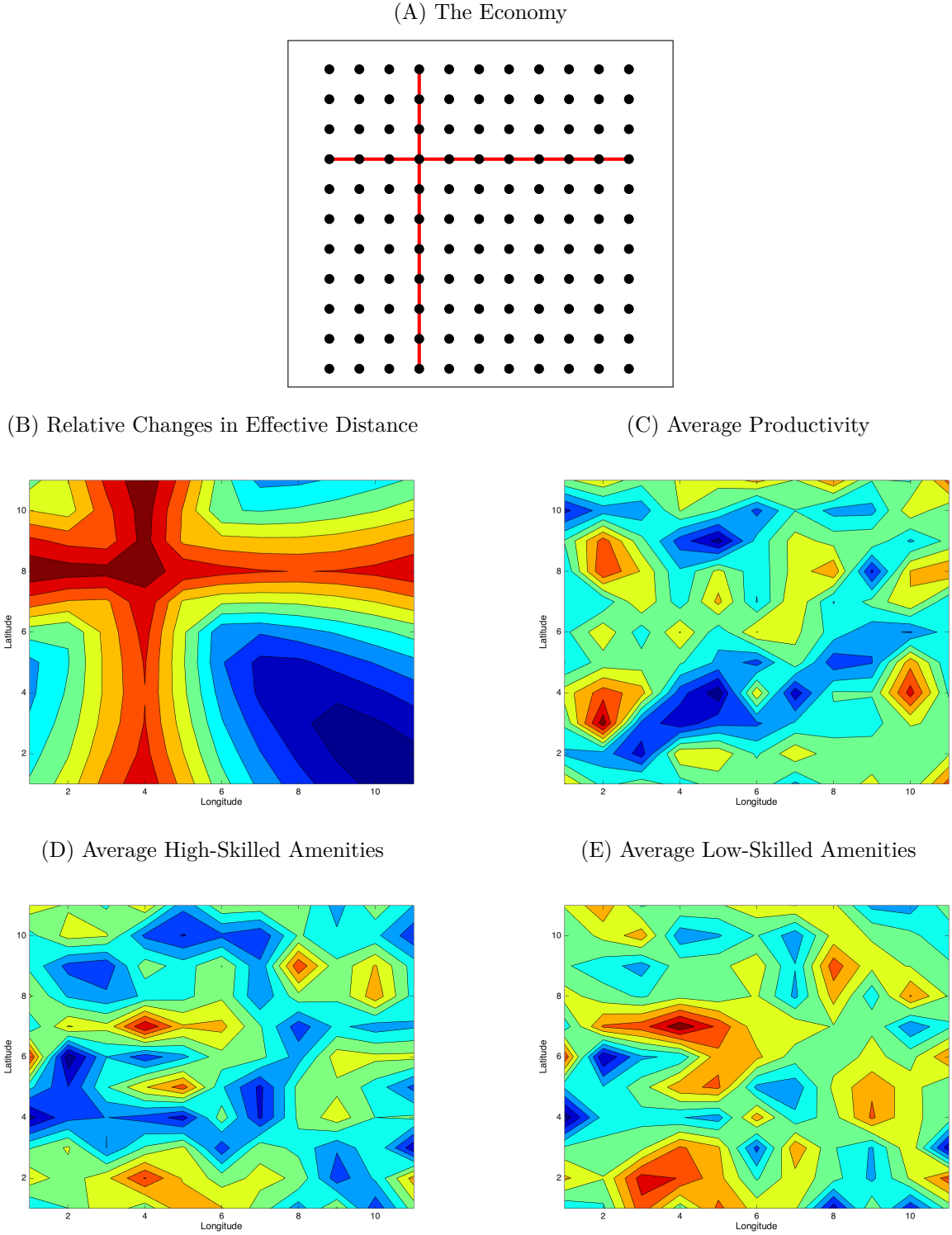


Figure 1.11: Modeling the Economy

Notes: The hypothetical economy for which the results in Section 1.6 are derived consists of 121 locations, modeled on a  $11 \times 11$  grid, as shown in Figure A. Each dot represents a location and the red lines mark the path of the new highway. Figures B through E show the average reduction in effective distance (warmer colors denote larger reductions), average productivity and average amenities for high-skilled and low-skilled workers. Warm (red) colors indicate higher values, while cold (blue) colors indicate smaller values.

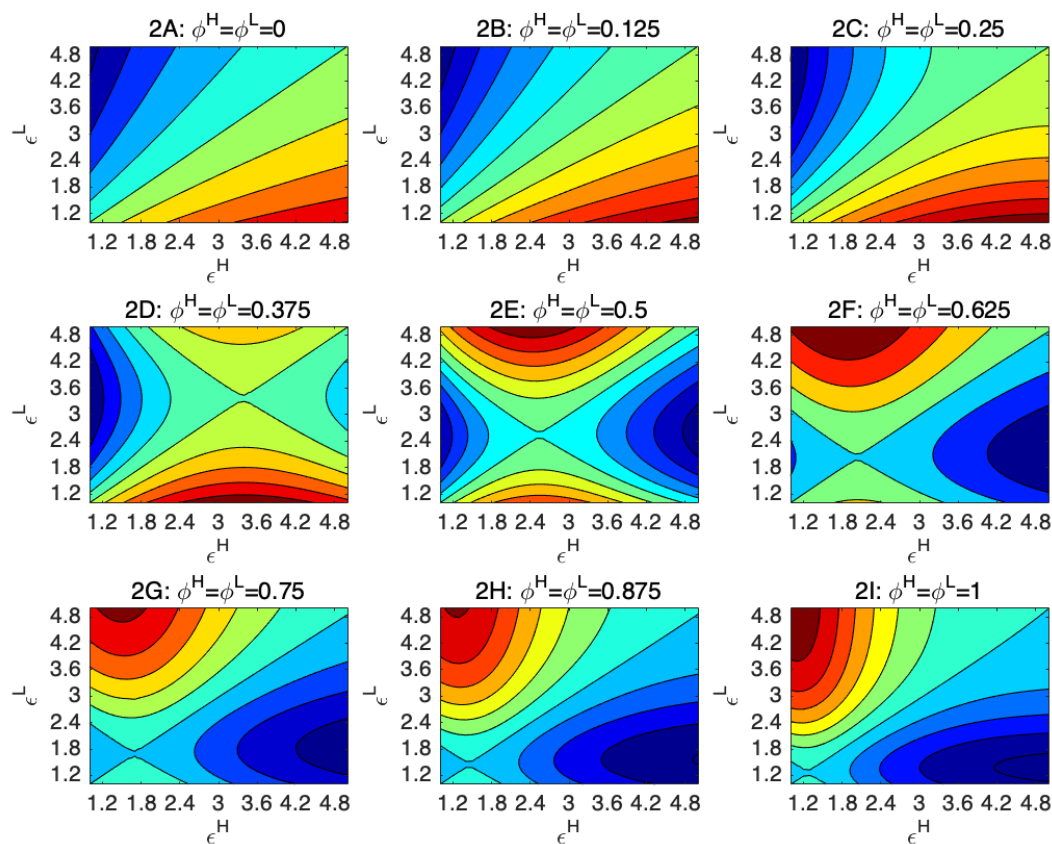


Figure 1.12: Treatment Effects for Heterogeneous Migration Elasticities

Notes: This figure shows the average treatment effect of highway connections on the college share for different combinations of migration elasticities  $\{\epsilon^H, \epsilon^L\}$ . Migration costs are symmetric across skill groups ( $\phi^H = \phi^L$ ). Cold (blue) colors indicate negative effects, while warm (red) colors indicate positive effects.

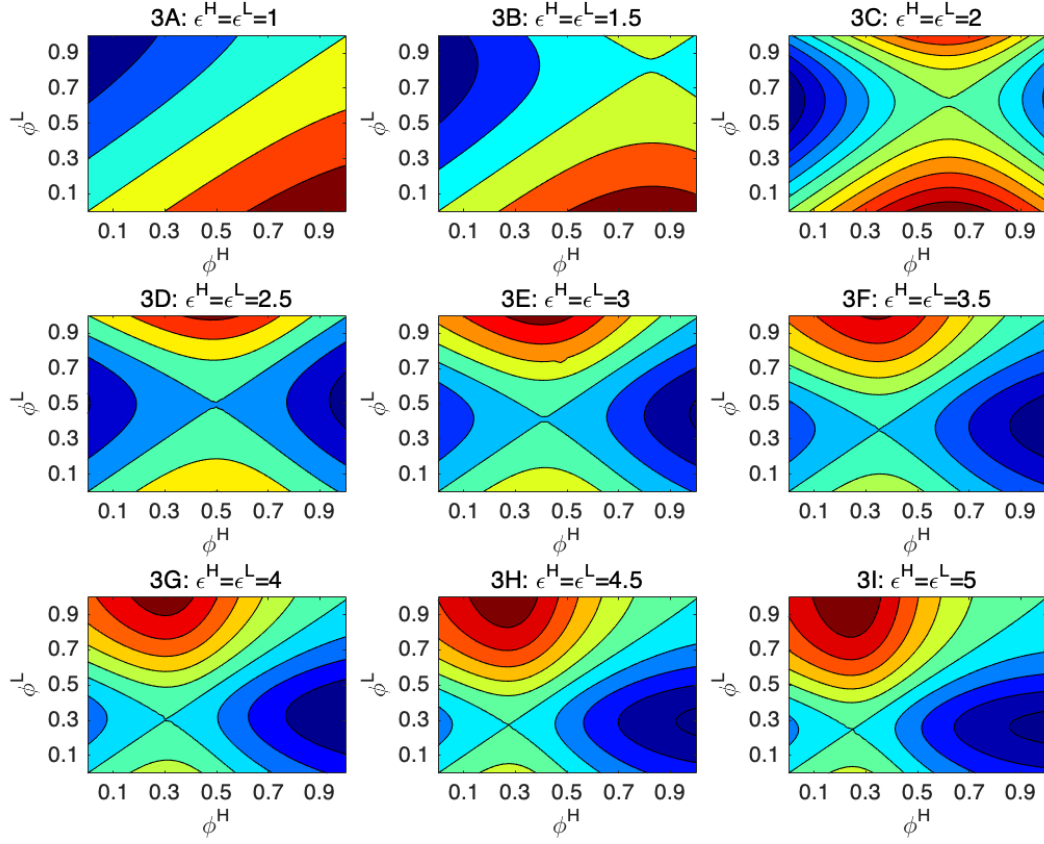


Figure 1.13: Treatment Effects for Heterogeneous Mobility Costs

Notes: This figure shows the average treatment effect of highway connections for different combinations of migration costs  $\{\phi^H, \phi^L\}$ . The migration elasticity with respect to real wages is assumed to be the same across skill groups ( $\epsilon^H = \epsilon^L$ ). Cold (blue) colors indicate negative effects, while warm (red) colors indicate positive effects.

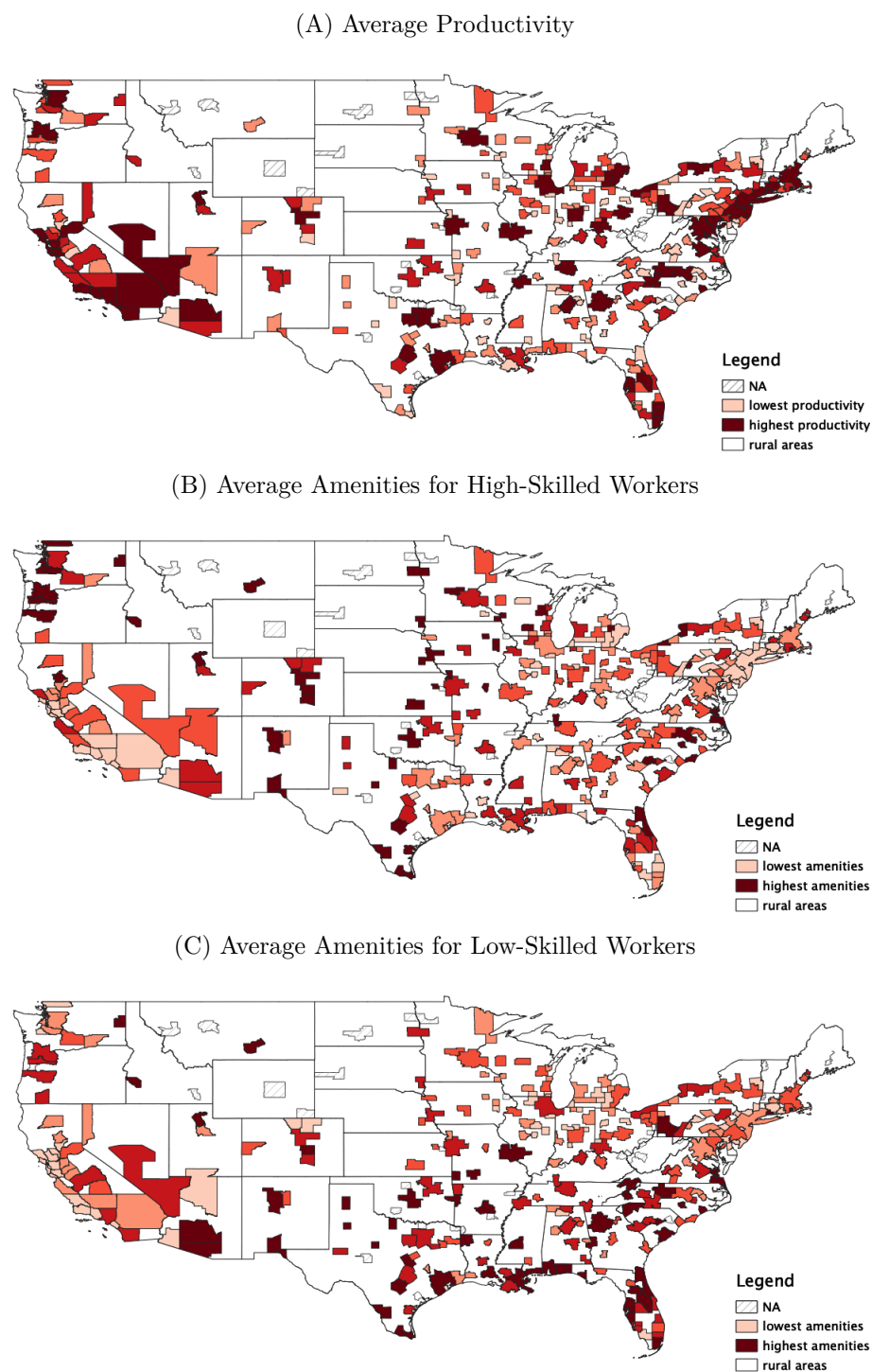


Figure 1.14: Distribution of Productivity and Amenities

Notes: Figures A through C show the average productivity and high(low)-skilled amenity levels for the 276 metropolitan areas in the 2000 IPUMS sample. Darker shades of red correspond to higher values. The amenity and productivity values were obtained after inverting the quantitative model using the travel time-specification of migration and trade costs.

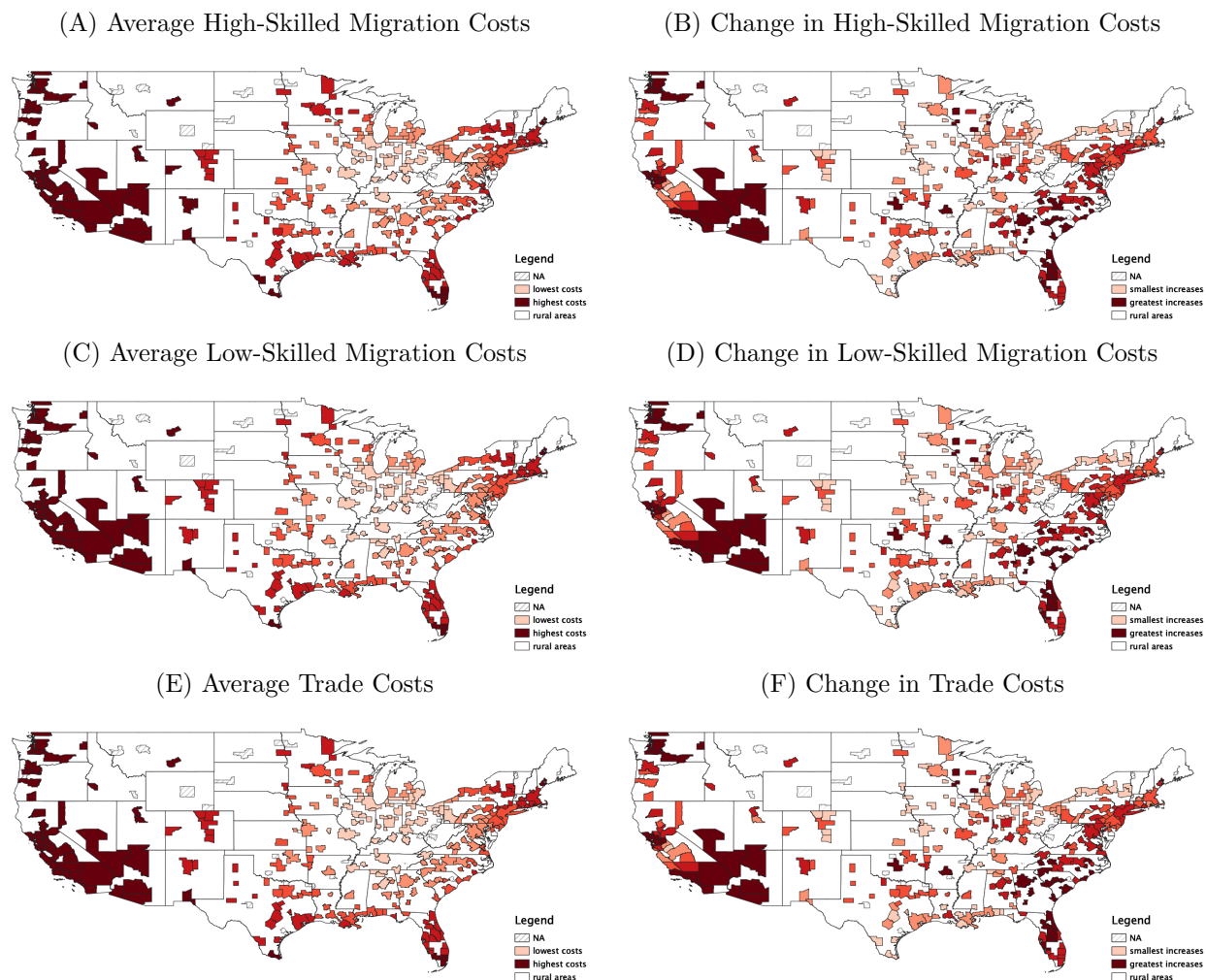


Figure 1.15: Migration and Trade Costs Based on Travel Times

Notes: Figures A, C and E show the average migration and trade costs to other destinations for each MSA in the 2000 IPUMS sample. Figures B, D and F show the increase in migration and trade costs in the case of a hypothetical removal of the Interstate Highway System. Darker shades of red correspond to higher values. Migration and trade costs are estimated as a function of travel times.

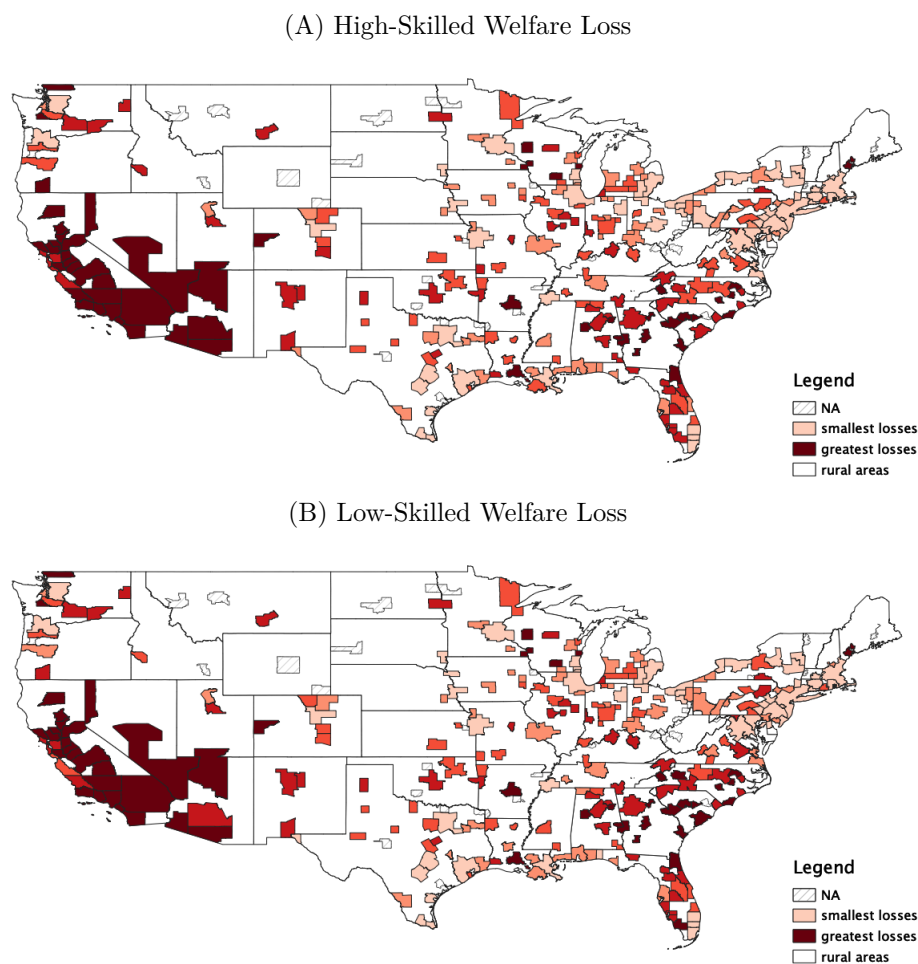


Figure 1.16: Distribution of Welfare Losses if IHS Is Removed

Notes: This figure shows the spatial distribution of welfare losses following a hypothetical removal of the Interstate Highway System. Darker shades of red correspond to greater losses. Migration and trade costs are estimated as a function of travel times.

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## Chapter 2

# Medieval Markets and Regional Development in the Long-Run

### Abstract

This chapter studies persistence in regional patterns of development in England and Wales from the middle ages to today. To this aim, I use the Gazetteer of Markets and Fairs to create a database of local markets established from c. 700 to c. 1600. I find that locations with a market that survived into the sixteenth century grew at faster rates in the late medieval period. Locations with an unsuccessful market, on the other hand, appear to have stagnated. Using nighttime light intensity as a measure for contemporary economic development, I show that places with a successful medieval market emit more light relative to other locations, the effect being similar across urban and rural areas. Overall, I find a high degree of persistence in the regional distribution of economic activity over several centuries.

**JEL codes:** F19, N93, R12

**Keywords:** medieval markets, trade, regional development, path dependence, England



## 2.1 Introduction

Economic activity is not uniformly spread across space: incomes and population densities exhibit significant variation both across and within countries. Furthermore, their spatial distribution is highly persistent over time.<sup>1</sup> In a seminal paper, Davis and Weinstein (2002) document that city sizes are extremely robust, even in the face of large exogenous shocks like the Allied bombing of Japan during World War II. In this paper, I study persistence in the very long-run by documenting a significant correlation between the establishment of medieval markets in England and Wales and contemporary development.

To this aim, I construct a database of medieval markets using the *Gazetteer of Markets and Fairs in England and Wales* (Letters, Fernandes, Keene, and Myhill, 2004).<sup>2</sup> The *Gazetteer* provides information on markets' year of establishment and whether they survived into the sixteenth century, as well as the urban status and tax valuation of localities where they were held. The final sample consists of 2,168 local markets. I combine this data with contemporary statistics on regional development. Because of the endogeneity of administrative boundaries, I divide England and Wales into a grid of 5 km-by-5 km cells and use the average nighttime light they emit as a proxy for income. As shown by Henderson, Storeygard, and Weil (2012) and Henderson, Squires, Storeygard, and Weil (2018), nighttime light intensity is a good measure for local development as it correlates with both population density and output per capita.<sup>3</sup> The quantitative analysis then proceeds in three steps.

In the first step of my analysis, I study the relationship between markets and development in the middle ages. The dominant view among medieval historians is that the twelfth and thirteenth centuries were a period of economic and commercial growth, with local and long-distance trade expanding to unprecedented levels (Britnell, 1996; Langdon and Masschaele, 2006). As evidence to this evolution, the number of weekly markets in England and Wales increased more than ten-fold from c. 1100 to c. 1300. A testable prediction is whether the distribution of the newly chartered markets correlates with regional development. Using county assessments in the 1334 lay subsidy as a measure for agrarian wealth, I find a positive and significant relationship between tax valuations and market density. Moreover, localities that were granted a market charter at an earlier date are, on average, wealthier by 1334. The relationship appears to be driven entirely by places with a successful market (i.e. one that survived into the sixteenth century). Specifically, the valuation of a locality in 1334 increased by 0.3 – 0.4% with each additional year they held a successful market;

<sup>1</sup>Bockstette, Chanda, and Putterman (2002) and Comin, Easterly, and Gong (2010) document persistence in economic development over several centuries. Acemoglu, Johnson, and Robinson (2002), on the other hand, show that former colonies experienced a “reversal of fortunes”: wealthy colonies in 1500 are nowadays underperforming relative to initially poorer colonies.

<sup>2</sup>Despite the remarkable information it provides on medieval development, the *Gazetteer* has not been fully exploited in the economics literature. To the best of my knowledge, Cantoni and Yuchtman (2014) and Angelucci, Meraglia, and Voigtländer (2017) are the only studies that use it in order to measure medieval commercialization and identify boroughs, respectively.

<sup>3</sup>As discussed further below, the correlation between nighttime light intensity and per capita value added decreases at finer levels of spatial disaggregation. The correlation with population density is strong and similar at all levels.

the coefficient for failed markets is smaller and statistically insignificant. While other confounding factors could explain this differential in growth rates, I do not find evidence for heterogeneous effects across urban and rural locations nor any systematic differences in first-nature characteristics for places with a surviving and failed market.

In light of the sharp differences in growth documented above, the second step of my analysis studies the determinants of market survival into the sixteenth century. If the twelfth and thirteenth centuries were propitious to the proliferation of markets, the next two hundred years marked an economic downturn, with severe population contraction due to famine and disease (Bailey, 1998; Campbell, 2010). Using population density to proxy for regional development,<sup>4</sup> I show that counties with the highest population gains from 1086 to 1290 also exhibited the largest increases in market density. The same counties experienced the sharpest population declines from 1290 to 1377 and had a larger density of failed markets by 1600. At the local level, I do not find evidence that first-nature characteristics are correlated with the probability of market survival, which is consistent with the lack of systematic difference in geography for successful and unsuccessful markets. Proximity to large urban centers, on the other hand, has a negative effect on survival. This is in line with findings in Bosker and Buringh (2017) that established towns decrease the urban chances of locations in their immediate vicinity. Institutional characteristics, however, have the highest explanatory power: survival was more likely in wealthier urban locations whose markets were established earlier.

The third step sheds light on how current development correlates with medieval markets. At the regional level, I find that population density and value added per capita is positively correlated with the density of successful markets: an additional market in an area of 100 square miles is associated with an increase in population density of 67% at the district level and an increase in per capita income of 22% at the NUTS-3 level. No relationship transpires for failed markets. Because the boundaries of administrative units are likely endogenous, I replicate the analysis at the grid cell level and use nighttime light intensity as the dependent variable. Cells with a failed rural market do not radiate more light at night than cells without a market; urban failed market, on the other hand, emit 30% more light than cells without a market. Surprisingly, light intensity is roughly 33% higher in urban and rural cells with a surviving market relative to their counterparts with a failed market. The results are robust across a variety of samples and estimation methods. In sum, my results suggest a positive and highly robust relationship between medieval market and current development.

While the evidence provided in this article relies mostly on correlations that preclude causal interpretations, there are several mechanisms through which medieval markets could have spurred growth in the long-run. First, they provided regular venues for local producers and consumers to meet, reducing transaction costs and increasing price transparency. England, whose network of markets developed early, exhibited less variation in wheat prices and thus higher market integration on the eve of industrialization relative to its continental neighbors (Shiue and Keller, 2007). Sec-

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<sup>4</sup>In a pre-industrial economy, Malthusian dynamics imply that any technological progress is offset by a proportional increase in population, such that per capita incomes are constant. Population density is thus an appropriate measure for development in this context.

ond, markets may have also increased competition and in this way encouraged innovation and the adoption of cost-saving technologies (Desmet and Parente, 2012, 2014; Desmet, Greif, and Parente, 2019). Thirdly, markets quickly became public forums, allowing information about to circulate faster. As they gained in importance and audience, the spread of markets prompted institutional reform and cultural change. Anti-competitive behavior was punished and concepts such as just price, fair profits or social responsibility became increasingly popular (Casson and Lee, 2011).<sup>5</sup> Finally, medieval markets may have functioned as a coordination device, attracting investments in the following centuries. All of these mechanisms appear reasonable and may have operated at different times; yet, in the absence of a clean identification strategy, one cannot rule out the existence of confounding factors that could be responsible for both market success in the medieval period and current development. My results suggest nonetheless an important legacy of history on current development.

The results in this article speak to several strands in the empirical literature studying the persistence of economic activity. First, a burgeoning body of work has sought to identify the fundamental (or “deep”) factors driving contemporary differences in income per capita across countries and regions.<sup>6</sup> These studies identify sources of long-term persistence in geography (Diamond, 1997; Olsson and Hibbs Jr, 2005; Ashraf and Galor, 2011), institutions (Bockstette et al., 2002; Acemoglu, Johnson, and Robinson, 2001), technology (Comin et al., 2010), ancestry (Putterman and Weil, 2010) or genetic distance (Spolaore and Wacziarg, 2009). By contrast, this paper studies persistence in a relatively homogeneous country: in this context, geography, institutions, technology or genetics are poor candidates to explain regional disparities in development. Locational fundamentals and path dependence, highlighted in the trade and urban literature, are more likely to account for divergence.

Since Davis and Weinstein (2002), a growing number of papers have provided evidence in favor of theories based on locational fundamentals. Davis and Weinstein (2002) show that the distribution of city sizes in Japan was little affected by the massive bombing during War World II, most cities returning to their pre-war levels by 1960. Similar results were obtained for Germany and Vietnam (Brakman, Garretsen, and Schramm, 2004; Miguel and Roland, 2011). Schumann (2014)’s and Hanlon (2017)’s results, on the other hand, show that even temporary shocks can have long-lasting effects. This is consistent with predictions of new economic geography models in which path dependence plays an important role. Bleakley and Lin (2012) highlight strong persistence in population density at portage sites in the US, despite the obsolescence of portage. Cermeño and Enflo (2019); Jia (2014); Jedwab and Moradi (2016) provide additional examples of path dependence. Michaels and Rauch (2018) use the fall of the Roman Empire as an exogenous shock to the urban networks in England and France to study the importance of locational fundamentals relative to path dependence. My contribution to this literature is to document persistence in economic activity in the very-long run. In particular, I show that spatial patterns of commercialization in the middle ages correlate strongly with contemporary development, despite the many shocks (famines,

<sup>5</sup>It would be misleading, however, to assume that medieval markets were perfectly competitive enterprises. Restrictions on trade were imposed to protect the interests of local commercial elites.

<sup>6</sup>Spolaore and Wacziarg (2013) reviews the advances made in this direction.

the Black Death, wars) and technological innovations (the Industrial Revolution) that separate the two periods.<sup>7</sup>

My study is also related to the literature addressing the impact of history on current economic development.<sup>8</sup> Existing research has stressed the importance of the printing press (Dittmar, 2011), medieval universities (Cantoni and Yuchtman, 2014), Protestantism (Becker and Woessmann, 2009; Cantoni, Dittmar, and Yuchtman, 2018), the French Revolution (Acemoglu, Cantoni, Johnson, and Robinson, 2011) or human capital (Squicciarini and Voigtländer, 2015) as drivers of change and growth in Europe. This paper contributes to this literature by documenting a positive relationship between medieval commercialization and growth in the very long-run. Through its focus on medieval trade activities, this paper speaks to Acemoglu, Johnson, and Robinson (2005), Jha (2013), Puga and Trefler (2014) and Wahl (2016).<sup>9</sup> Acemoglu et al. (2005) analyze the impact of Atlantic trade on urbanization and document significant interactions between trade and political institutions. Jha (2013) finds that medieval trade in India is associated with less religious tensions in the nineteenth and twentieth centuries. Similarly, in their study of Venice from 800 and 1350, Puga and Trefler (2014) show that long-distance trade can have heterogeneous effects on domestic institutions depending on initial conditions. Wahl (2016) demonstrates that regions at the intersection of main medieval trade routes have higher income per capita nowadays. In contrast to these papers, the focus here is not on long-distance trade. The vast majority of markets in my sample served local communities and their impact on growth is likely to be more limited spatially.

Finally, this article contributes to the literature studying the emergence of the European urban network. Bosker, Buringh, and Van Zanden (2013), for instance, analyze the factors that allowed European cities to overtake their Islamic rivals in the middle ages. Similarly, Bosker and Buringh (2017) study what drove European cities to locate in a specific place, distinguishing between first-nature and second-nature characteristics. While my empirical methodology builds on theirs, the scope is larger here as the analysis includes localities of all sizes, including rural areas.

The remainder of this chapter proceeds as follows. Section 2.2 presents the data and reports summary statistics. In Section 2.3, I discuss the historical context within which the rich network of medieval markets emerged. Section 2.4 presents evidence on the relationship between weekly markets and growth during the twelfth and thirteenth centuries. In Section 2.5, I assess the relationship between population contraction and the demise of many medieval markets. I also estimate how first-nature, second-nature and institutional variables correlate with market survival. Section 2.6 shows how markets are related to development nowadays and discusses several mechanisms that could explain this pattern. Section 2.7 concludes. Appendix 2.8 provides additional material.

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<sup>7</sup>Appendix 2.8.2 summarizes the main findings of this literature.

<sup>8</sup>Nunn (2014) provides a recent survey of this literature.

<sup>9</sup>Older research into the effects of medieval trade on institutions includes Greif (1993, 1994). He shows how different trading practices between the Genovese and the Maghribis led to the emergence of different institutions regulating trade.

## 2.2 Data

This study uses data on market establishment in the late medieval England as well as contemporary data on a series of economic outcomes. In this section, I present the data and discuss several concerns raised by the use of medieval sources. Appendix 2.8.1 provides further information.

### 2.2.1 Market data

The data on medieval markets come from the *Gazetteer of Markets and Fairs in England and Wales* (Letters et al., 2004). The Gazetteer inventories all legally established markets from c. 700 to 1516. For each town and village with a market, the Gazetteer provides the following information: geographic coordinates, urban status (i.e. whether it was a borough and/or had a royal mint), the value as assessed in the Lay Subsidy of 1334 (1336 for Cumberland, Northumberland and Westmorland), the type of market (prescriptive or chartered), the year when it was granted and whether it survived into the sixteenth century. Additional information regarding the specific place where the market was to be held (i.e. “at the manor” or “at the borough”), the day of the week and the identity of the person receiving the grant is mentioned when available. As an example, a typical entry in the Gazetteer takes the following form:

**BISHOPS ITCHINGTON** 4388 2577. 1334 Subsidy 83.37. See also VCH Warwickshire, vi, p. 122.

**M** (Charter) Wed; gr 2 Jun 1259, by K Hen III to Roger, bp of Coventry and Lichfield, the King’s cousin. To be held at the manor (CChR, 1257–1300, p. 19). VCH provides no further evidence for the market.

This reads as follows. The grid references for Bishops Itchington in Warwickshire are 4388 (easting) and 2577 (northing). Bishops Itchington was assessed in the 1334 Lay Subsidy at 83.37 pounds. There is evidence of a market being chartered there in 1259 by Henry III to the bishop of Coventry and Lichfield. The market was to be held at the manor. Because the entry does not include the mention “Market town c.1600”, one can conclude that the market did not survive into the sixteenth century.

The use of the Gazetteer as a database for medieval markets raises several concerns. First, prescriptive markets (i.e. markets held by custom) did not require royal authorization (Britnell, 1981, p. 211). As a consequence, dating their foundation is particularly difficult: the vast majority of prescriptive markets appear in historical records only in the thirteenth century. To address this anomaly, I date them using the year the town either became a borough or functioned as a royal mint whenever this predates the first official reference of the market.<sup>10</sup> For instance, Exeter was a borough by the tenth century and had a functioning mint from 924 to 1154. Its market, however, is

<sup>10</sup>Boroughs denote places with urban characteristics and are assumed to have functioned as trade centers (Masschaele, 1997, p. 70-1). Similarly, mints were regularly established in locations that were market centers (Letters et al., 2004).

first referenced in 1213. I thus record Exeter’s market as being founded in the early tenth century instead of 1154.

Second, even though after the Norman conquest of England in 1066 the grant of markets came to be recognized as a royal monopoly, it was only during King John’s reign (1199-1216) that the right to sanction new markets became fully observed. Dating chartered markets before 1200 is therefore subject to measurement error. A related concern is whether a royal grant corresponded to the establishment of a new market or simply reflected the formal recognition of a pre-existing one. Royal charters were usually accompanied by instructions to local sheriffs to publicize the new market and assess whether it was detrimental to neighboring markets.<sup>11</sup> As argued by Letters et al. (2004), this procedure would not make sense if market charters simply recognized pre-existing ones. In this respect, the authors of the Gazetteer identify only ten cases where a grant confirmed the right to have a market that was already operating.

Third, the Gazetteer identifies markets that survived into the sixteenth century using Everitt (1967)’s list of places described as “market towns”. It is very likely that some markets ceased to function well before 1600 and some may never have been set up to begin with (Masschaele, 1994). I complement the data in the Gazetteer with information on which markets were still operating by 1350 from historical monographs. The caveat is that this information is only available for a select few counties. Throughout the paper, I will refer to markets that survived into the sixteenth century as surviving markets. Robustness checks that use survival by 1350 as a criterion will also be reported.

The final sample includes 2168 locations with a market. Table 2.6 in Appendix 2.8.3 provides summary statistics. A third among them were boroughs and can be viewed as serving a predominantly urban population. Approximately 15% are known to have existed before 1200 and more than two thirds did not survive into the sixteenth century.

### 2.2.2 Medieval Population Data

Most attempts at constructing population estimates for the late Middle Ages exploit poll tax returns and lay subsidy returns. The methodology usually requires prior assumptions on multipliers that convert the number of taxpayers into total population. Despite the critiques that such procedures have raised,<sup>12</sup> the estimates they produce are the best approximations one can make given the lack of alternative sources.

To identify urban centers, I use Campbell (2008)’s list of leading towns in terms of residents in 1290. Given a population of four million, he identifies 63 towns whose population exceeded 2000. Broadberry, Campbell, and van Leeuwen (2010) provide total population at the county level in

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<sup>11</sup>Royal charters included provisions that new markets were allowed to be established only if they were not prejudicing neighboring markets (the *nisi sit ad nocumentum* clause). Specifically, a market was considered harmful if it was located within six and two-thirds miles of another market and met on the same day. Local sheriffs were responsible for both making sure that granted market rights were respected and prohibiting markets that were deemed harmful (Masschaele, 1992, p. 85).

<sup>12</sup>As argued by Rigby (2010), different choices for the multiplier may lead to contradictory conclusions. The multipliers themselves could and perhaps should be region and even town specific.

1086, 1290, 1377 and 1600.<sup>13</sup>

### 2.2.3 Contemporary Data

In addition to data on medieval markets, this study also uses data on a series of contemporary economic outcomes. To investigate the legacy of medieval markets, I consider several measures for regional development. The first is the population density. The Office for National Statistics (ONS, 2011) provides detailed local labor market statistics at various levels of aggregation. Using data from the 2011 Census, I compute the population density for 319 districts.<sup>14</sup> In addition to population, I also collect data on other socio-economic measures, such as educational attainment and employment.

The second measure of regional development is per capita gross value added. Regional gross value added calculated using production and income approaches is reported by the Office for National Statistics (ONS, 2018) at three levels of aggregation: NUTS-1, NUTS-2 and NUTS-3.<sup>15</sup> I conduct the analysis at the smallest level of aggregation, that is NUTS-3 regions. I aggregate London regions into five larger units. The final sample thus consists of 129 regions.

One of the disadvantages of using these data aggregated at these levels is that they do not allow to gauge the effect of markets at the local level. While the Office for National Statistics does provide labor markets statistics at much finer levels of aggregation, such as super output areas or electoral wards, these come with several limitations as well. Electoral wards, for example, vary significantly both in terms of population and area, with smaller, more densely populated wards occurring in larger urban areas. Cities themselves often include several electoral wards, making the assignment of medieval markets to a given ward potentially arbitrary. Instead, I represent England and Wales as a grid of 5-by-5 kilometer cells and use nighttime light intensity as a measure for regional development.

Starting with Henderson et al. (2012), the use of nighttime light intensity as a proxy for regional development has become increasingly common. I use the 2011 data set provided by the National Oceanic and Atmospheric Administration (NOAA, 2010) to construct the average nighttime light intensity in each grid cell. Because of strong amplification required to observe low levels of light, the brightest locations are top-coded. As an alternative, the 2010 Global Radiance Calibrated Nighttime Lights data set uses a smaller number of observations obtained at low lunar illumination. This allows for a significantly smaller gain setting such that the light sensor is no longer saturated.

<sup>13</sup>Broadberry et al. (2010) use a higher national population in 1290 than Campbell (2008), but assume identical county shares of total population.

<sup>14</sup>In 2011, England was divided into 326 districts: 36 metropolitan boroughs, 55 unitary districts, 201 non-metropolitan districts, 32 London boroughs, the City of London and the Isles of Scilly. I aggregate London boroughs into five larger units and drop the Isles of Scilly. This produces a sample of 297 districts. Wales was divided into 22 districts: 3 cities, 9 counties and 10 county boroughs.

<sup>15</sup>The Nomenclature of Territorial Units for Statistics (NUTS) classification provides a hierarchical division of EU member states and the UK for statistical purposes. NUTS-1 consists of major socio-economic regions, NUTS-2 of basic regions and NUTS-3 of even smaller regions. England is divided into 9 NUTS-1 regions, 33 NUTS-2 regions and 145 NUTS-3 regions.

As a robustness check, I also report results using the calibrated data set.<sup>16</sup> Overall, England and Wales are divided into 6592 grid cells of roughly the same size (coastal cells are slightly smaller) for which I observe the nighttime light intensity in 2011.

#### 2.2.4 Other Data

As the economic distribution of economic activity is shaped by geography, I collect data on a series of first-nature variables. First, I use the Digital Atlas of Roman and Medieval Civilizations (McCormick, 2013) to compute the distance to the nearest Roman Road. The vast majority of markets in my sample are located near a Roman road: almost half of locations are within five kilometers of a Roman road, and more than three quarters are less than ten kilometers away.

Second, it is argued that navigable rivers and canals have played a significant role in shaping the movement of goods in the Middle Ages in England (Blair, 2007). Using the database constructed by Oksanen (2018), I compute the distance to the nearest navigable river. Half of markets are located less than 9 kilometers away from a river, and three quarters are located within 16 kilometers. As coastal navigation was growing in importance (Acemoglu et al., 2005; Bosker et al., 2013), I also compute the distance to the coast.

Finally, I use data from the SRTM 1-ArcSecond Global database developed by the U.S. Geological Survey (USGS, 2000) to calculate the elevation for each location and grid cell in the sample. I follow Nunn and Puga (2012) and compute an index of terrain ruggedness.

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<sup>16</sup>Henderson et al. (2018) discuss in greater detail the differences between the calibrated and non-calibrated data sets.

## 2.3 Historical Background

There is a growing consensus among medieval historians that the English economy underwent a swift process of “commercialization” in the centuries leading up to the Black Death (Britnell, 1996; Masschaele, 1997). A weak definition of commercialization implies an increase in *aggregate* commercial activity. A stronger definition requires an increase in *per capita* commercial activity. This section reviews the historical evidence for commercial expansion from 1100 to 1300 and the downturn that followed.

### 2.3.1 The commercialization of England c. 1100-1300

The twelfth and thirteenth centuries were a propitious time for the expansion of commerce. A relative peace, good weather and an increasing money supply were the exogenous factors that stimulated entrepreneurial activity. Endogenous population growth further fueled it. While the lack of detailed, local data curtails any definitive conclusion, the evidence points towards a growing share of the population participating in trade-related activities.

Broadberry et al. (2010) approximate the population of England in 1086 at 1.71 million. The figure almost tripled during the next two hundred years, to reach 4.75 million by 1290. Growth was not, however, a steady process. Langdon and Masschaele (2006, p. 55-6) argue for the existence of two phases: an early phase, ending in the middle of the twelfth century and characterized by slow growth, and a later phase extending into the fourteenth century during which growth rates were significantly higher. Northern counties show the largest gains, with Northumberland’s population rising more than tenfold. Southern counties had smaller growth rates, albeit still consequential. In Middlesex, which contains London, population doubled. Eastern counties were the most densely populated areas throughout the period.<sup>17</sup>

Population growth was also accompanied by an increase in urbanization. In 1086, 10 per cent of the population lived in locations with somewhat urban characteristics. By the fourteenth century, the share of townsmen was 15 percent, if not 20 per cent (Britnell, 1994, p. 195; Dyer, 1995, p. 173). This increase in the fraction of individuals who were less likely to live off their own agricultural production is consistent with the idea of a growing reliance on trade for satisfying subsistence needs.

An analysis of the assessments in the lay subsidies over this period reveals a growing aggregate wealth. The lay subsidies were taxes levied by the crown with the approval of Parliament. From 1207 to 1290, every taxpayer had his movable property individually assessed and paid a stated fraction of it. Any study of these payments comes with several caveats. There is convincing evidence of systematic undervaluation and the steady increase in the number of goods exempted from taxation suggests widespread fraud (Hadwin, 1983, p. 205). Notwithstanding these limitations,

<sup>17</sup>As Campbell (2008, p. 937-40) observes, the geographic patterns of population growth led to significant imbalances. Specifically, eastern counties were more populous in 1290 than they would be in 1756, limiting the availability of arable land and the capacity of rural households to produce agricultural surpluses. This created a problem of “structural poverty” that acted as a curb on further growth. In contrast, counties in the north, north-west and south-west had significantly smaller population densities in 1290 than in 1756.

the 1290 lay subsidy generated more revenue than all previous subsidies and any of the subsequent ones (Campbell, 2008, p. 896).

Money supply grew considerably from the eleventh to the thirteenth century. The discovery of silver in the Northern Pennines in the twelfth century provided a massive injection of bullion into the English economy. International trade further contributed to the expansion of money supply: the volume of currency is estimated to have increased by 147% from 1250 to 1290 (Campbell, 2008, p. 920).

For commercialization to take root, agricultural produce and manufactured goods had to be easily transported from one location to another. The historical evidence supports the existence of well-integrated transport network, capable of managing growing traffic volumes (Edwards and Hindle, 1991, p. 124). In addition to the relatively few routes identified in the Gough Map, most of the Roman roads were still in use and new routes formed through habitual use. The period from 900 to 1200 also witnessed an increase in bridge construction (Cooper, 2006, p. 15). To these, one needs to add the extensive river network that expanded over more than 2400 miles and which connected the major medieval towns (Edwards and Hindle, 1991, p. 128). The transition from oxen to horses further reduced transportation costs, increasing hauling speeds from 1.5–2 to 3–4 miles per hour (Langdon and Claridge, 2011, p. 866). Using administrative records on royal purveyancing for wheat, Masschaele (1993, p. 276) concludes that transportation in the eighteenth century was roughly 40% more expensive than in the fourteenth century. Not all modes of transportation, however, were equally efficient. Land transport was twice as expensive as river transport, which was four times more expensive than sea transport.

As a result of an increasing population, a growing money supply and an accommodating transport infrastructure, trade expanded both internationally and domestically. England saw its exports surge during this period, supplying continental markets especially with wool, woolfells and hides. In 1279–80 nearly 25,000 sacks of wool were taxed; thirty years later, 35,000 sacks would enter the custom records (Langdon and Masschaele, 2006, p. 49).<sup>18</sup> By all accounts, internal trade was equally, if not more important. According to Dyer (1989a, p. 305), internal trade may have accounted for almost a quarter of England's GNP. The proliferation of markets provided the institutional framework within which this growing commercial activity took place.

### **2.3.2 Market Establishment and Commercialization**

The multiplication of local markets from c. 1100 to 1300 attests to the economic transformation underwent by the English economy during this time (Langdon and Masschaele, 2006, p. 43–4). Panel A of Table 2.1 shows the number of markets chartered in a given period and for different regions in England and Wales.

Overall, Letters et al. (2004) identify 584 prescriptive markets for England and 74 for Wales. These markets were held by prescription and did not require royal authorization. More than half are

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<sup>18</sup>In order to grasp the magnitude of these volumes, it is worth mentioning that nine million sheep are required to produce 35,000 sacks of wool.

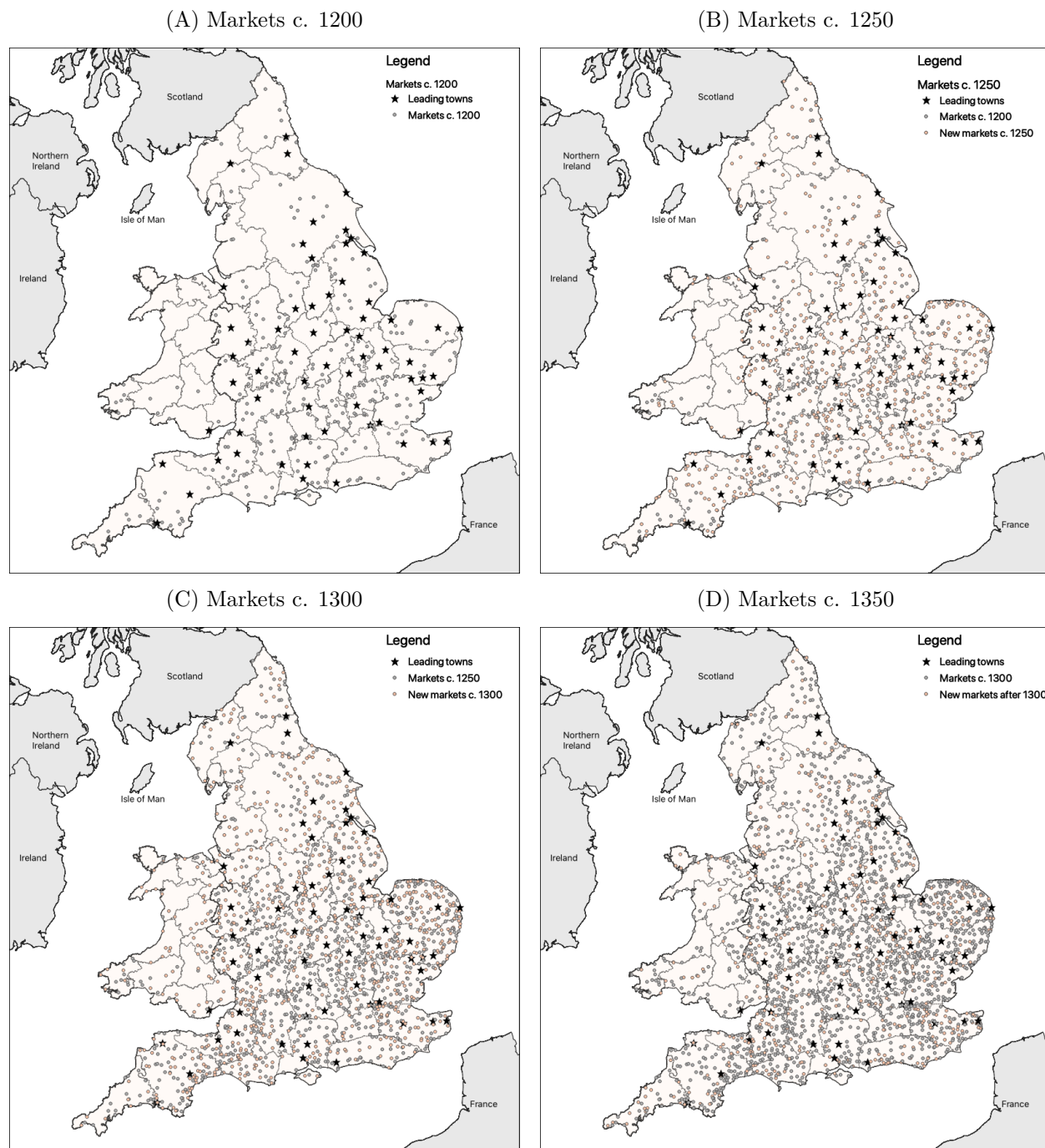


Figure 2.1: Evolution of Medieval Markets, 1200-1350

Notes: The leading towns of medieval England are identified using population estimates from Campbell (2008). Data on market location and the year they were granted come from Letters et al. (2004).

known to have been functioning by 1100. In contrast, less than 5 percent of the chartered markets in the Gazetteer met before the twelfth century. The peak for market creation occurred between 1250 and 1275, when almost four hundred new market licenses were granted. Issuing continued during the following decades, albeit at a slower rate. In terms of their spatial distribution, Figure 2.1

shows that eastern counties had the highest market density, which is consistent with the finding that these counties had the highest population density. For instance, Norfolk, the most densely populated county after the capital, had six markets in area of 100 square-kilometers, seven times more than the least dense county, Westmorland.

The importance of these local markets is a subject of debate among historians. While conceding that many transactions escaped formal trading institutions, Britnell (1981) argues that the proliferation of markets was the consequence of expanding commercial activity in the countryside. The increase in the volume of trade made necessary the development of formal trading institutions. He concludes that the most likely sellers in these markets were rural craftsmen, laborers and tradesmen whose livelihood depended upon selling their produce to small, rural households.<sup>19</sup> Similarly, Dyer (1989a) makes the case that social groups below the gentry bought most of their goods in the nearest markets, irrespective of their size, the nobility and clergy preferring London or the higher rank market towns.

Masschaele (1994) has a more nuanced view. He rightly stresses that royal grants did not always materialize into a functioning market. Nor were all markets founded equal. In particular, the timing of establishment is argued to have been important for a market's subsequent success. The period from 1100 to 1225 was fundamental in laying the basis for a network that was to persist during the following centuries. Most of the markets founded after this date remained at the periphery and their contribution to internal trade was at best marginal. Even though it is beyond the scope of this paper to settle this debate, Section 2.4 provides quantitative evidence of the relationship between local markets and regional growth in the late middle ages.

### 2.3.3 Economic Decline after 1300

The fourteenth century stands in sharp contrast with the two preceding ones. Interstate conflict, bad weather, disease and a shrinking money supply generated a severe contraction of economic activity that took centuries to recover from.

Among the most important pre-plague shocks to affect the English economy was the famine of 1315-7.<sup>20</sup> All crops experienced consecutive bad harvests, although wheat was the most severely hit. The yield in 1316 was 40% lower relative to the 1270-1429 trend (Campbell, 2010, p. 288). It is estimated that ten percent of the population may have died during the Great Famine of 1315-7 (Bailey, 1998, p. 238). Bad harvests occurred again in 1521, when yields dropped by a third relative to the previous year. In addition, an outburst of cattle plague spreading from the continent reached England in 1319. The disease halved the bovine population in less than 18 months (Campbell, 2010, p. 289). The socio-economic consequences were dramatic: grain prices rose, real wages declined,

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<sup>19</sup>Long-distance trade concerned mainly bulk transactions and favored alternative trading institutions, like fairs. Nor was the presence of large households, such as abbeys or manors, instrumental in the establishment of new markets. By a process of elimination, the most likely attendees of rural markets were thus small households purchasing small quantities (Britnell, 1981, p. 218).

<sup>20</sup>The previous famine dates to the early 1290s, when yields dropped by a quarter in 1293 alone. However, the situation 20 years later was different, as prices were much higher and real wages significantly lower.

Table 2.1: Medieval Markets by Type, Region and Year of Establishment

	England				Wales
	Total	South	Midlands	North	
<i>Panel A: Established Markets</i>					
Prescriptive markets	584	389	104	91	74
Chartered markets	1457	871	362	224	53
Before 1199	55	36	13	6	1
1200-1249	404	255	102	47	6
1250-1299	564	316	150	98	32
After 1300	434	264	97	73	14
<i>Panel B: Market Towns c. 1600</i>					
Prescriptive markets	337 (58%)	215 (55%)	68 (65%)	54 (59%)	41 (55%)
Chartered markets	341 (23%)	201 (23%)	79 (22%)	61 (27%)	15 (28%)
Before 1199	33 (60%)	21 (58%)	9 (69%)	3 (50%)	1 (100%)
1200-1249	140 (35%)	83 (33%)	39 (38%)	18 (38%)	3 (50%)
1250-99	100 (18%)	50 (16%)	23 (15%)	27 (28%)	10 (59%)
After 1300	68 (16%)	47 (18%)	8 (8%)	13 (18%)	1 (7%)
<i>Panel C: Population Statistics</i>					
Population 1290	4 million	2.35 million	0.99 million	0.66 million	0.25 million
% Urban	9.15%	9.29%	8.67%	9.35%	0.80%

Notes: The market data come from Letters et al. (2004). Population data are taken from Campbell (2008). Urbanization rates are computed using the available population estimates for the largest towns in the sample.

the number of marriages and births plunged and the number of deaths surged (Campbell, 2010, p. 292).

The higher propensity of late medieval rulers to wage war compromised the relative peace of previous centuries. After a short interlude, the Scottish War of Independence resumed in 1332.<sup>21</sup> In 1337, Edward III also declares war on France. This led to severe destruction in northern counties and high levels of taxation and purveyance (Bailey, 1998, p. 238). In addition, significant quantities of bullion were transferred overseas to support the war effort, limiting the money supply.

The largest shock arrived nonetheless in the summer of 1348 when the Black Death reached England through the port of Weymouth and spread over the entire island (Christakos, Olea, Serre, Wang, and Yu, 2005, p. 220). The immediate effect was a sharp decline in population.<sup>22</sup> Broadberry et al. (2010) estimate that England's population was 2.5 million in 1377, almost 50% lower than in 1290. Recovery was extremely slow. Britnell (1994, p. 205) argues that few towns had returned to their pre-plague levels by 1520 and Rigby (2010) finds that urbanization rates were at best stable

<sup>21</sup>War with Scotland first erupted in 1296 following Edward I's invasion of Scotland. Following the English defeat at Bannockburn in 1314, Scottish raids intensified in northern England, adding further stress to the local economy (Campbell, 2010, p. 290).

<sup>22</sup>Shrewsbury (1970, p. 123) proposes a mortality rate of 5% for England. More recent research, however, rejects this figure and suggests much higher mortality rates, in the range of 50% (Dewitte and Kowaleski, 2017, p. 6-7).

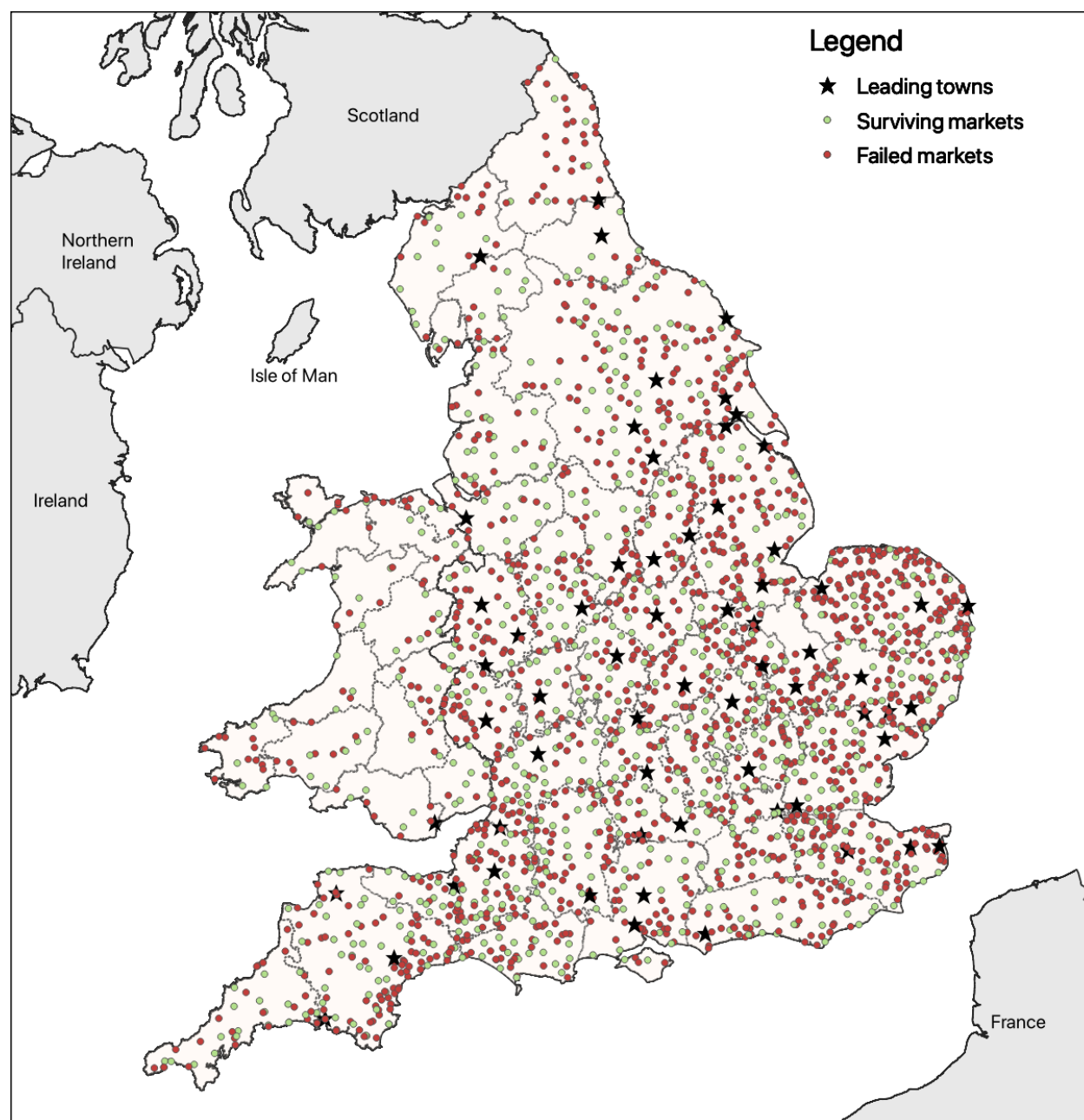


Figure 2.2: Market Towns by 1600

Notes: The leading towns of medieval England are identified using population estimates from Campbell (2008). Information on whether the market survived in the the sixteenth century is taken from Everitt (1967).

in the post-plague period, if not lower.<sup>23</sup>

The cumulative effect of these shocks compromised the profitability of many of the markets

<sup>23</sup>The long-run consequences of the plague pandemic were not entirely negative, quite the contrary. Voigtländer and Voth (2013b) argue that the Black Death was a major negative shock that allowed Europe to escape the low-income equilibrium and transition to a higher-income equilibrium. Voigtländer and Voth (2013a) show that the Black Death generated a shift into pastoral farming, which improved labor opportunities for women and lowered fertility. This allowed the European economy to sustain an equilibrium with higher incomes.

established previously. First, the share of wage-earners in the countryside declined significantly. In 1300, laborers and servants accounted for 50% of the population; by 1500, they represented less than a third of the population (Britnell, 2000, p. 12). This evolution was at least in part due to the switch to pastoral farming and away from arable farming. The former was more advantageous in a period of rising wages as it was characterized by a smaller labor intensity. Second, the raise in living standards increased the demand for higher quality products and for goods produced abroad (Dyer, 1989b; Hatcher, 1994, p. 17). This change in preferences reduced the demand for manufactures produced locally. Thirdly, with exports playing a more important role in the national economy, mercantile elites gained in influence and preponderance. Employment in manufacturing and commerce became concentrated in a handful of locations (Britnell, 2000, p. 15). The result was a decline in internal trade that persisted at least until the middle of the fifteenth century. Many of the medieval markets were thus deprived of the diffuse, rural demand that made their previous success.

By 1600, only a third of medieval markets were still functioning, as shown in Panel B of Table 2.1. Survival rates were the highest among the older and better established prescriptive markets, although even among them more than 40 per cent disappeared. Concerning chartered markets, only one in five survived into the sixteenth century. Survival probabilities are higher for older markets. Those chartered after 1250 performed particularly poorly, with a survival probability of less than 20%. There was significant regional variation as well, with markets in western counties faring significantly better than those in eastern counties: survival rates were, on average 1.5-2 times larger in the west than in the east. Figure 2.2 plots their geographic distribution, as well as the leading towns in terms of population during the late Middle Ages.

## 2.4 Local Markets and Medieval Development

The first step in the quantitative analysis of medieval markets seeks to understand their contribution to the spatial pattern of development in the middle ages. Due to the scarcity of direct evidence of the distribution of wealth during this period, I use the assessments in the 1334 lay subsidy as a proxy for a location's wealth.

### 2.4.1 A measure for medieval wealth

The 1334 lay subsidy marked a significant change relative to previous levies. Instead of taxing the wealth of individual taxpayers as had been previously done, localities were now assessed collectively and decisions about who should pay were left to local communities. Boroughs were taxed a fifteenth of their assessed wealth while rural areas paid only a tenth.<sup>24</sup> Whether these assessments are accurate reflections of the distribution of wealth is open to debate. Jenks (1998) shows that county valuations co-moved with the figures for London between 1275 and 1334 and concludes that they provide reliable and consistent information. More recently, Nightingale (2004) compares the assessments in the subsidies with the Statute Merchant certificates of debt. She finds that the two series evolved similarly up to 1294; after this date, valuations in the subsidies experienced greater declines during periods of contraction and failed to recover during periods of growth. This was most likely due to massive and widespread evasion and an increase in the number of goods exempted from taxation.<sup>25</sup> The exclusion of cash means that the 1334 lay subsidies failed to capture urban commercial wealth. Similarly, by disregarding wool, northern counties were under-assessed. The valuations in the lay subsidies should therefore be seen as a measure of agrarian wealth.

### 2.4.2 Regional economic development and market density

According to the commercialization hypothesis, increasing internal trade made necessary the emergence of more formal modes of organization. We would therefore expect to see more markets being established in areas where commercial activity was more intense. I measure regional development using the county tax valuation per square mile in the 1334 lay subsidy. In a pre-industrial economy, this will be an appropriate measure for economic performance if it correlates with population density. In a Malthusian economy, population density is the correct measure of development, as technological progress leads to an increase in population rather than per capita income.

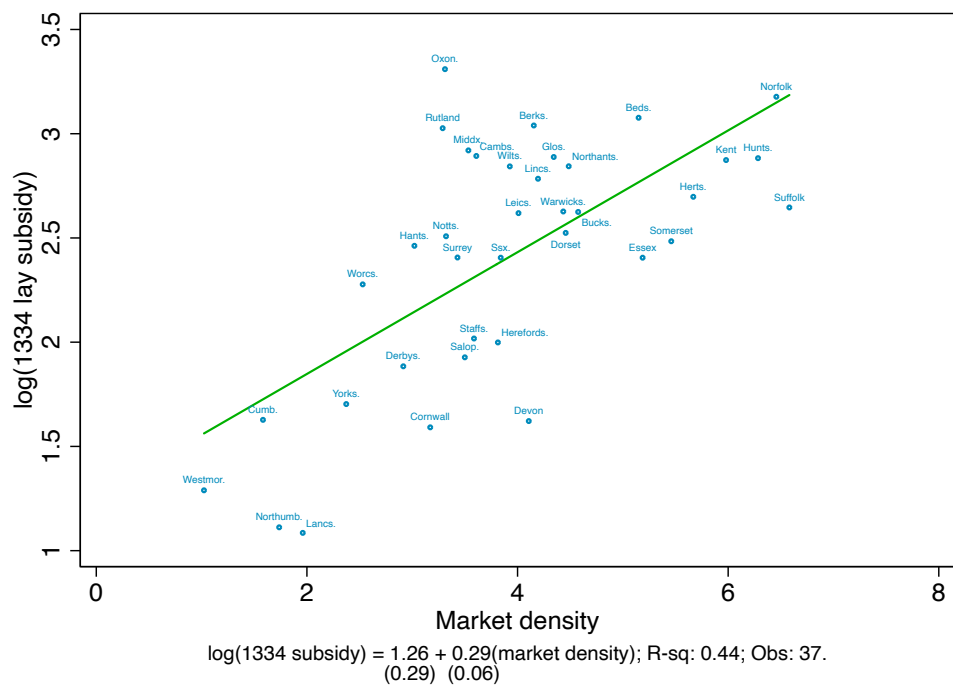
Figure 2.3A plots the relationship between county tax valuations (per square mile) in 1334 and market density. The two variables are highly correlated. Each additional market founded in an area of 100-square miles is associated with a 34% increase in tax valuation. The positive

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<sup>24</sup>The counties of Cheshire, Cumberland, Durham, Northumberland and Westmorland were not included in the 1334 lay subsidy. Locations in Kent were not individually assessed either. For Cumberland, Northumberland and Westmorland, I use the valuations from the 1336 subsidy.

<sup>25</sup>The lay subsidies of 1294 and 1295 exempted rural areas from paying tax on coin and plate. The exemption progressively extend to urban areas as well. Despite the volume of currency doubling between 1282 and 1319, the amount of cash recorded in the subsidies decreased. Wool also became a customary exemption, which explains the lack of a significant correlation between wool production and tax valuations (Nightingale, 2004, p. 6-7).

(A) 1334 Lay Subsidy and Market Density at the County Level



(B) 1334 Lay Subsidy and Year of Market Grant

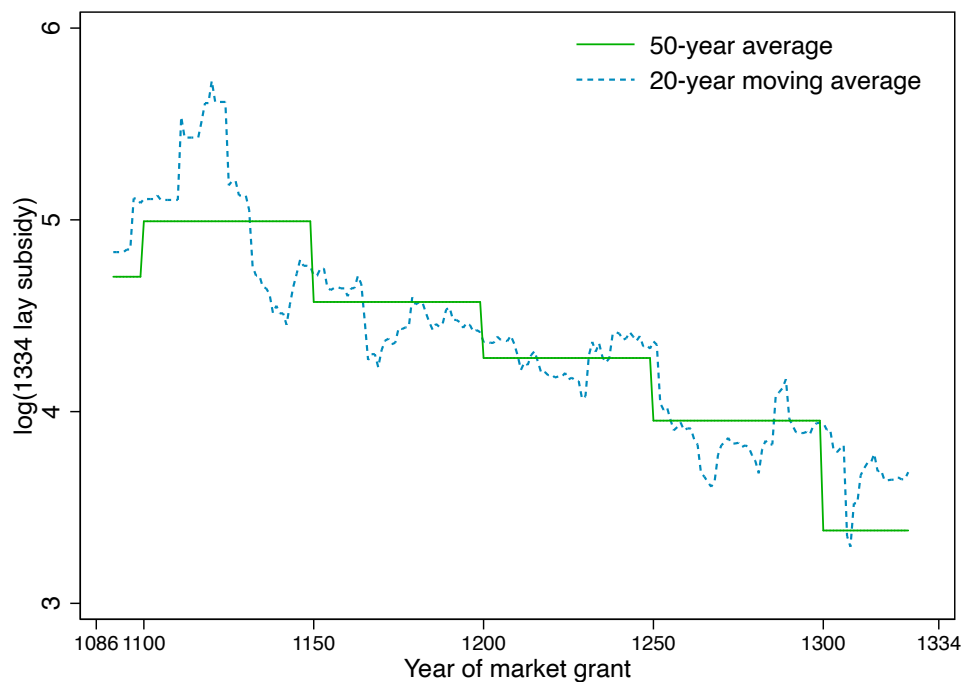


Figure 2.3: Medieval Markets and Late Medieval Growth

Notes: Figure A shows county valuations per square mile in the 1334 lay subsidy as a function of market density, defined as the number of markets in an area of 100 square miles. Figure B shows the average assessed value in the 1334 lay subsidy for boroughs, depending on the year when their market rights were recognized.

relationship is robust to alternative specifications. Adding credit to tax valuations delivers an even larger coefficient (0.45 with a standard error of 0.08). Aggregating valuations only for places with a market – and thus disregarding the valuations of locations with no markets but assessed in the subsidy – produces a coefficient of 0.40 (standard error of 0.09). The relationship also holds whether one uses the density of surviving or failed markets. Overall, these results suggest a strong and positive correlation between regional wealth and the number of markets established in the middle ages.

### 2.4.3 Medieval economic growth and market survival

A related question is whether the presence of a market correlates with growth at the locality level. Given that petitioning the King was costly (Masschaele, 1994, p. 264) and that setting up a market involved considerable fixed costs (Britnell, 1981, p. 216), one can presume that markets were established only when trade volumes were large enough to warrant such investments. This entails a negative correlation between the year of the grant and wealth in 1334. Figure 2.3B illustrates the average tax valuation for places that obtained a market grant in a given period. Because of potential differences in the way urban and rural areas were assessed, the figure only shows the average for boroughs. As expected, places that secured a market charter earlier are, on average, wealthier in 1334: the assessed valuation in the 1334 lay subsidy increases with the age of the market.

In order to better gauge the effect of markets on medieval development, I use a simple model that delivers a relationship between tax valuations in 1334 and annual growth rates. First, I assume that in order for a market to be established, a location's wealth needs to exceed a certain threshold, denoted by  $\overline{\text{value}}$ .<sup>26</sup> Intuitively, the number of potential transactions in a market depends on the location's wealth. If landlords are to make a profit, the collected tolls and market rents have to exceed the costs of setting up the market. This implies that there is a cutoff value for the number of transactions, and thus wealth, below which profits are negative (and no market is established) and above which profits are positive (and a market is established). Importantly, this assumption entails that a location's valuation in the year it was granted a market is  $\overline{\text{value}}$ .

Second, I assume that growth rates have two components: an idiosyncratic component that is city-specific, denoted by  $g_i$ , and a component that is common to all cities, denoted by  $\bar{g}$ , and which captures the effect of having a market. The annual growth rate is then  $e^{g_i + \bar{g}}$ . Given this, the value of location  $i$  in 1334 is  $\text{value}_i = \overline{\text{value}} \left[ e^{(g_i + \bar{g})} \right]^{1334 - \text{year\_grant}_i}$ . Third, I assume that the true wealth is observed with error in the tax assessments of 1334:  $\text{subsidy}_{1334} = \text{value}_i \epsilon_i$ , where  $\epsilon_i$  is an iid error. Taking logs yields the following equation to be estimated:

$$\log(\text{subsidy}_{1334}) = \log(\overline{\text{value}}) + (g_i + \bar{g})(1334 - \text{year\_grant}_i) + \log(\epsilon_i) \quad (2.1)$$

---

<sup>26</sup>One could also assume the threshold to vary across locations, in which case the regressions below would yield the average value of individuals thresholds.

The coefficient on the number of market years captures the sum of the market-induced growth rate,  $\bar{g}$ , and the nationwide average of the location-specific growth rates,  $g_i$ .

A straightforward estimation of equation (2.1) by ordinary least squares shows that locations grew at an average rate of 0.4% between the year they were granted a market and 1334.<sup>27</sup> The estimate is robust to controlling for geography (altitude and ruggedness) and transportation infrastructure (distance to the coast, navigable rivers and Roman roads), as well as including county-specific fixed effects.<sup>28</sup> Using a Poisson Pseudo-Maximum Likelihood (PPML) estimator produces similar coefficients.<sup>29</sup>

While interesting in their own right, these regressions do not allow us to differentiate between the average city-specific growth rate and the effect of having a market. Moreover, equation (2.1) imposes that all locations with a market grew at an additional rate of  $\bar{g}$ , regardless of the success or failure of their markets. I relax this assumption and re-estimate the previous equation while allowing for heterogeneous growth rates depending on whether the local market survived into the sixteenth century or not. The results are reported in columns (1) through (3) of Table 2.2. Locations with a surviving market grew at a rate of 0.4% (significant at 1%), whereas places with a failed market grew at 0.1% (significant at 10%). Controlling for transport infrastructure and geographic covariates does not alter the estimates in a meaningful way, although the coefficient for failed markets is no longer significant (column 2). Because of potential geographic variation in tax evasion and the impact of legal exemptions, the specification in column (3) adds county-specific fixed effects. Successful markets are still estimated to have grown at a rate of 0.4% per year (significant at 1%), whereas unsuccessful markets grew at a shy 0.03% (not significant). Overall, these regressions suggest that places with a successful market grew at a faster rate than places with a failed market. The relationship is not necessarily causal. Places with a successful market may have had higher idiosyncratic growth rates on average.

To explore this possibility, I consider an additional level of heterogeneity. Arguably, urban status is correlated with a series of unobserved characteristics, ranging from institutions to agglomeration and innovation. If places differ in the distribution of their idiosyncratic growth rates, then urban status is the dimension along which one would expect to observe such heterogeneity. I therefore regress tax valuations in the 1334 lay subsidy on the number of market years interacted with dummy variables for urban and survival status. Columns (4) through (6) in Table 2.2 report the results. Boroughs with a successful market grew at an annual rate of 0.4% (significant at 1%)

<sup>27</sup>For each location, I only keep the oldest market. Because the year of establishment is not accurately identified prior to 1086, I only consider markets founded after this date. Cheshire, county Durham and Wales were not taxed, so they are excluded from the sample. Similarly, localities in Kent were not individually assessed and they are dropped. The final sample consists of 1629 locations with a market: 404 are boroughs and 517 of them are recorded as having a market functioning by the sixteenth century.

<sup>28</sup>Among the geographic covariates, only altitude enters the regression with a significant coefficient and is negatively correlated with tax valuations in 1334. Among the transport infrastructure variables, the coefficient on distance to Roman roads is significant when not controlling for county-specific fixed effects. All other covariates are insignificant.

<sup>29</sup>PPML estimates have two main advantages over OLS. First, PPML methods allow for zero-valuations. Roughly 12% of locations have zero assessments and are dropped from the regression when I take logs. Second, as highlighted by Silva and Tenreyro (2006) for gravity equations,  $\log(\epsilon_i)$  may be correlated with the regressors if the variance of  $\epsilon_i$  depends on the number of market years. PPML is robust to this type of heteroskedasticity.

Table 2.2: Medieval Markets and Late Medieval Growth  
Dependent variable:  $\log(1334 \text{ lay subsidy})$ 

	(1)	(2)	(3)	(4)	(5)	(6)
Surviving markets	0.0042*** (0.0005)	0.0042*** (0.0005)	0.0040*** (0.0005)			
Failed markets	0.0013* (0.0006)	0.0011 (0.0007)	0.0003 (0.0007)			
Surviving borough markets				0.0043*** (0.0005)	0.0043*** (0.0006)	0.0042*** (0.0006)
Failed borough markets				0.0000 (0.0008)	0.0003 (0.0007)	0.0004 (0.0009)
Surviving non-borough markets				0.0048*** (0.0006)	0.0042*** (0.0005)	0.0032*** (0.0004)
Failed non-borough markets				0.0023** (0.0007)	0.0017** (0.0007)	0.0002 (0.0007)
Constant	3.7522*** (0.1536)	4.5026*** (0.2893)	4.4175*** (0.2245)	3.7176*** (0.1557)	4.4737*** (0.3039)	4.4165*** (0.2224)
Observations	1,439	1,439	1,439	1,439	1,439	1,439
Adjusted R-squared	0.0802	0.1653	0.3117	0.0857	0.1665	0.3122
<u>Baseline controls:</u>						
Transport infrastructure	No	Yes	Yes	No	Yes	Yes
Geographic covariates	No	Yes	Yes	No	Yes	Yes
Historical county FE	No	No	Yes	No	No	Yes

Notes: All regressions are estimated by ordinary least squares. The final sample consists of 1386 locations with a market granted between 1086 and 1334. The explanatory variables are the number of years between the year of the grant and 1334, interacted with the corresponding binary variables. The transport infrastructure covariates include the log of distance to the coast, nearest navigable river and Roman road. The geographic covariates include the log of altitude and terrain ruggedness index. Robust standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10% , \*\* significant at 5%, \*\*\* significant at 1%.

while those with a failed market stagnated. Growth rates in villages were 0.5% (significant at 1%) if their market survived and 0.2% (significant at 5%) otherwise. Controlling for transport infrastructure and geography (column 5) does not alter the results in a significant way, although the point estimates are smaller for rural areas. In column (6), I include county-specific fixed effects, such that identification comes from variation in tax valuations of locations within the same county. Growth rates of boroughs and rural areas with a successful market were of the same order of magnitude and are not statistically distinguishable. In contrast, both urban and rural places with a failed market experienced little growth in the period spanning the grant of their market and 1334. In sum, urban status does not appear to affect the distribution of growth rates before 1334: the main distinction remains that between locations with a surviving market and locations with a failed one.

#### 2.4.4 Discussion

To what extent do these results support the hypothesis of a causal effect of medieval markets on growth? A sufficient condition would be that the average of idiosyncratic growth rates,  $g_i$ , is

zero across all four groups of places. The previous regressions suggest that that was the case for urban and rural locations with a failed market. In order to assess whether one can generalize this to locations with a surviving market, Figure 2.7 in Appendix 2.8.4 plots the cumulative density function for different outcomes for each group. In Panel A, I show the cumulative probability for the grant years. As expected, for both urban and rural areas, surviving markets tend to have been established earlier than failing ones. However, early establishment is not a necessary condition for survival: successful rural markets were granted in the same period as failing urban markets. Panels B, C and D show the cumulative distribution of distance to the nearest coastline, navigable river and Roman road, respectively. Thriving urban markets tend to be located further away from the coastline and navigable rivers than failed urban markets, while no such difference is observed for rural places. Both urban and rural surviving markets appear to be located closer to Roman roads than their failed counterparts, but the differences are not statistically significant. Similarly, the differences in altitude and ruggedness across groups are not statistically significant. These comparisons do not reveal any systematic differences across the four groups that could explain higher average individual growth rates. While I cannot rule out the existence of unobserved factors that could lead to higher idiosyncratic growth rates in places with a functioning market, the evidence is consistent with medieval markets having a positive causal effect on medieval growth.

Finally, it should be noted that in the simple model described above, the estimated constant has a precise meaning: it captures the value at which it becomes profitable for a place to establish a market. According to the estimates in Table 2.2, this value ranges between 41 pounds and 90 pounds. While the real value at which markets became profitable is not observed, one can check whether the tax valuations of places receiving a grant shortly before 1334 are within this range. There are 106 charter markets granted between 1314 and 1334 and their average (median) valuation is 56 (41) pounds. For the 134 markets granted after 1334, the average (median) assessment in the 1334 lay subsidy is 49 (36) pounds.

## 2.5 Economic Contraction and Market Rationalization

The twelfth and thirteenth century witnessed an impressive increase in the number of local markets. However, more than two thirds failed to survive into the sixteenth century. In this section, I explore the determinants of market failure.

### 2.5.1 Population expansion and contraction as drivers of market success

As discussed in Section 2.3, commercial expansion was closely linked to population growth during the twelfth and thirteenth centuries: opening new market venues was a profitable enterprise only in a context of expanding local demand. Figure 2.4A plots the relationship between changes in county population and market density from 1086 to 1290. As is apparent from the graph, the two variables are positively correlated: a rise in population density equal to the average (65 individuals per square mile) is associated with an increase in market density of 0.83. The county of Norfolk best exemplifies this trend. Its population density more than tripled during this period and increased by 165 residents per square mile. The number of licensed markets also rose from only six at the beginning of the period to 116 by the end of it.

Conversely, the severe population contraction of the fourteenth century limited the viability of many local markets. Following the Great Famine of 1315-22, the Black Death in the late 1340s and the further outbreaks of plague in 1361-62, 1369 and 1375, England's population may have declined by up to 50% between 1290 and 1377 (Broadberry et al., 2010). As Figure 2.4B illustrates, the regional distribution of population losses is highly correlated with the number of failed markets. A decrease in population density equal to the average (48 individuals per square mile) corresponds to an increase in the number of failed markets per 100 square miles of 0.81. Again, Norfolk epitomizes this evolution. Its population density dropped by 151, reaching early medieval levels. Of the 110 markets established there between 1086 and 1290, only 17 survived into the sixteenth century.

### 2.5.2 Determinants of market success

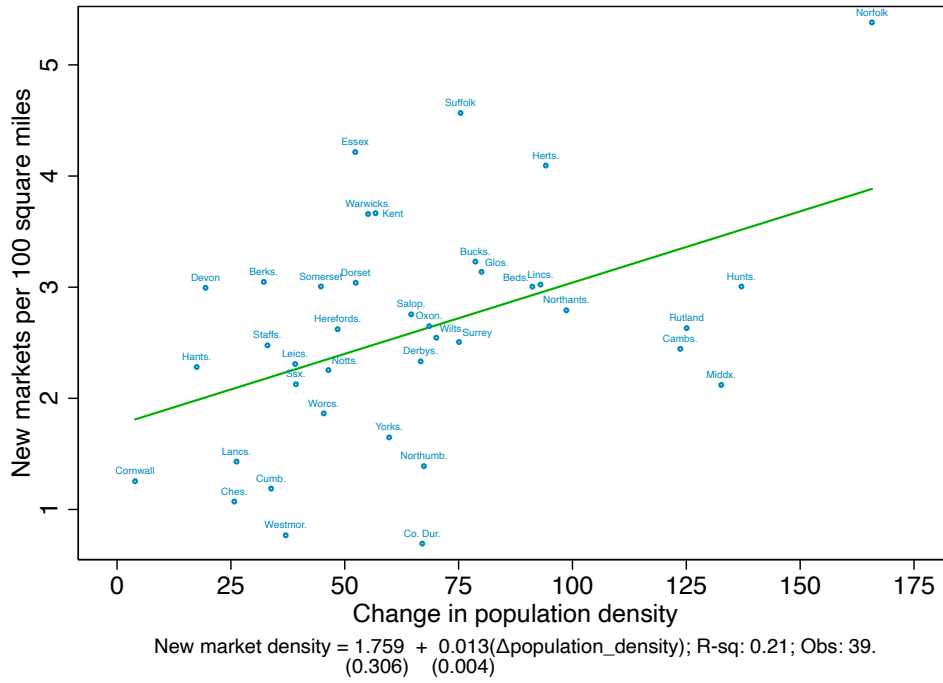
Whether the demise of many local markets was simply the result of nationwide economic decline or was part of a latent process of integration and rationalization is still debated among historians. According to the rationalization theory, minor markets progressively disappeared as they were not fitted to compete with larger, better-established trade centers. In order to quantitatively assess this possibility and investigate the determinants of market survival, I estimate the following linear probability model:<sup>30</sup>

$$Survive_i = \alpha_0 + \alpha_1 Distance_i + \alpha_2 First\_nature_i + \alpha_3 Institutions_i + \epsilon_i, \quad (2.2)$$

---

<sup>30</sup>The sample includes all places with a market established between 700 and 1600. For each location, I only consider the oldest market. I also exclude locations with a population above two thousand inhabitants. This produces a sample of 2103 places.

(A) 1334 Lay Subsidy and Market Density at the County Level



(B) 1334 Lay Subsidy and Year of Market Grant

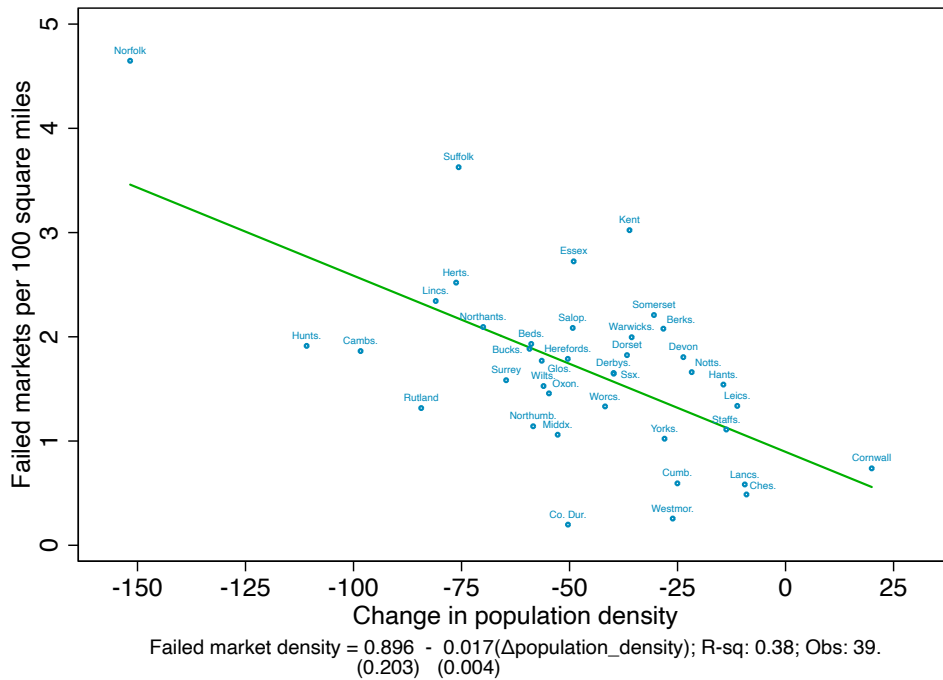


Figure 2.4: Population Change and Market Dynamics

Notes: Figure A shows the density of new markets established from 1086 to 1290 as a function of population density change during the period. Figure B shows the density of failed markets as a function of population density decline during 1290 and 1377.

where  $Survive_i$  is an indicator for market survival into the sixteenth century;  $Distance_i$  is the distance to the nearest leading medieval town and captures the effect of regional competition on the probability of survival;<sup>31</sup>  $First\_Nature_i$  is a set of first-nature covariates, including geographic and transportation variables;  $Institutions_i$  is a set of institutional covariates; and  $\epsilon_i$  is an error term. If the rationalization thesis is correct, then  $\alpha_1$  is positive, meaning that markets located closer to major trade centers were less likely to survive into the modern era.

The results are shown in Table 2.3. Column (1) reports the coefficients from a regression in which the only independent variable is distance to the nearest leading town. The point estimate is positive and highly significant: doubling the distance to the nearest leading town is associated with a 10% increase in the probability of survival. The point estimate is robust to including first-nature and institutional covariates (column 2) as well as county-specific fixed effects (column 3). In column (4), I re-estimate equation (2.2) by Probit. The coefficient on distance remains positive and highly significant.

One concern with the previous specification is that distance to the nearest leading town may not be an accurate measure of regional competition. In particular, the actual size of the nearest leading town may be instrumental for survival. I therefore consider an alternative measure for spatial competition, given by:

$$UP_i = \sum_{j=1}^{63} \frac{Population_j^{1290}}{Distance_{ij}},$$

where  $j$  indexes major towns;  $population_j^{1290}$  is population in town  $j$ ; and  $Distance_{ij}$  is the distance between location  $i$  and town  $j$ . This corresponds to the urban (market) potential commonly used in the literature (De Vries, 1984; Bosker et al., 2013). Places located closer (smaller distance) to bigger cities (larger population) have a higher urban potential. In the context of medieval markets, higher urban potential implies tougher regional competition. The results using this alternative measure are shown in columns (5) through (8). Consistent with the previous finding, the coefficient on urban potential is negative: locations closer to existing trading centers have a lower probability to have survived into the sixteenth century. The estimate is robust to controlling for first-nature covariates, including county-specific fixed effects or using a Probit model.

Figure 2.5 shows the relationship between local competition and market survival by plotting the distribution of distance to the nearest leading town for successful (thick blue line) and unsuccessful markets (dashed green line). The former appears to be shifted to the left. Also, it is interesting to remark that the difference between the two groups is not large. Successful markets were located only three kilometers further away from a large town than failed markets. Overall, the results presented here would thus suggest that proximity to urban centers was detrimental to local markets and provide support for the rationalization theory. That being said, distance to the nearest leading town or urban potential have little explanatory power on their own: the R-squared is less than 2%.

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<sup>31</sup>Leading towns in the late middle ages are defined as locations with more than two thousand residents in 1290. Campbell (2008) provides a list of 63 locations that meet this criterion. 59 of them had borough status and 36 had been at one point a royal mint. All markets being held in these locations survived into the sixteenth century.

Table 2.3: Determinants of Market Survival  
Dependent variable: Binary Variable = 1 if Market is Recorded in 1600

	(1) OLS	(2) OLS	(3) OLS	(4) Probit	(5) OLS	(6) OLS	(7) OLS	(8) Probit
<u>Second nature characteristics</u>								
log(Distance to leading town)	0.099*** (0.015)	0.095*** (0.021)	0.099*** (0.022)	0.121*** (0.031)				
log(Urban potential)					-0.112** (0.039)	-0.157* (0.071)	-0.242* (0.126)	-0.192** (0.096)
<u>First nature characteristics</u>								
log(Distance to coast)		0.006 (0.011)	0.020 (0.013)	0.006 (0.014)		0.017 (0.017)	0.029* (0.014)	0.021 (0.022)
log(Distance to river)		0.001 (0.010)	-0.002 (0.010)	0.001 (0.012)		0.008 (0.010)	0.003 (0.009)	0.011 (0.012)
log(Distance to Roman roads)		-0.010 (0.016)	-0.013 (0.014)	-0.011 (0.019)		-0.015 (0.014)	-0.014 (0.013)	-0.017 (0.017)
log(Altitude)		0.012 (0.016)	0.007 (0.015)	0.015 (0.020)		0.004 (0.023)	0.004 (0.017)	0.005 (0.029)
log(Ruggedness)		-0.024* (0.012)	-0.033** (0.010)	-0.031* (0.016)		-0.026* (0.012)	-0.032** (0.010)	-0.032** (0.015)
<u>Institutional characteristics</u>								
Borough		0.402*** (0.026)	0.388*** (0.030)	0.413*** (0.035)		0.386*** (0.023)	0.384*** (0.028)	0.392*** (0.027)
Mint		0.076* (0.034)	0.071** (0.030)	0.101 (0.063)		0.080** (0.033)	0.078** (0.029)	0.106* (0.062)
Prescriptive		0.060** (0.023)	0.069** (0.024)	0.073*** (0.021)		0.069** (0.028)	0.070** (0.026)	0.086*** (0.028)
Founded after 1200		-0.129*** (0.029)	-0.125*** (0.027)	-0.136*** (0.026)		-0.137*** (0.029)	-0.132*** (0.026)	-0.142*** (0.027)
Founded after 1300		-0.054* (0.028)	-0.058** (0.024)	-0.074* (0.042)		-0.061* (0.027)	-0.063** (0.024)	-0.085** (0.043)
log(1334 lay subsidy)		0.101*** (0.013)	0.123*** (0.014)	0.130*** (0.018)		0.110*** (0.011)	0.124*** (0.014)	0.138*** (0.015)
Observations	2,103	1,612	1,612	1,612	2,105	1,613	1,613	1,613
R-squared	0.019	0.308	0.321	-	0.007	0.303	0.317	-
Historical county FE	No	No	Yes	No	No	No	Yes	No

Notes: Columns (1) through (3) and (5) through (7) show results from linear probability regressions of a market survival binary variable on a set of first and second nature variables. Columns (4) and (8) show results from Probit regressions. For the Probit regressions, we report marginal effects calculated at the sample mean. Standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

How do these results relate to previous findings in the literature? Bosker et al. (2013) document positive and significant interactions between cities along religious lines between 800 and 1800 in Europe, the Middle East and North Africa.<sup>32</sup> One potential explanation for the discrepancy between their results and mine is that Bosker et al. (2013) focus on large urban locations, whose population exceeded 10,000 inhabitants at least once in their history. By contrast, my sample consists of lower-rank cities and villages that made up the hinterlands of the towns studied by Bosker et al. (2013). While large towns may benefit from while towns may benefit from locations closer to equally large cities through facilitated exchanges of goods and technology, growth in smaller locations may be inhibited by such proximity. This result echoes the findings of Bosker and Buringh (2017). In their study of the origins of the European city network, Bosker and Buringh (2017) show that close proximity (less than 20 kilometers) with an already existing city reduces a location's urban chances. It is only at moderate distances (20-100 kilometers) that proximity exerts a positive effect on city establishment.

The estimated coefficients on first-nature covariates are reported in columns (2) through (4) and (6) through (8). The results suggest that geography is not a strong predictor of market survival. This is surprising in light of the importance first-nature characteristics are documented to have played in the timing of urbanization and development (Bosker et al., 2013; Motamed, Florax, and Masters, 2014; Bosker and Buringh, 2017; Henderson et al., 2018). The coefficient on distance to the coast is small and statistically insignificant: doubling distance to the coast increases the survival probability by only 2 to 3 percentage points. The positive coefficient is in line with Campbell (2008)'s observation that, unlike its Celtic neighbors, many of England's prominent cities were actually inland. The importance of coastal access may have become relevant for development only after the discovery of the New World (Acemoglu et al., 2005). The coefficient on distance to the nearest river is even smaller and less robust. This is also consistent with historians' assessment of the importance of river transport in Medieval England. While an extensive river network may have existed in the early middle ages, the conflict between navigation and other river uses (such as watermills and fish nets) may have limited the extent of water transportation in later centuries (Langdon, 1993; Jones, 2000). The coefficient on distance to Roman roads is negative, albeit small and not significant. The "correct" sign on this variable conforms with Symonds (1999)'s finding, for instance, that the transportation of pottery products in the tenth century depended more on the Roman road network than river transport. The coefficient on elevation is not significant, which is consistent with Motamed et al. (2014)'s results. Higher ruggedness, on the other hand, is associated with lower probability of market survival, which is in line with the findings of Nunn and Puga (2012).

Institutional characteristics, on the other hand, are strongly correlated with market survival and are responsible for the increase in the R-squared of the regressions reported in columns (2)-(3) and (6)-(7). Markets located in boroughs were 40 percentage points more likely to survive into the

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<sup>32</sup>Specifically, Bosker et al. (2013) find positive coefficients on urban potential in the Muslim world during the golden age of Islam; this contrasts with Christian Europe, where positive interactions between cities only become apparent after the twelfth city.

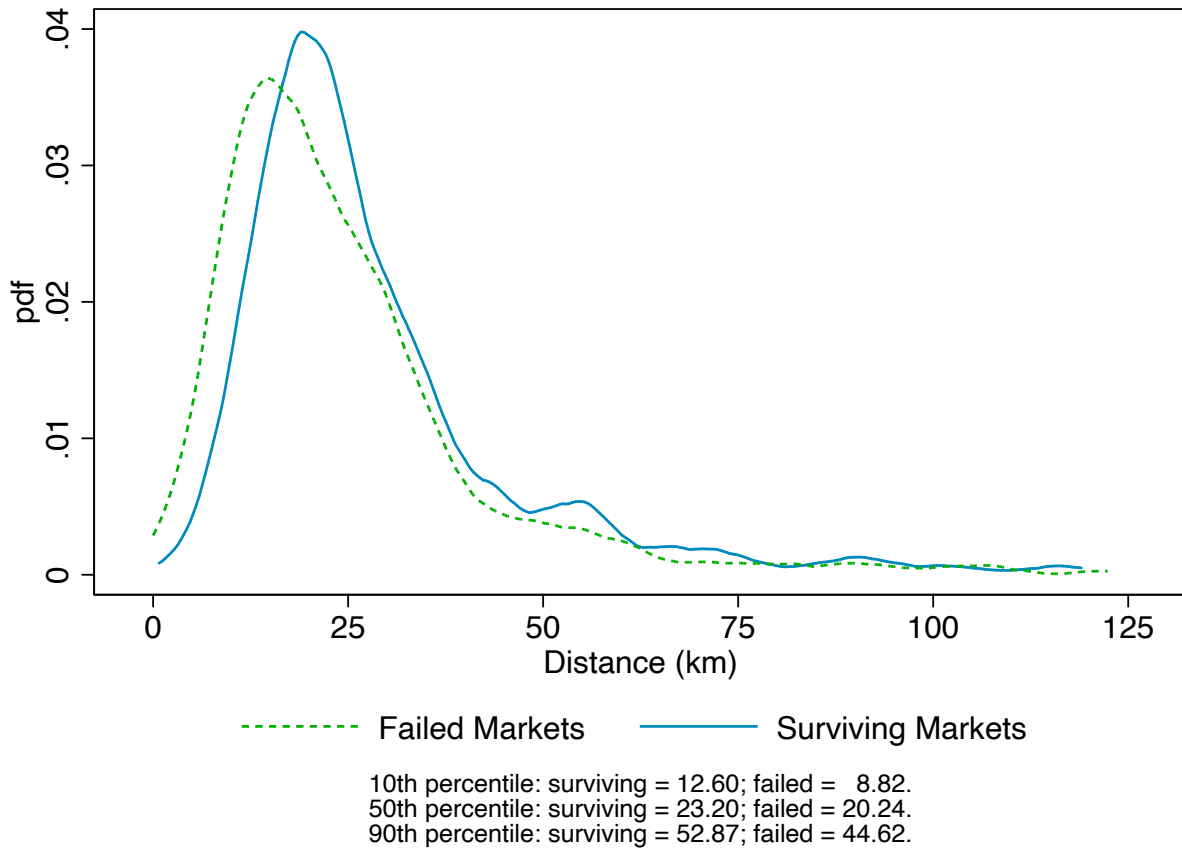


Figure 2.5: Distribution of Distance to Nearest Leading Town

Notes: Figure A shows the distribution of distance to the nearest leading town for locations with markets that survived and markets that did not survive into the 16th century (kernel density estimates, Epanechnikov kernel, bandwidth= 2.5).

sixteenth century than rural markets, the estimate being highly significant. Having had a functioning mint further raises the probability of survival by approximately 7 percentage points. The age of a market is also correlated with market success. Prescriptive markets are 6 to 7 percentage points more likely to survive, while establishing a market after 1200 reduces this probability by 13 percentage points. Establishment after 1300 further reduces it by 6 percentage points. Finally, locations with a higher agricultural wealth in 1334 were more likely to have a surviving market: increasing the value in the lay subsidy by 10% increases the probability of survival by 0.01 percentage points.

### 2.5.3 Discussion

The evidence provided in this section supports the claim that the population contraction that ensued during the fourteenth century was correlated with the failure of many of the markets established in the previous centuries. There is also evidence of market integration and rationalization of the trade network: the markets that survived into the sixteenth century tended to be in wealthier locations

and located at (slightly) larger distances from urban centers. Geography appears to have played only a marginal (if any) role in shaping the commercial success of medieval localities. Institutional variables were much more instrumental. That being said, the explanatory power of all covariates is surprisingly low: the R-squared is less than 30%, even in regression with county fixed effects. This leaves the door wide open for either unobserved variables affecting survival or idiosyncratic local shocks.

That being said, my results remain silent about the efficiency of unsuccessful markets. It could well be that, as Masschaele (1994) argues, many of these markets were peripheral in the national network and may have not even been set up. It could also be that, while not promoting further growth in the late middle ages, unsuccessful markets provided local communities with a regular venue where they could sell their produce (Britnell, 2000). Their viability was not compromised by a lack of efficiency or scale, but by the disappearance of local demand following the negative population shocks of the fourteenth century.

## 2.6 Medieval Markets and Development in the Long-Run

Having established that local markets were correlated with growth in the late middle ages and that population decline following the Black Death led to a restructuring of the trade network, it is now time to assess the relationship between medieval markets and regional development in the long-run.

### 2.6.1 Market density and regional development

In order to study how the geographic concentration of medieval markets correlates with subsequent development, I estimate the following regression:

$$Outcome_{ij} = \beta_1 Market\_density_{ij} + \beta_2 Geography_{ij} + \beta_3 Transport_{ij} + \delta_j + \epsilon_{ij}, \quad (2.3)$$

where  $i$  indexes districts and  $j$  historical counties;  $Outcome_{ij}$  is a measure of contemporary development (i.e. population density or per capita gross value added);  $Market\_density_{ij}$  is the number of medieval markets established in an area of 100 square miles;  $Geography_{ij}$  is a set of geographic covariates;  $Transport_{ij}$  is a set of transport infrastructure covariates;  $\delta_j$  are county fixed effects; and  $\epsilon_{ij}$  is a random error. I estimate equation (2.3) by ordinary least squares and report standard errors clustered at the regional level.<sup>33</sup> Table 2.4 reports results from regressions with population density as the dependent variable.

Because successful and unsuccessful markets did not correlate with medieval growth in a similar fashion, I carry the distinction into the current analysis. In columns (1) through (3), I regress the population density on the density of surviving markets, whereas columns (4) through (6) use the density of failed markets as the independent variable. Contemporary population density at the district level is highly correlated with the density of surviving markets (column 1): a one-unit increase in the density of successful markets is associated with a two-fold increase in current population density. The point estimate is somewhat smaller once I control for first-nature characteristics (column 2) and is robust to the inclusion of county-specific fixed effects. All coefficients are significant at 1%. In sharp contrast, the coefficients on the density of failed markets are negative in all specifications: contemporary population density is estimated to decrease by 6 to 14 per cent with each additional failed market. That being said, the point estimates are not statistically significant in any specification.

With respect to transport infrastructure, all coefficients have the expected sign: larger distances to the coast, navigable rivers and Roman roads are associated with lower population density. Only the point estimates for the distance to the coast and Roman roads are statistically significant, though. Neither elevation, nor ruggedness enter the regression with a significant coefficient and their sign depends on whether county fixed effects are included or not.

Table 2.7 in Appendix 2.8.3 provides further evidence on the relationship between medieval and contemporary development, as measured by income per capita. Because this data is not available at

<sup>33</sup>I had the choice between different levels of clustering. I cluster the standard errors on NUTS-1 regions as this produces the largest standard errors.

Table 2.4: Medieval Markets and Long-Run Growth  
Dependent variable: log(Population density)

	Surviving Markets			Failed Markets		
	(1)	(2)	(3)	(4)	(5)	(6)
Market density	0.695*** (0.069)	0.512*** (0.077)	0.513*** (0.078)	-0.061 (0.133)	-0.134 (0.117)	-0.090 (0.121)
<u>Baseline controls:</u>						
log(Distance to coast)		-0.157 (0.089)	-0.242** (0.094)		-0.215** (0.081)	-0.323*** (0.097)
log(Distance to river)		-0.119 (0.136)	-0.129 (0.127)		-0.228* (0.121)	-0.266* (0.140)
log(Distance to Roman road)		-0.406** (0.127)	-0.386** (0.138)		-0.505*** (0.124)	-0.471** (0.148)
log(Elevation)		0.017 (0.258)	-0.293 (0.174)		0.015 (0.258)	-0.292 (0.235)
log(Ruggedness)		-0.502 (0.451)	0.210 (0.457)		-0.554 (0.405)	0.321 (0.436)
Constant	5.769*** (0.169)	7.402*** (0.970)	8.812*** (0.678)	6.334*** (0.167)	8.517*** (0.844)	9.933*** (0.748)
R-squared	0.163	0.264	0.321	0.003	0.198	0.239
Historical county FE	No	No	Yes	No	No	Yes
Observations	319	319	315	319	319	315

Notes: The dependent variable is the log of population density in 2011, calculated at the district level. The market density is calculated as the number of markets established in an area of 100 square kilometers. All regressions are estimated by ordinary least squares. Standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

the district level, I estimate equation (2.3) at the NUTS-3 regional level. As shown in Panel A, the change in the level of aggregation does not significantly alter the previous results. Once I control for first nature characteristics and include county-fixed effects, the coefficient on the surviving market density remains of the same order of magnitude: 0.595 and statistically significant at 1%. The estimates for failed markets are negative and not significant.

The correlation between medieval markets and contemporary per capita value added is positive and statistically significant. Once I factor in transport and geographic covariates, per capita value added is estimated to increase by 17% with each additional surviving medieval market. The coefficients on failed markets are negative and not distinguishable from zero. These results are consistent with findings in Wahl (2016). He documents a robust positive correlation between medieval long-distance trade and contemporary GDP per capita for 839 NUTS-3 regions in ten European countries.

## 2.6.2 Medieval markets and local development

One of the concerns raised by the previous analysis is the likely endogeneity of administrative boundaries. In particular, more densely populated districts tend to be smaller in terms of area and account for a higher share of economic activity. Further, they do not allow to gauge whether local

markets are associated with greater economic activity in their immediate proximity. To address this, I divide England into a grid of 5-by-5 kilometer cells. Arguably, this procedure generates a random drawing of each unit's boundaries. Because detailed data are not available for this geographic level, I follow Henderson et al. (2012, 2018) and use the average nighttime light intensity reflected by each cell as a proxy for development.

As remarked by Henderson et al. (2018), light intensity is a function of both population density and income per capita. Figure 2.9 in Appendix 2.8.4 plots the relationship between these variables at different levels of aggregation. Using the coarse NUTS-1 classification, one finds a strong positive correlation between light intensity and both income per capita (Panel A) and population density (Panel B). At smaller levels of aggregation, however, the correlation between light intensity and income per capita is much weaker (Panels C and E). The relationship between light intensity and population density remains strong (Panels D and F). Moreover, using the (log) nighttime light intensity as the dependent variable and re-estimating equation (2.3) for NUTS-3 regions produces positive and significant coefficients on the density of surviving markets and negative and insignificant coefficients on the density of failed markets (Panel C of Table 2.7). In light of these results, I conjecture that nighttime light intensity is as good as it gets proxy for development at the cell level.

Finally, I define a series of binary variables that take the value one if a medieval market with certain characteristics existed in a given cell. For instance, for each cell I record whether a market was established there, as well as its status (urban or rural) and survival into the sixteenth century. I then use these variables on the right-hand side of equation (2.3) as my measure of medieval markets.<sup>34</sup> Table 2.5 shows the main results.

Consistent with previous findings, cells with a medieval market have a nighttime light intensity that is 50% higher than cells without a market. The estimated coefficients are smaller once I condition on transport and geographic covariates (column 2) or include county fixed-effects (column 3), but remain statistically significant. In columns (4) through (6), I further distinguish between surviving and failed markets. Relative to other locations, cells with a market now have nighttime light intensity that is approximately 30% higher. The estimate is somewhat smaller once I factor in additional covariates (column 5) or add county-fixed effects (column 6) and is not always significant. However, if the market survived into the sixteenth century, nighttime light intensity is further increased by somewhere between 48.29% and 54% depending on the specification. The point estimates are in this case always significant. These results suggest that most of the positive correlation documented in columns (1) through (3) is actually driven by surviving markets.

In order to achieve a better understanding of the relationship between medieval markers and contemporary development, Panel B considers an additional level of heterogeneity: that between urban and rural markets. In columns (1) through (3) I only consider the urban/rural distinction. Cells with an urban market have a light density that is 85% (or 62% when additional covariates are

<sup>34</sup>Most medieval markets are located in a unique cell: less than 15% share the same location. Figure 2.10 in Appendix 2.8.4 shows England and Wales in grid form and displays cells with a surviving/failed market.

Table 2.5: Medieval Markets and Long-Run Growth  
Dependent variable: log(Nighttime light intensity)

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Medieval Markets by Survival Status</i>						
Market	0.420*** (0.091)	0.270*** (0.043)	0.267*** (0.046)	0.249** (0.098)	0.084 (0.051)	0.110** (0.047)
Surviving market				0.434*** (0.069)	0.469*** (0.066)	0.394*** (0.039)
<i>Panel B: Market Markets by Urban and Survival Status</i>						
Borough market	0.614*** (0.079)	0.531*** (0.059)	0.482*** (0.055)	0.296** (0.112)	0.240** (0.080)	0.263*** (0.054)
Surviving borough market				0.456*** (0.111)	0.417*** (0.100)	0.314*** (0.049)
Non-borough market	0.307** (0.096)	0.115** (0.044)	0.133*** (0.040)	0.242** (0.100)	0.050 (0.050)	0.073 (0.045)
Surviving non-borough market				0.304*** (0.076)	0.307*** (0.062)	0.291*** (0.050)
<u>Baseline controls:</u>						
Transport infrastructure	No	Yes	Yes	No	Yes	Yes
Geographic covariates	No	Yes	Yes	No	Yes	Yes
Historical county FE	No	No	Yes	No	No	Yes

Notes: The dependent variable is the log of nighttime light intensity in 2011, calculated at the grid cell level. The market variables are binary variables taking the value 1 if a given market existed in a grid cell. All regressions are estimated by ordinary least squares. Standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

included) higher than places without a market. This coefficient likely conflates both the effect of medieval markets and urbanization effects. Cells with a rural market have light density that is 36% (or 14% with additional covariates) higher than cells without a market. In columns (4) through (6), I exploit both the urban/rural and the surviving/failed distinction. Cells with a failed rural market do not appear to be more developed nowadays than cells without a market once I control for first-nature characteristics. While the point estimate is positive, it is not statistically significant. Locations with a failed urban market, on the other hand, enter the regression with a much higher and statistically significant coefficient: they have, on average, a light intensity that is roughly 30% higher than places without a market. In light of the little evidence that these markets had an impact on city growth in the medieval period, one can conjecture that this effect corresponds to an urban premium that is unrelated to medieval trade activities. Rural places with a successful market are also, on average, 30% more developed nowadays than their counterparts with a failing market. Surprisingly, the same holds for surviving borough markets: their nighttime intensity is roughly 30% higher than in urban cells with a failed medieval markets.

### 2.6.3 Robustness Checks

Table 2.8 in Appendix 2.8.3 reports results from several robustness checks. For comparison, column (1) shows estimates of the specification allowing for heterogeneous effects across rural/urban locations and places with a surviving/failed market.

*Outliers.* There is significant variation in the average nighttime light intensity at the cell level. While some locations do not emit any light (for instance, the mountainous regions of northern and south-west England and mid-Wales), others emit so much light that they need to be top-coded (for instance, the cities of London, Birmingham, Manchester, Leeds and Newcastle). In column (2), I test the sensitivity of my results to outliers by dropping cells with a light intensity below the 5th percentile and above the 95th percentile. The point estimates are only marginally smaller and are significant at the same confidence levels as in the baseline specification.

*Access to the transport infrastructure.* Another potential confounding factor is integration within the transport network. Better connections with other locations may impact development in the long-run through mechanisms that are only imperfectly captured by geographic distance. I therefore re-estimate equation (2.3) for places that are not located in the immediate proximity of a coast, navigable river or Roman road. Column (3) shows the results obtained after I drop locations within a 5-kilometer distance to the coast. The point estimates are not significantly altered. Excluding cities within 2.5 kilometers of a navigable river or a Roman road produces similar results, although the coefficient on failed rural markets is now marginally significant.<sup>35</sup>

*Urban externalities.* An additional concern is that large human agglomerations might exert positive externalities on locations in their vicinity. To study whether this is the case, I re-estimate equation (2.3) for places that are not found within 5 kilometers of a leading medieval town. The point estimates, which I report in column (4), are similar to those in the baseline specification. The only difference is that the effect of rural failed markets is now marginally significant.

*Top-coding of nighttime light intensity.* As discussed in Section 2.2, because of the high amplification used to observe low levels of light, NOAA's sensor is saturated in the brightest locations. Consequently, light intensity in these cells is top-coded. In column (5), I check whether my results are sensitive to this type of censoring by using the 2011 calibrated data set instead. As is apparent, my results are robust to the use of the non-coded data set.

*Local characteristics.* The inclusion of county fixed effects allows me to control for time-invariant regional specific fixed effects that may have determined growth patterns both during the middle ages and more recently. However, I cannot rule out the existence of factors that are operating at a smaller level. To test this possibility, column (6) includes NUTS-3 fixed effects instead of county fixed effects. The coefficients are in line with those obtained in the baseline specification.

*Spatially correlated standard errors.* Spatially correlated errors may be another source of concern for statistical inference. Column (7) reports standard errors which are robust to spatial correlation based on Conley (1999) and assume a linear decay of 100 kilometers. The obtained standard errors are actually smaller than in the baseline specification.

*Alternative estimation method.* As the nighttime light intensity is bounded by 0, taking log leads to many observations being dropped from the sample used in estimation. In column (8),

<sup>35</sup>By choosing a distance of 5 kilometers to the coast, I exclude coastal cells and their immediate neighbors. This reduces the size of the sample by 20%. I choose a smaller threshold for distance to rivers and Roman roads as these are, on average, smaller than the distance to the coast. By choosing a threshold of 2.5 kilometers for rivers and Roman roads, 17% and 23% of observations are excluded from the sample.

I check whether this is a source of bias by re-estimating equation (2.3) using Poisson Pseudo-Maximum Likelihood techniques. The coefficients are now slightly smaller, but remain consistent with the effects found in the baseline specification.

*Alternative classifications.* The analysis has, so far, only considered the urban-rural divide. Table 2.9 in Appendix 2.8.3 considers alternative classifications based on the type of the market, medieval agrarian wealth and the year of establishment.

The first alternative classification I study is that between prescriptive and non-prescriptive markets. Prescriptive markets were held by custom and did not require a royal grant. More than two thirds of prescriptive markets were held in cities while only one in five chartered markets was held in a borough. Estimating equation (2.3) reveals that failed chartered markets are not associated with higher nighttime light intensity once I control for geographic covariates. Prescriptive failed markets are associated with a light intensity that is 30% higher. Prescriptive markets, even when they did not survive into the sixteenth century, may still be indicative of higher growth rates in the middle ages. Consequently, having a prescriptive market could translate into higher levels of development nowadays due to factors that are not related to market survival. Having a surviving prescriptive market increases the light intensity by 37% relative to a failed prescriptive market, while a successful chartered market increases the light intensity by 44% relative to an unsuccessful chartered market. The results are therefore consistent with the previous finding that survival leads to similar increases in light intensity for different types of markets.

A second classification I consider seeks to assess whether the effects documented above are driven by the richest locations in the sample. Panel B shows that this is not the case: failed markets with a lay assessment above and below the median in 1334 are both associated with an increase in nighttime light intensity of 9% and 8%, respectively, the effects being barely significant. Relative to these, successful markets in places with an assessment above and below the median are 46% and 52% more developed nowadays. There is therefore little evidence that agrarian wealth in 1334 is driving the positive effect observed for surviving markets.

The third and final classification looks at the age of markets and distinguishes between early markets (founded before 1250) and late markets (founded after 1250). Panel C shows the results. As was the case previously, the correlation between failed markets and development is weak, especially after controlling for geographic covariates. Locations with a surviving market, on the other hand, show nighttime light intensities that are significantly higher than those in places with a failed market.

#### **2.6.4 Discussion**

The evidence presented in this section shows that locations with a successful medieval market are better developed nowadays. Figure 2.6 displays this pattern for the county of Northumberland. The city of Newcastle emits the largest amount of light at night (dark shades of blue), which is consistent with its position as one of the leading towns in the middle ages. Locations with a surviving market also radiate more light at night (light shades of blue) than locations with a failed

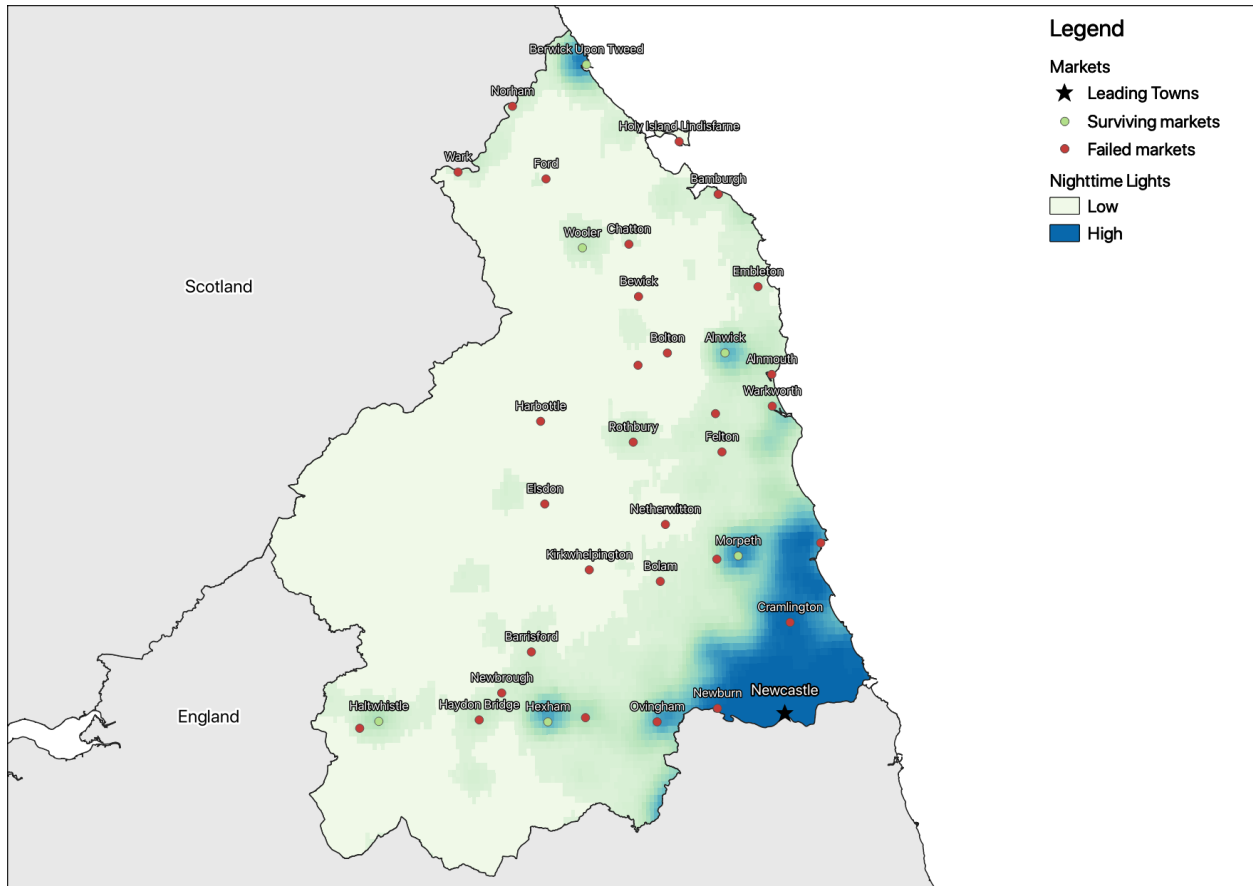


Figure 2.6: Nighttime Lights and Market Survival in Northumberland

Notes: This figure shows the nighttime light intensity and the location of surviving and failed medieval markets in the county of Northumberland. Source: NOAA's National Geophysical Data Center; Campbell (2008); Everitt (1967).

market (dark shades of green), which themselves are occasionally brighter than places without a market (light shades of green).

Do these results imply a causal relationship between medieval markets and contemporary development? Even though the preceding quantitative analysis does not warrant a definite answer, it is worthwhile to discuss the mechanisms that could explain a long-run positive effect of medieval markets. First, the establishment of a market provided local communities with a regular venue where buyers and sellers could meet and engage in trade activities at a relatively low cost. There is a consensus among historians that an important share of the population participated in medieval markets, be it to sell their produce and increase their incomes or buy products at relatively stable prices. Markets had the potential to boost specialization and encourage innovation through higher price transparency, reduced transaction costs and increased competition. The extent to which this actually happened is debatable. If anything, the results in this paper suggest that there was significant heterogeneity among medieval markets, with more than two thirds appearing not to have marked development in the long-run. The earlier proliferation of markets in England relative to its continental neighbors may nonetheless explain the higher market performance in England on the

eve of the Industrial Revolution (Shiue and Keller, 2007).

Second, the functions of medieval markets extended well beyond the simple exchange of merchandise. By the thirteenth century, markets had effectively become the main venue for public gatherings (Masschaele, 2002). Consequently, both secular and church officials used them to diffuse information and directives. For instance, kings often had proclamations read in markets detailing the commercial policies of the kingdom and the status of the coinage. As Masschaele (2002) argues “for the first time in the history of western Europe, peasants and burgesses were being invited into networks of knowledge and communication that previously had extended only to the gentry and the nobility”. In other words, medieval markets may have fostered the emergence of the commercial elite that was to play a significant role in England’s development during the following centuries. Markets also facilitated the development of social networks that no longer stopped at the boundary of the village or town. Information could flow more freely and technology diffuse much faster. The growing importance of medieval markets also prompted institutional change through an increase in regulation. Courts punished anti-competitive practices like forestalling (buying goods before they reached the market in order to increase the price), engrossing (hoarding merchandise in times of expected inflation) and regrating (buying merchandise and reselling it at a higher price in the same market).<sup>36</sup> While the law prohibited the manipulation of prices and quantities (Richardson, 2004), it allowed for tolls to be levied on outsiders and non-burgesses, effectively protecting the commercial interests of local elites.

Third, economic geography theory has highlighted the possibility of multiple spatial equilibria in the presence of increasing returns to scale and transportation costs (Krugman, 1991). These models typically imply an indeterminacy between locations with similar first-nature characteristics. The selected equilibrium depends largely on history. In this sense, medieval markets acted as a coordination device, much like portage sites in the US (Bleakley and Lin, 2012), treaty ports in China (Jia, 2014) or town foundations by administrative fiat in Sweden (Cermeño and Enflo, 2019).

Lastly, it is important to note that the results presented in this study might be driven by an unobserved factor that was responsible for both the success of medieval markets and contemporary development. One likely factor could be geography. That being said, the evidence in Section 2.5 shows little correlation between market survival and the first-nature variables that are most commonly used in the literature. Moreover, most long-term effects are robust to conditioning on them.<sup>37</sup> Another potential confounding factor is human capital. Investments in education may have exhibited significant historical spatial variation that could explain patterns of growth in the middle ages and nowadays. The lack of data on educational attainment in the middle ages at the local level does not allow me to test this hypothesis. The existence of potential confounding

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<sup>36</sup>Securing low food prices and the preventing monopolies figured among the main objectives of market authorities. Thompson (1971)’s “moral economy of the crowd” of the eighteenth century is argued to have medieval origins and be founded in concepts like just price and fair profits (Casson and Lee, 2011)

<sup>37</sup>The results in Table 2.5 show that the coefficients for urban markets and rural successful markets are not significantly affected by the inclusion of first-nature covariates. The coefficient for rural failed markets, on the other hand, is smaller and loses significance after conditioning on geography, which would suggest a selection into treatment for these locations relative to places without a market.

factors, while undermining the case for a causal impact of medieval markets on contemporary development, does not alter the results pertaining to the high persistence of the spatial distribution of economic activity in England and Wales. Overall, the analysis carried out in this study shows that contemporary development is highly correlated with medieval patterns of development, as measured by a higher degree of commercialization.

## 2.7 Conclusion

A growing body of literature documents significant persistence in the spatial distribution of economic activity across and within countries. In this article, I study whether regional patterns of development in England have medieval origins. To this aim, I construct a data set of medieval markets based on Letters et al. (2004) and combine it with contemporary measures of development. My quantitative analysis then proceeds in three steps.

First, I document that medieval markets correlate with economic growth in the middle ages. Wealthier counties exhibited higher market densities and wealthier locations established their markets earlier on. Using tax valuations from the 1334 lay subsidy, I find that annual growth rates were significantly higher for locations with a successful market than for other locations. Second, I show that counties that experienced a more severe population contraction in the wake of the Black Death also witnessed a larger reduction in their market density. The network of markets that emerged in the sixteenth century appears to have been rationalized: markets with better institutional characteristics and located further away from existing trade centers were more likely to survive. Third, I show that locations with a surviving medieval market systematically emit more light at night.

Assessing the importance of the different factors driving the spatial distribution of economic activity is crucial when evaluating the efficiency of spatial policies. If the patterns of development were determined through complex processes, spreading over several centuries if not millenia, then the ability of governments to mitigate spatial disparities would appear as severely limited. The results in my paper document a high persistence in the distribution of economic activity. However, they mask significant changes in the ranking of locations. York and Bristol were the largest towns (after London) from the late middle ages up until the early modern period, where they were overtaken by the new industrialized centers. Liverpool's, Manchester's and Birmingham's population did not exceed 2,000 residents in the medieval period, yet became the largest cities by the nineteenth century. History shapes the distribution of economic activity, but the pattern is not definitive. Achieving a better understanding of the determinants of growth would allow for more efficient spatial policies that help mitigate spatial inequalities.

## 2.8 Appendix

### 2.8.1 Data Description

Variable	Source	Sample	Notes
Market Data	The Gazetteer of Markets and Fairs in England and Wales (Letters et al., 2004)	The gazetteer provides information on all markets established between 700 and 1600 in England and Wales. The final sample includes 2168 locations with a market.	The following data is provided for each location: geographic coordinates, borough status, mint status, assessment in the 1334 lay subsidy, market status in 1600, market type, year of grant, day of the week, identity of the grantee.
Medieval population	Campbell (2008) and Broadberry et al. (2010)	Campbell (2008) provides population estimates for the leading towns in medieval England and Wales. Broadberry et al. (2010) provide estimates of population at the county level for 1086, 1290, 1377 and 1600.	Campbell (2008) assumes a total population of 4 million in 1290 and uses the number of taxpayers in the 1327/1332 and 1377 lay subsidies to estimate urban populations. Broadberry et al. (2010) use a higher population level in 1290, but assume the same county shares as Campbell (2008).
Modern population	The Office for National Statistics Office for National Statistics (2016)	The Office for National Statistics provides the number of residents at different levels of aggregation. I compute the number of individuals at the district and NUTS-3 level. This produces 319 districts and 129 NUTS-3 regions.	London districts are aggregated into 5 larger units for both districts and NUTS-3 regions. Other levels of aggregation are: 10 NUTS-1 regions and 35 NUTS-3 regions. Other statistics included in the data set: educational outcomes, employment status.
Gross value added	The Office for National Statistics (Office for National Statistics, 2018)	The Office for National Statistics provides estimates of the gross-value-added at the regional level for NUTS-3 areas, computed using the income approach. The final sample includes 129 regions.	The London boroughs are aggregated into 5 larger units.

Variable	Source	Sample	Notes
Nighttime light intensity	National Oceanic and Atmospheric Administration (2010)	The Oceanic and Atmospheric Administration produces estimates of the nighttime light intensity and large resolutions. I compute the average nighttime light intensity for every cell of the grid dividing England and Wales. The size of each cell grid is 5×5 kilometers. The sample includes 6592 cells.	The 2011 data set top codes the intensity for the brightest locations. As a robustness check I also use the 2010 Global Radiance Calibrated Nighttime Lights data set.
Distance to Roman roads	The Digital Atlas of Roman and Medieval Civilization (McCormick and project team (eds.), 2013)	The data set provides GIS information on the location of Roman Roads constructed during the Roman occupation of the British Isles.	The distance to Roman roads is the “as the crow flies” distance to the nearest road.
Distance to rivers	Oksanen (2018)	The data set provides GIS information on the location of rives and canals for which there is historical evidence that they were used in medieval times for transport-related activities.	The distance to rivers is the “as the crow flies” distance to the nearest river or canal.
Distance to coast	European Environment Agency	The data set provides geographic information on the British coastline.	The distance to the coast is the “as the crow flies” distance to the nearest coast.
Elevation and ruggedness	U.S. Geological Survey (2000)	the SRTM-1 ArcSecond Global database provides information on digital elevation at a very high resolution.	The ruggedness index is computed following the procedure described in Nunn and Puga (2012).

## 2.8.2 Literature Review

The spatial distribution of economic activity exhibits remarkable variation across and within countries. One theoretical approach views locational fundamentals (also called “first-nature” characteristics) as being the key determinants of such heterogeneity.<sup>38,39</sup> In these models, cities are characterized by an optimal size and are particularly resilient even in the face of large temporary shocks. An alternative view posits that variation in city sizes results from stochastic processes (Gabaix, 1999). Growth follows a random walk and even a small shock has permanent effects. Finally, new economic geography models put the emphasis on economies of scale and the geographic location within the urban network (also referred to as “second-nature” characteristics).<sup>40,41</sup> These models typically generate multiple equilibria and temporary shocks can have permanent effects if they shift the economy into another equilibrium. Still, mean-reversion is not ruled out if path dependence is strong enough.

One straightforward test of these theories consists of investigating the effects of large, temporary shocks. Davis and Weinstein (2002) show that large-scale bombing during World War II had little impact on city size in Japan. By 1960, most cities had returned to their pre-war relative size. The persistence of Japanese cities would therefore favor an explanation based on locational fundamentals. Brakman et al. (2004) reach similar conclusions in their study of the allied bombing of Germany. They document mean-reversion in city sizes for Western Germany although, unlike in Davis and Weinstein (2002), the shock had not fully dissipated by 1963. Similarly, Miguel and Roland (2011) do not find a negative impact of US bombing in Vietnam on population density at the district level by 2002. Koyama, Jedwab, and Johnson (2019) study the effects of a large population shock, the Black Death, on city growth in the late middle ages and early modern period. While most cities recovered their pre-plague populations by 1600, neither mortality rates nor population levels in the aftermath of the plague are accurate predictors of recovery. Locational fundamentals, such as agricultural suitability and access to the transport network, played a much more important role in driving city growth in the post-plague period.

For mean-reversion to occur in models of locational fundamentals, two conditions have to be satisfied. First, the housing supply needs to adjust following the shock and be able to accommodate

<sup>38</sup>For instance, temperate climates (Masters and McMillan, 2001), agricultural suitability (Nunn and Qian, 2011) and coastal access (Rappaport and Sachs, 2003) are singled out as important drivers of economic growth.

<sup>39</sup>Henderson et al. (2018) study the potential of two first-nature characteristics, suitability for growing food and proximity to transportation networks, to account for the worldwide distribution of economic activity. They demonstrate that the importance of agricultural suitability has decreased over time, while that of suitability for trade has increased. In developed countries, however, the distribution of economic activity is shaped relatively more by agricultural productivity, while transportation networks play a more significant role in developing countries.

<sup>40</sup>In the standard two-region, two-sector model with one of the two factors of production spatially mobile and the other immobile, higher trade costs lead to more dispersion (Krugman, 1991). Intuitively, the agglomeration gains are outweighed when trade costs are sufficiently high. In this case, it is advantageous to firms to relocate in the smaller region.

<sup>41</sup>Bosker and Buringh (2017) analyze the importance of first-nature and second-nature geography in the emergence of the European urban network. Their results suggest that first-nature characteristics, and especially access to water and land transportation, were the main determinants of city establishment. Second-nature characteristics also mattered, but to a lesser degree. Close proximity with an already established urban center reduced a location’s own urban chances.

the influx of migrants. Brakman et al. (2004) find that in Eastern Germany, where the government did not support rebuilding efforts, bombing led to permanent changes in the relative size of cities.<sup>42</sup> Second, locational fundamentals need to be constant over time. The English urban network, for example, reconfigured following the collapse of the Roman Empire and favored locations with coastal access. This reflected the comparative advantage of water transport over land transport in the middle ages. In northern France, where the shock was less severe, the network did not reset and cities remained trapped in sub-optimal locations (Michaels and Rauch, 2018).

A more recent literature has shown that temporary, exogenous shocks can have long-lasting effects. Schumann (2014) is the first to have documented such a case for post-war Germany. He compares mid-size localities along the border separating the American and French occupation zones and exploits the fact that German refugees were not allowed to settle in the latter. As a result, villages and towns in the American zone experienced population growth rates that were 21.6% higher in the aftermath of World War II. 80% of this difference could still be observed 20 years after the end of the occupation zone system. Hanlon (2017) studies the impact of the disruption in cotton trade caused by the US Civil War on British cities specializing in the textile industry. He finds that population growth from 1861 to 1871 in exposed cities was 8 to 14 percentage points lower relative to other locations. After the war ended, the difference went back to being insignificant. Thus, the disruption in international trade persistently decreased population levels in exposed cities.

A second test of the theories mentioned above consists of searching for direct evidence of path dependence.<sup>43</sup> Separating the effects of locational fundamentals from path dependence is difficult as the former tend to be remarkably persistent over time. Bleakley and Lin (2012) overcome this issue by studying portage sites in the US. During the settlement of North America, portage sites benefited from natural advantages that enhanced their trade opportunities. Urban centers emerged at most intersections of a river and the Atlantic Seaboard Fall Line. With transport technology improving in the early to mid-1800s, this advantage disappeared. Yet, portage continues to correlate with population density today. These results cast doubt on theories of locational fundamentals. Population did not relocate to places whose natural advantage did not become irrelevant, as the latter predict. Instead, Bleakley and Lin (2012) argue that historically sunk investments at portage sites helped solve the coordination problems that arise in setups with strong scale effects and potentially multiple equilibria.

Additional evidence on path dependence is provided in Jia (2014), Jedwab and Moradi (2016) and Cermeño and Enflo (2019). Jia (2014) investigates whether Chinese prefectures that became treaty ports during the 19th century experienced different growth patterns relative to neighboring cities. She finds that the population rose in treaty ports at a faster rate, a trend that was interrupted

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<sup>42</sup>Chaney and Hornbeck (2016) discuss the institutional obstacles to population recovery in the Muslim-populated areas of the Kingdom of Valencia following the expulsion of Moriscos in 1609. The persistence of extractive institutions prevented labor mobility, which in turn delayed convergence in population.

<sup>43</sup>Allen and Donaldson (2018) develop a state-of-the-art model of path dependence in which initial conditions determine long-run steady-state outcomes. Simulating the model for the US, they find that local historical shocks can have a significant impact on the spatial distribution of economic activity, highlighting the potential for path dependence.

by the Communist revolution. By restricting the sample to cities near the coast and along the Yangtze river, these results point towards a higher importance of path dependence relative to locational fundamentals. Jedwab and Moradi (2016) exploit the construction of the Mombasa-Lake Victoria railway in Kenya as a natural experiment to identify path dependence. They show that proximity to the railway line led to higher European and Asian settlement in the decades leading up to independence. They also find that urban population in 1962 is positively correlated with population in the decades following the departure of European and Asian settlers and the demise of the railroad network. Using historical data on town foundations by the Swedish crown in the early modern period, Cermeño and Enflo (2019) document persistence only after the trade monopolies granted to these cities expired. They argue that initial trade advantages and sunk investments increased expectations about future growth, spurring agglomeration in later centuries. Their results stress the importance of path dependence in explaining contemporary agglomeration in locations that lacked initial natural advantages.

A third test consists of searching for multiple equilibria. While theories of locational fundamentals predict a unique steady state, this is not necessarily the case in models with increasing returns. Davis and Weinstein (2008) argue for the existence of a unique steady-state equilibrium in the context of post-war Japan. Using the same methodology, Bosker, Brakman, Garretsen, and Schramm (2007) find that Germany in the aftermath of World War II was best described by a model with two stable equilibria. Redding, Sturm, and Wolf (2011) use the division and reunification of Germany to identify exogenous shocks to a specific industry, namely the air hub industry. Following division, Frankfurt replaced Berlin to become Germany's main air hub. They provide convincing evidence that this corresponded to a shift between multiple steady states, the differences between all potential locations being marginal. If Frankfurt ended up being selected, it was only because of small historical shocks, such as the US army's decision to use Frankfurt's airport as their European terminal.

Overall, the existing literature documents high spatial persistence of economic activity over time. This is at odds with predictions of random growth theories, which argue that even small, temporary shocks should have permanent effects. The existence of path-dependence and multiple equilibria favors explanations rooted in new economic geography models. This does not, however, make locational fundamentals irrelevant. The evidence suggests that locational fundamentals, such as portage suitability, helped solve coordination problems and explain why economic activity ended up locked in given locations to begin with.

## 2.8.3 Additional Tables

Table 2.6: Medieval Market Locations – Descriptive Statistics

	All markets: 2168 locations				Borough markets: 718 locations			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Prescriptive	9.30	0.46	0	1	0.61	0.49	0	1
Chartered	0.70	0.46	0	1	0.39	0.49	0	1
Establishment year	1243.49	94.52	601	1582	1182.21	122.50	601	1492
Mint	0.05	0.22	0	1	0.14	0.35	0	1
Market c. 1600	0.34	0.47	0	1	0.66	0.47	0	1
1334 lay subsidy	79.88	275.15	0	11000	118.88	480.09	0	11000
Altitude (m)	67.35	53.47	0	346	68.42	53.99	0	273
Ruggedness	1.25	1.04	0	12.50	1.34	1.13	0	9.75
Distance to coast (km)	34.65	29.69	0.01	119.33	35.11	31.80	0.02	117.89
Distance to river (km)	10.57	9.21	0	60.95	10.70	10.43	0	54.59
Distance to Roman road (km)	9.17	14.40	0	145.89	11.40	17.85	0	140.03
Latitude	52.23	1.12	50.08	55.77	52.16	1.23	50.08	55.77
Longitude	-1.29	1.61	-5.62	1.75	-2.08	1.48	-5.54	1.73

Notes: The market data come from Letters et al. (2004). For each location, only the earliest known market is kept. The following counties were either not assessed in the 1334 lay subsidy or the assessment is unavailable: Cheshire, County Durham and Kent, as well as Wales. Geographic variables are constructed using GIS software.

Table 2.7: Medieval Markets and Long-Run Growth

	Surviving markets			Failed markets		
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: log(Population density)</i>						
Market density	1.222*** (0.230)	0.919*** (0.139)	0.595*** (0.159)	−0.176 (0.213)	−0.158 (0.194)	−0.177 (0.174)
R-squared	0.194	0.346	0.468	0.011	0.255	0.421
<i>Panel B: log(GDP per capita)</i>						
Market density	0.263** (0.105)	0.174** (0.070)	0.160* (0.090)	−0.026 (0.031)	−0.003 (0.030)	−0.072 (0.072)
R-squared	0.149	0.338	0.326	0.004	0.279	0.286
<i>Panel C: log(Nighttime light)</i>						
Market density	0.541*** (0.120)	0.356*** (0.092)	0.201** (0.085)	−0.057 (0.102)	−0.044 (0.082)	0.014 (0.064)
R-squared	0.123	0.282	0.406	0.004	0.236	0.386
Observations	129	129	121	129	129	121
Baseline controls:						
Transport infrastructure	No	Yes	Yes	No	Yes	Yes
Geographic covariates	No	Yes	Yes	No	Yes	Yes
Historical county FE	No	No	Yes	No	No	Yes

Notes: All regressions are estimated by ordinary least squares. The dependent variable is calculated at the NUTS-3 statistical region level. The market density is defined as the number of markets in an area of 100 square miles. Standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 2.8: Medieval Markets and Long-Run Growth – Robustness Checks  
Dependent variable:  $\log(\text{Nighttime light intensity})$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Borough market	0.263*** (0.054)	0.228*** (0.044)	0.236** (0.083)	0.268*** (0.056)	0.194*** (0.052)	0.266*** (0.060)	0.263*** (0.053)	0.177*** (0.045)
Non-borough market	0.073 (0.045)	0.048 (0.037)	0.032 (0.048)	0.101* (0.045)	0.057 (0.050)	0.075* (0.040)	0.073* (0.041)	0.024 (0.043)
Surviving borough market	0.314*** (0.049)	0.277*** (0.046)	0.342*** (0.052)	0.281*** (0.052)	0.309*** (0.072)	0.311*** (0.049)	0.314*** (0.050)	0.232*** (0.051)
Surviving non-borough market	0.291*** (0.050)	0.289*** (0.054)	0.310*** (0.046)	0.288*** (0.051)	0.202** (0.063)	0.286*** (0.035)	0.291*** (0.043)	0.261*** (0.057)
<u>Baseline controls:</u>								
$\log(\text{Distance to coast})$	-0.093** (0.040)	-0.082** (0.035)	0.038 (0.159)	-0.090* (0.044)	-0.033 (0.039)	-0.147*** (0.026)	-0.093** (0.040)	-0.057 (0.037)
$\log(\text{Distance to river})$	-0.143*** (0.031)	-0.126*** (0.023)	-0.142*** (0.041)	-0.129*** (0.032)	-0.156*** (0.036)	-0.128*** (0.025)	-0.143*** (0.025)	-0.115*** (0.020)
$\log(\text{Distance to Roman road})$	-0.093*** (0.024)	-0.078*** (0.020)	-0.075*** (0.022)	-0.093*** (0.025)	-0.087*** (0.022)	-0.078*** (0.019)	-0.093*** (0.024)	-0.061*** (0.016)
$\log(\text{Elevation})$	-0.037 (0.080)	-0.014 (0.063)	-0.054 (0.092)	-0.039 (0.076)	-0.019 (0.062)	-0.020 (0.074)	-0.037 (0.058)	-0.012 (0.042)
$\log(\text{Ruggedness})$	-0.337** (0.135)	-0.279** (0.093)	-0.480** (0.169)	-0.342** (0.134)	-0.332** (0.128)	-0.412*** (0.093)	-0.337** (0.131)	-0.174* (0.102)
Observations	6,156	5,848	4,970	5,234	6,148	6,156	6,156	6,156
R-squared	0.433	0.400	0.475	0.429	0.386	0.535	0.160	0.306

Notes: This table shows robustness checks for the results presented in Table 2.5. Specifications in columns (1) through (7) are estimated by ordinary least squares. The specification in column (8) is estimated by Poisson pseudo-maximum likelihood. Column (1) reports results from the baseline specification. The sample used in column (2) excludes the top and bottom 2.5% of the nighttime light distribution. The sample used in column (3) excludes locations within 5 kilometers of the coast. The sample used in column (4) excludes locations within 5 kilometers of a leading town. The dependent variable in column (5) is constructed using the radiance-calibrated version of the nighttime light intensity data set. In column (6), the fixed effects control for NUTS-3 characteristics instead of county characteristics. All other regressions include county-specific fixed effects. Column (7) reports Conley (1999) standard errors with a 100-km kernel. In all other regressions, standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 2.9: Medieval Markets and Long-Run Growth - Alternative Classifications  
 Dependent variable: log(Nighttime light intensity)

	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Medieval Markets by Type and Survival Status</i>						
Prescriptive market	0.634*** (0.102)	0.482*** (0.065)	0.443*** (0.048)	0.360** (0.121)	0.220** (0.097)	0.251*** (0.057)
Surviving prescriptive market				0.450*** (0.082)	0.430*** (0.093)	0.314*** (0.059)
Chartered market	0.312*** (0.085)	0.162*** (0.035)	0.176*** (0.044)	0.223** (0.096)	0.050 (0.047)	0.074 (0.048)
Surviving chartered market				0.319** (0.107)	0.405*** (0.078)	0.366*** (0.052)
<i>Panel B: Medieval Markets by Wealth and Survival Status</i>						
Wealthy market	0.458*** (0.093)	0.296*** (0.064)	0.277*** (0.035)	0.238** (0.098)	0.054 (0.067)	0.090* (0.043)
Surviving wealthy market				0.462*** (0.073)	0.502*** (0.068)	0.379*** (0.049)
Non-wealthy market	0.195** (0.085)	0.185** (0.068)	0.188** (0.060)	0.102 (0.085)	0.069 (0.068)	0.078 (0.066)
Surviving non-wealthy market				0.346** (0.115)	0.436*** (0.106)	0.419*** (0.077)
<i>Panel C: Medieval Markets by Age and Survival Status</i>						
Early market	0.583*** (0.105)	0.402*** (0.046)	0.371*** (0.040)	0.316** (0.125)	0.122 (0.070)	0.122** (0.045)
Surviving early market				0.496*** (0.085)	0.520*** (0.076)	0.458*** (0.045)
Late market	0.285** (0.095)	0.163** (0.056)	0.185** (0.059)	0.244** (0.100)	0.088 (0.057)	0.116* (0.059)
Surviving late market				0.176* (0.085)	0.322*** (0.093)	0.289*** (0.076)
<u>Baseline controls:</u>						
Transport infrastructure	No	Yes	Yes	No	Yes	Yes
Geographic covariates	No	Yes	Yes	No	Yes	Yes
Historical county FE	No	No	Yes	No	No	Yes

Notes: All regressions are estimated by ordinary least squares. In Panel A, markets are classified according to their type: prescriptive markets were held by custom, while chartered markets were set up by a royal grant or charter. In Panel B, markets are classified according to the level of subsidies they paid in 1334: wealthy markets paid subsidies higher than the median, while non-wealthy markets paid subsidies lower than the median. In Panel C, markets are classified according to their age: early markets were established before 1200, while late markets were established after 1250. Standard errors, clustered at the NUTS-1 level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

## 2.8.4 Additional Figures

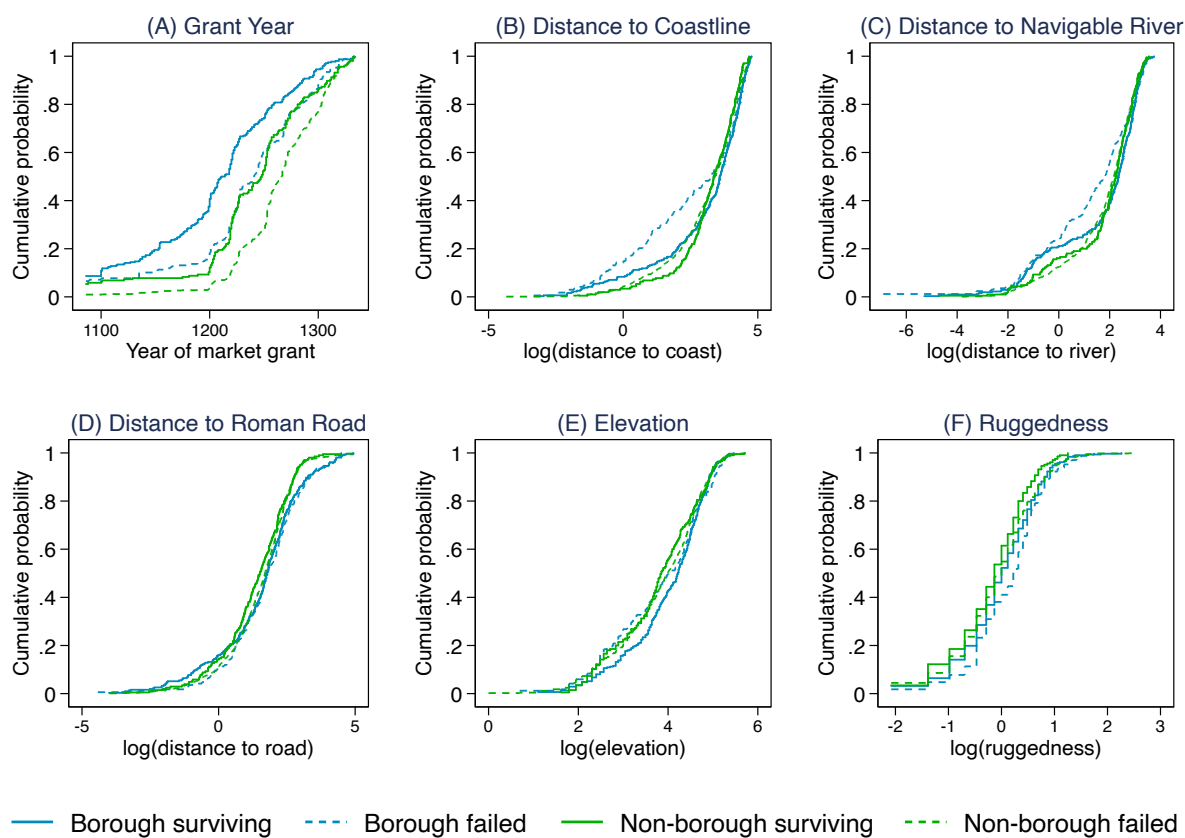


Figure 2.7: CDFs for Main Variables by Urban and Surviving Status

Notes: This figure shows the cumulative probability for different variables by distinguishing places by urban status and the survival of the market into the sixteenth century.



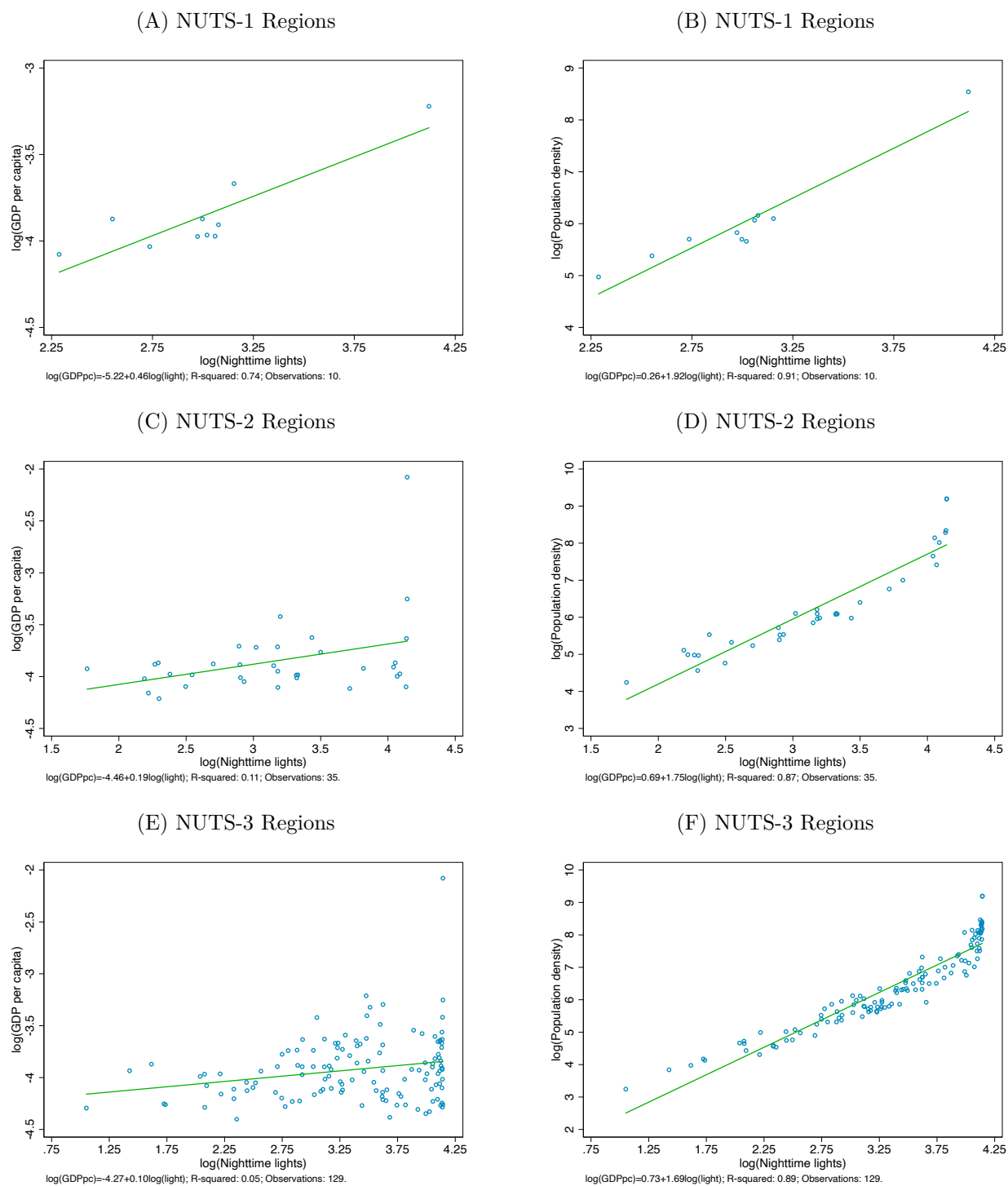


Figure 2.9: Nighttime Lights, Population Density and GDP per capita

Notes: These figures show the correlation between nighttime light intensity and GDP per capita and population density, at different aggregation levels. Source: NOAA's National Geophysical Data Center; Office for National Statistics.

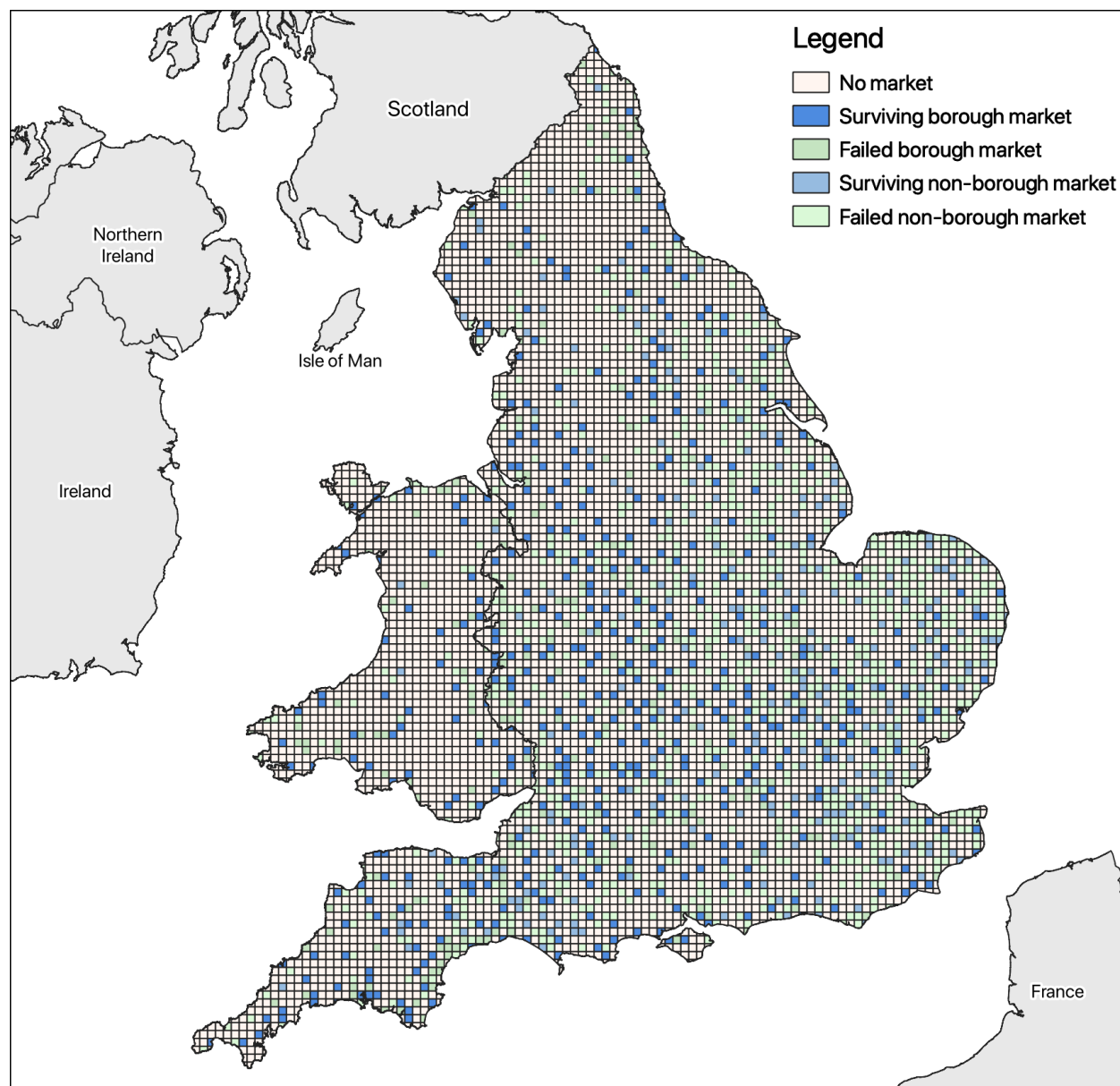


Figure 2.10: Cells with Surviving/Failed Medieval Markets

Notes: This figure shows the 6592 cells that make up England and Wales. Different colors indicate whether there was a market established in a given grid cell, as well as its urban status (borough v. non-borough) and survival status (surviving v. failed).

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## Chapter 3

# Asylum Policies, International Tensions and Trade Flows

### Abstract

This chapter studies the relationship between asylum policies and international tensions. To this aim, we construct a data set of asylum applications in the European Union from 1999 to 2017. We show that, in addition to humanitarian conditions in the origin country, asylum policies are correlated with several measures of international rivalry. Specifically, we provide evidence that EU countries are more likely to accept refugees fleeing rival states, even after controlling for conflict and political terror in the origin country. We use this result to rationalize a robust and negative relationship between asylum policies and European imports from the rest of the world.

**JEL codes:** F14, F22, F59

**Keywords:** asylum, refugees, recognition rates, international relations, international trade



### 3.1 Introduction

Over the past several years, the European Union has witnessed a surge in the number of individuals seeking asylum on its soil.<sup>1</sup> As Figure 3.1 illustrates, the number of asylum demands doubled in less than a year, exceeding one million applications in 2016 and 2017. The ensuing public debate did not focus exclusively on the international humanitarian context. National security, economic and cultural concerns received extensive treatment in the media as well (Berry, Garcia-Blanco, and Moore, 2016). In this article, we study the extent to which non-humanitarian factors, such as political economy considerations, shape asylum policies and highlight their importance for empirical studies in international trade.

The existing literature documents significant variation in asylum recognition rates (i.e. the share of asylum seekers who are granted refuge) across EU states, even among individuals originating from the same country (Neumayer, 2005a). As an example, Table 3.1 shows the number of asylum applications from Turkish citizens in Great Britain, Germany and France from 1999 to 2017. Despite having received a similar number of demands, Germany admitted substantially more Turkish refugees than France, its recognition rate being twice as large as the French rate. Great Britain received substantially fewer applications, yet had an acceptance rate in between those of France and Germany. The apparently different treatment of asylum seekers facing similar conditions of oppression and political terror in their home country is at odds with a normative view of asylum policies, according to which demands should be evaluated exclusively in terms of their humanitarian merit.

A simple model that would rationalize the observed heterogeneity in asylum policies is to assume that governments derive utility from providing assistance to refugees and other activities. At the optimum, the marginal utility of refugee assistance should equal that of other activities. If diplomatic interests or national security concerns make up an important part of the non-assistance-related activities, then utility maximization will lead to variation in recognition rates across countries, even among refugees from the same country of origin. In this article, we focus on one such non-humanitarian factor, namely foreign policy concerns.

The idea that asylum policies are informed by diplomatic considerations is not new and has received significant treatment in the political science literature. Scheinman (1983) argues that asylum policies have become a tool of the receiving state's foreign policy vis-à-vis the sending country, a view that is further explored by Teitelbaum (1984). As the argument goes, host countries admit refugees in order to signal human rights violations in the origin country and mount, in this way, international pressure on adversary regimes.<sup>2</sup> Similarly, governments should be less inclined to

<sup>1</sup>Throughout this paper, we refer to individuals filing a request for refuge as asylum seekers. Asylum seekers whose requests are approved become refugees, while those whose requests are denied lose the right to stay in the host country and may be deported.

<sup>2</sup>Alternative motivations are possible. Refugee admissions may create dissident communities in exile or drain the origin country of human capital. Concerns about relations with a third party may also play a role in shaping asylum policies. Basok (1990) asserts that the Costa Rican government adopted a more generous asylum policy towards Nicaraguan refugees relative to Salvadorans in an attempt not to antagonize the United States, an important aid donor.

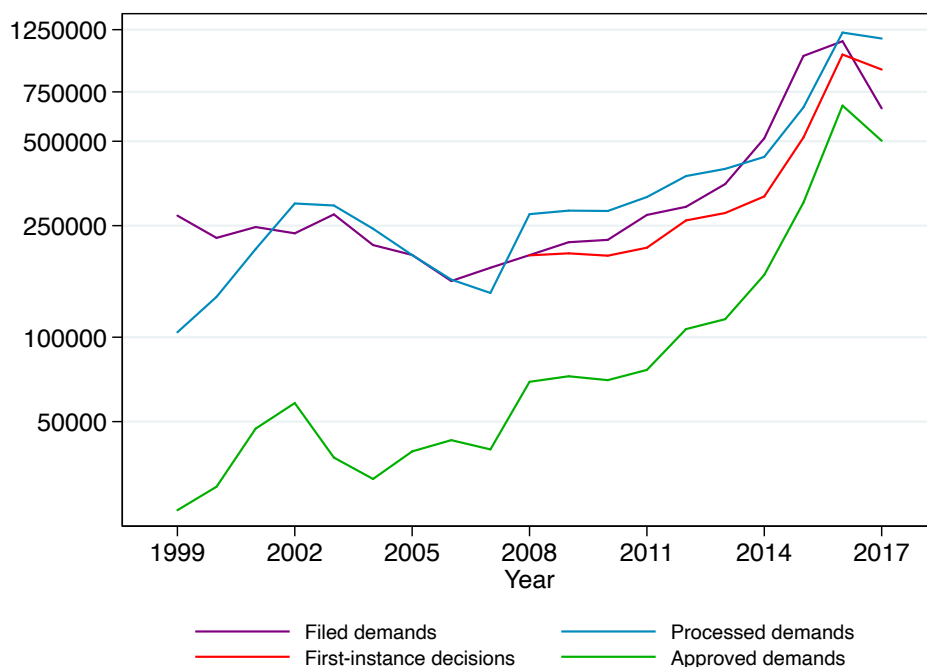


Figure 3.1: Evolution of Asylum Applications in the EU

Notes: This figure shows the evolution of asylum applications in the EU-15 countries from 1999 to 2017. The number of filed demands corresponds to the number of applications for asylum submitted in a year. The number of processed demands corresponds to the number of applications for which a decision was made. First-instance decisions refer to decisions made in response to a demand at the first instance level of the procedure. The number of approved demands corresponds to the number of applications for which a positive decision was made and includes both first-instance and final decisions. Data for the following countries is missing: Belgium (2002, 2007), Germany (1999, 2000), Denmark (2002), Spain (1999, 2000), Great Britain (1999-2001), Greece (1999-2002), Ireland (2000-2002), Italy (1999, 2007), the Netherlands (2007) and Portugal (1999).

grant asylum to individuals fleeing partner countries, as this could generate bilateral tensions and be construed by domestic opposition groups as evidence of complicity with an oppressive regime.

History provides many examples of strategic admissions of refugees, ranging from the massive inflow of asylum seekers in the US fleeing communist countries during the Cold War, to Tanzania's more benevolent attitude towards refugees from Burundi as compared to Rwandans (Jacobsen, 2002). Quantitative studies of political determinants of asylum policies include Rosenblum and Salehyan (2004), Salehyan and Rosenblum (2008), Moorthy and Brathwaite (2016) and Jackson and Atkinson (2019). We build on this previous work and estimate the relevance of political economy determinants in shaping asylum policies in the EU from 1999 to 2017. To this aim, we build a matrix of bilateral refugee flows using data provided by Eurostat (2018). Specifically, for each bilateral pair, we observe the number of filed applications, the number of processed demands and the number of positive decisions. We also gather data on measures of conflict and political violence in the origin states, as well as measures of bilateral cooperation, including voting in the UN General Assembly, free trade agreements and international incidents.

Consistent with the evidence in Hatton (2016) and Neumayer (2005a,b), we find that both

Table 3.1: Recognition Rates for Turkish Asylum Seekers

	Processed applications (1)	Positive decisions (2)	Recognition rate (%) (3)
Great Britain	17295	2580	15
Germany	71230	13270	19
France	80055	7450	9

Notes: This table shows the total number of applications filed by Turkish asylum seekers in three EU countries from 1999 to 2017. We also show the number of positive decisions (applications which led to the grant of refugee status) and the corresponding recognition rate.

asylum seeker flows and recognition rates increase in response to humanitarian crises in the countries of origin. However, our results also show that, conditional on humanitarian conditions, European countries are more likely to admit refugees coming from rival countries. In particular, recognition rates are negatively correlated with an index of voting similarity in the UN General Assembly and the presence of a free trade agreement. Moreover, we show that international disputes are associated with higher recognition rates, while episodes of cooperation are associated with lower recognition rates. It is important to mention that our regressions include country-pair fixed effects, such that all bilateral, time-invariant factors such as history or cultural proximity are controlled for. In sum, we show that previous results in the political science research survive a more rigorous quantitative assessment.

The second main contribution of our paper is to assess the relevance of our results for the empirical international trade literature. Several recent studies have used refugees as an instrument for migrant flows in order to estimate the pro-trade effects of migration (Steingress, 2018; Parsons and Vézina, 2018). If our argument is correct and asylum policies are indeed informed by considerations related to strategic and diplomatic interests, then it seems unlikely that the exclusion restriction will be met in more general setups.

We test this hypothesis by estimating the relationship between international trade flows and asylum policies using a gravity regression model. We find a robust, negative correlation between European imports and both the number of refugees and asylum recognition rates. The effect, however, is not persistent, and appears to fade away in two-to-three years. Moreover, we find evidence that the effect is mainly driven by trade in homogeneous goods. We conjecture that, for this type of products, the positive effects related to a larger diaspora (for instance, reduced informational costs) are minimal and therefore dominated by the component capturing international tensions. We do not find evidence of a contemporaneous effect for European exports. While our results rely mainly on correlations, they invite nonetheless to caution when using refugee flows as an instrument for international migration.

Our paper contributes to three main strands in the literature. First, it speaks to the scholarship that studies the determinants of asylum policies.<sup>3</sup> Neumayer (2005a) documents significant

<sup>3</sup>Chin and Cortes (2015) provide a recent survey of the literature on asylum seeker and refugee flows. Becker and Ferrara (2019) review the evidence on economic and political consequences of forced migration. In addition to this,

variation in refugee acceptance rates across European countries from 1980 to 1999 and a lack of convergence in asylum policies. He shows that recognition rates are nonetheless sensitive to humanitarian conditions in the origin country and, to some extent, to the economic conditions in the destination country. Hatton (2009) confirms the importance of humanitarian conditions in shaping asylum policies and finds that tougher admission policies explained only a third of the sharp drop in applications that occurred from 2001 to 2006. We contribute to this literature by studying the political economy considerations that affect admission rates. In particular, we show that recognition rates are correlated in a robust and significant way with bilateral measures of international tensions.

Second, our paper speaks to a large body of work studying the relationship between migration and international trade.<sup>4</sup> The existing literature has firmly established a positive correlation between migrant networks and international trade (Gould, 1994; Head and Ries, 1998; Dunlevy and Hutchinson, 1999; Girma and Yu, 2002; Rauch and Trindade, 2002). Within this literature, several recent studies have measured a positive causal effect of migrant stocks on trade flows. Parsons and Vézina (2018) use the random allocation of Vietnamese refugees across US states to identify pro-trade effects after trade restrictions with Vietnam were lifted in 1994. Steingress (2018) uses the random allocation of political refugees across US states as an instrumental variable and demonstrates that higher stocks of recent immigrants raise both imports and exports with the immigrants' origin countries. Bahar, Hauptmann, Özgüzel, and Rapoport (2018) use the repatriation of Yugoslavian refugees under temporary protection in Germany to study the link between migration and trade. They find a high elasticity of trade with respect to return migration. In contrast to these results, we document a robust, negative correlation between asylum policies and trade patterns. While not causal, this result is nevertheless surprising and we rationalize it as being confounded by international tensions.

Insofar as the negative correlation between asylum policies and trade flows is due to interstate rivalries, our study is also related to the literature on the deleterious effects of conflict on trade. Michaels and Zhi (2010), Fuchs and Klann (2013), Davis, Fuchs, and Johnson (2019) and Crozet and Hinz (2016) provide ample evidence of the negative impact of international tensions and conflicts on bilateral trade flows. By connecting asylum policies to interstate conflicts, our study shows how the latter could potentially confound the relationship between refugees and trade.

The remainder of the paper proceeds as follows. Section 3.2 presents the data and the methodology used to construct the final sample. In Section 3.3, we discuss the complex relationship between asylum policies and international tensions and provide empirical evidence on it. Section 3.4 introduces the theoretical framework that we use to study the link between international trade flows and asylum policies and the estimation method we employ. Section 3.5 presents the results. Finally, Section 3.6 concludes. Appendix 3.7 provides additional material.

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Brell, Dustmann, and Preston (2020) discuss the labor market integration of refugees.

<sup>4</sup>Refugees differ from other migrants in several respects. First, they are more likely to report exposure to persecution prior to migration. Second, there is less selection on characteristics valued in the labor market. Refugees exhibit lower educational attainment, lower linguistic aptitudes and worse health (Chin and Cortes, 2015).

## 3.2 Data

This study uses data from various sources. In this section, we discuss the data sets and outline the methodology employed to construct the final sample.<sup>5</sup> We also present summary statistics.

### 3.2.1 Data Sources

The core of this paper analyzes the interplay between the normative and interest-based factors that shape asylum policies in the EU. We use the data sets on asylum applications compiled by Eurostat, the Statistical Office of the European Union. Eurostat provides the number of annual demands processed in every EU member state from 1999 to 2017.<sup>6</sup> It is important to note that the number of processed applications (i.e. applications for which a decision was made) is not equal to the total number of claims filed in a given year, although they are highly correlated. In this article, we focus on processed applications because they enter as the denominator in the formula for recognition rates. Another methodological issue is related to the type of decisions reported in the data sets. Prior to 2008, Eurostat did not distinguish between first-instance and final decisions. For the post-2008 period, we combine the first-instance and final decision samples and compute the total number of applications. In order to account for this change in reporting, we include year fixed effects in all specifications. Finally, we disregard all internal flows within the EU as they never materialize into the grant of asylum. We thus construct a matrix of bilateral recognition rates, defined as the share of asylum seekers from a given non-EU country who were granted protection in a EU country. The final sample consists of 27 EU countries (including Great Britain) and 145 non-EU countries.<sup>7</sup>

To study the determinants of asylum policies, we use information on humanitarian conditions in refugees' countries of origin, as well as bilateral measures of interstate relations. The normative variables capturing humanitarian conditions include the intra-national conflict score (Marshall, 2018) and the political terror scale (Gibney, Cornett, Wood, Haschke, Arnon, and Pisanò, 2018). The conflict score is the summed magnitude of several measures of societal and inter-state violence, each ranging from 0 (lowest magnitude) to 10 (highest magnitude). This measure captures direct threats to the safety of an individual, such as war or civil violence.<sup>8</sup> The political terror scale captures the degree of political violence and ranges from 1 in countries with a secure rule of law to 5 in countries with generalized violations of civil and political rights. In contrast to the conflict score, the political terror scale reflects institutionalized forms of oppression.

The measures for interstate tensions include an index of voting similarity in the UN General

<sup>5</sup>Appendix 3.7.1.1 lists the main variables, their source and coverage and describes how we process them.

<sup>6</sup>Not all member states reported asylum statistics in every year of the period we study. New member states typically start reporting asylum statistics much later. For instance, Croatian data are available only from 2012. Appendix 3.7.1.3 discusses in greater detail the implications of missing values in our study.

<sup>7</sup>We observe asylum outcomes for the 28 countries of the European Union. Because in the trade data Luxembourg and Belgium form a single entity, we aggregate the asylum data for these two countries as well. We further drop non-European countries that did not send any refugees throughout the sample period. Table 3.9 in Appendix 3.7.3 lists the countries included in our sample.

<sup>8</sup>The complete list of these events is available at <https://www.systemicpeace.org/warlist/warlist.htm>

Assembly and an indicator variable for the presence of a free trade agreement (FTA). The UN voting index is computed as the probability that two states voted in the same way in a given year and uses data from Voeten, Strezhnev, and Bailey (2009).<sup>9</sup> We only consider votes marked in the database as important, as these are more likely to capture international relations.<sup>10</sup> The FTA dummy variable is taken from the CEPII database (Head, Mayer, and Ries, 2010) and takes the value 1 if there is a bilateral free trade agreement between the two countries.

We complement this data with information on the occurrence of international events. We use the Global Data on Events, Location and Tone (GDELT) to construct a bilateral matrix of international incidents. The GDELT data set contains more than 200 million geolocated reports from 1979 to the present.<sup>11</sup> Because our focus is on inter-state tensions, we include only events that involve national governments. Furthermore, we keep events that are marked in the original data set as important. Overall, we identify 11,783 international incidents that can be classified as conflicts and 91,413 incidents that can be classified as episodes of cooperation. Table 3.10 in Appendix 3.7.3 breaks down events by category.<sup>12</sup>

Finally, we use the BACI database to construct a bilateral matrix of trade flows. The BACI data set is based on UN Comtrade data and reports trade flows between country pairs at the HS6 level since 1995 (Gaulier and Zignago, 2010). We aggregate these flows at the country pair level.

### 3.2.2 Descriptive Statistics

Figure 3.1 shows the evolution of the total number of asylum claims from 1999 to 2017. Because data are unavailable for many of the new member states in the beginning of our sample period, we restrict the sample to the EU-15 countries. Several patterns emerge. First, the number of asylum applications in the 2000s averaged 250,000 per year. With the outbreak of the European Migrant Crisis in 2015, this figure multiplied by a factor of 4 (the peak started around 2008 with the conflicts in Iraq and Afghanistan). Second, the number of processed claims was highly correlated with the number of filed applications. The coefficient of correlation between the two series is 0.86. Third, prior to the crisis, the number of processed claims exceeded that of filed applications, as the former also includes appeals to first-instance rulings. On average, first-instance rulings accounted for 70% of the total number of decisions. Fourth, the number of approved applications increased even before 2015, although growth rates have since accelerated.

Another important feature of the asylum data is the geographic concentration of asylum seekers. The EU-15 countries received more than 95% of the total number of applications and 3 countries,

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<sup>9</sup>The UN affinity index is equal to the ratio of the number of votes when both states agree (they either both vote “yes” or both vote “no”) to the total number of joint votes. Davis et al. (2019) and Umana Dajud (2013) use the voting similarity index as a measure of political proximity.

<sup>10</sup>For instance, voting similarity with the US is extremely low when including non-key votes. Focusing on important votes produces greater similarity between the European bloc and the US.

<sup>11</sup>We present in Appendix 3.7.1.2 the procedure we employ to create the international event matrix.

<sup>12</sup>Verbal disputes make up 63% of the total number of conflicts. Expressing disapproval is the most common form of verbal dispute. Among material conflicts, coercing and reducing relations are most recurrent. Verbal agreements account for almost 95% of cases of cooperation. Consulting is the most common form of verbal cooperation. Yielding and providing aid are the most common forms of material cooperation.

France, Germany and Great Britain, accounted for more than 50% of the asylum claims in our data set. Furthermore, as Panel A of Figure 3.5 in Appendix 3.7.4 shows, not only did the average number of asylum demands increase significantly, but so did its standard deviation. Over the period we study, a small number of origin countries made up an increasing share of asylum demands. The five countries that sent the highest numbers of asylees accounted for 33% of applications in 2010 and 40% in 2014; in 2016, the top five countries made up 60% of demands.

Panel B of Figure 3.5 shows the average recognition rate in every sample year. Following relatively high levels in the beginning of our sample period, acceptance rates experienced consequential declines in the early 2000s. This pattern does not appear to be an artifact of the changing composition of our sample during this period, as similar declines can be observed in most of the countries in our sample. Starting in 2005, acceptance rates steadily increased before jumping to 26% in 2014 and remaining constant thereafter. Despite having significantly fewer demands, new member states exhibit similar recognition rates as the EU-15 countries. Throughout the period, the average recognition rate was 20%.<sup>13</sup>

The average conflict score was marginally higher in the beginning of our sample period and stable subsequently as demonstrated in Panel C. There was significant variation across countries, the 95% confidence interval being particularly wide.<sup>14</sup> In sharp contrast, none of the EU countries experienced any episode of violence from 1999 to 2017. The evolution of the average political terror scale over time follows an inverted-U shape (Panel D). Among the countries with the most severe violations of political freedom one finds Afghanistan, the Congo, Iraq, North Korea, Sudan, Syria and Yemen. The average political terror scale is significantly lower for EU countries (1.61) than for non-EU countries (2.84).

Similarity in voting patterns in the UN General Assembly shows remarkable shifts over time, starting from 80% in 1999 and dropping to 60% in less than three years. Towards the end of the period we study, there is evidence of an increasing trend in voting similarity. Among the larger countries, South Korea, the Ukraine, Japan, Serbia and New Zealand vote systematically along European lines, while North Korea, Syria, Iran, Cuba and China show the largest dissimilarity. The probability that a non-European country and a EU member state are linked through a free trade agreement increased over time (Panel F). There was a jump in this probability in 2004 when, in addition to an association agreement with Egypt being ratified, the new member states entered free trade agreements with a number of non-European countries. A significant increase also occurred in 2008 when the CARIFORUM-EU Economic Partnership Agreement came into force, followed by other free trade agreements in the late 2010s.

<sup>13</sup>The average probability of an asylum seeker being granted refugee status was slightly higher, around 27%.

<sup>14</sup>The countries experiencing the largest internal conflicts were Afghanistan (1999-2001), Angola (1999-2002), the Congo (2013-2017), Ethiopia (1999-2000), Iraq (2003-2010), the Philippines (1999-2000), Pakistan (2005-2017), Serbia (1999), Sudan (1999-2017), Syria (2011-2017) and, surprisingly, India (1999-2017). The high magnitude for the latter is due to ethnic tensions in the north-east.

### 3.3 Asylum Policy and Interstate Tensions

A growing body of work in the political science literature highlights the tension between norms and strategic interests that shape asylum policies. Granting asylum to vulnerable individuals is widely recognized as a fundamental value in western democracies. Receiving refugees is nonetheless a costly action and usually implies strategic trade-offs. This section provides a brief discussion of this literature and documents a significant relationship between asylum policies and international tensions.

#### 3.3.1 Asylum Policies as a Tool of Foreign Policy

The international relations scholarship has approached asylum policies from two, often competing angles. On the one hand, *constructivists* argue that human rights play a key role in international relations. Finnemore and Sikkink (1998), for instance, argue that norms related to the protection against bodily harm are more salient to the general public and more likely to secure the support of the international community. In this context, the last decades have witnessed the emergence of a legal system in which the rights of the *individual* take precedence over traditional notions of *citizenship* (Jacobson, 1996). According to this line of reasoning, the goal of asylum policies is to offer protection to individuals who are subject to discrimination and other forms of abuse in their home country, irrespective of the cost such a policy might entail.

*Instrumentalists*, on the other hand, claim that states are self-interested agents, seeking to maximize a utility function that depends, among others, on their diplomatic and strategic interests. Governments will thus deviate from international commitments whenever it is profitable to do so (Mearsheimer, 1994). This argument allows for the possibility that economic, diplomatic and national security considerations play an equally important role in determining asylum policies.

Foreign policy considerations as a driving factor of asylum policies have received great attention from political scientists. The grant of refuge is often construed by host countries as an overt acknowledgement of serious human rights violations and used to mount international pressure on a rival regime. Teitelbaum (1984) writes that “from the perspective of receiving countries, refugee admission policies have been guided in many important cases by the belief that refugee outflows serve to embarrass and discredit adversary nations”. Furthermore, admitting refugees can encourage the development of dissident communities,<sup>15</sup> as well as deprive rivals of part of their human capital.<sup>16</sup> By the same token, governments should be reluctant to grant protection to asylees from friendly countries. Admitting refugees in this case might not only generate diplomatic tensions, but also be interpreted domestically as evidence of the government’s cooperation with a regime that its own bureaucracy recognizes as oppressive.

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<sup>15</sup>Granting asylum to individuals fleeing rival neighboring countries was often used as a means of encouraging opposition groups. For instance, the counter-revolutionary army that sought to overthrow Fidel Castro in 1961 comprised 1400 CIA-trained Cuban refugees living in exile in the US.

<sup>16</sup>It is claimed that President Lyndon B. Johnson maintained the “open door” policy for Cuban refugees in an attempt to continue what was perceived as the “brain drain” of Cuban intellectuals (Pedraza, 1996). For a more in-depth discussion of the political and geo-strategic implications of asylum policies, see Loescher (1994).

Foreign policy interests would thus imply a positive correlation between interstate rivalries and asylum recognition rates: good diplomatic relations are associated with low recognition rates, while the opposite is true for tense relations. It is important to mention that a more sophisticated version of the instrumentalist view does not deny the importance of normative factors. In many cases, humanitarian concerns and strategic interests prescribe the same course of action. During the Cold War, the US admission of refugees fleeing communist regimes could be justified in terms of human rights protection and used to discredit the Soviet Bloc. In more general setups, one can argue that, *conditional* on humanitarian conditions, governments are more likely to admit refugees from rival countries than from partner states.

There is a plethora of historical evidence that supports the instrumentalist view. For instance, prior to the passing of the Refugee Act in 1980, only individuals from communist countries and the Middle East were legally allowed to claim asylum in the US. Despite facing similar humanitarian conditions, refugees from enemy states like Cuba or Nicaragua were admitted at higher rates than refugees from partner states like Haiti, Guatemala or El Salvador (McBride, 1999). During the Carter and Reagan administrations, Cuban refugees underwent a perfunctory screening process and were granted asylum almost automatically. By contrast, Haitians were detained in prisons, treated as economic migrants and more often than not deported (Stepick, 1992). Similarly, Pakistan was reluctant to accept refugees from Iran, but welcomed refugees from Afghanistan (Moorthy and Brathwaite, 2016). During the Mozambican Civil War, Zimbabwe refused to grant asylum to fleeing Mozambicans in order not to compromise good relations with their neighbor (Jacobsen, 1996).

### 3.3.2 Normative and Interest-Based Determinants of Asylum Policies

To the best of our knowledge, Rosenblum and Salehyan (2004) provide the first quantitative study of the importance of norms and strategic interests as determinants of asylum policies. They construct a sample of 42 countries sending refugees to the US from 1983 to 1989 and consider two normative factors (the political terror scale and polity score indices) and four interest-based measures (indicator variables for military aid, economic sanctions, and trade and undocumented migrant flows). Both types of factors have predictive power, albeit their importance changes over time (trade variables become more important in later years). They also find that interest-based variables account for more of the variation in recognition rates than normative factors.<sup>17</sup>

Rottman, Fariss, and Poe (2009) use a sample of decisions made by asylum officers and immigration judges in the US on applications from 96 countries from 1999 to 2004. They find that humanitarian concerns are less important when immigration judges process claims and that the linguistic heritage of asylum seekers is correlated with acceptance rates. Moorthy and Brathwaite (2016) use a large panel data set covering the period from 1951 to 2008 and find support for the instrumentalist view. Governments are more likely to accept refugees from rival countries and less

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<sup>17</sup>In a follow-up paper, Salehyan and Rosenblum (2008) study how accounting for public and congressional attention to immigration alters their previous results. Overall, they find that increased public attention amplified the importance of normative factors. Congressional hearings have an ambiguous effect on recognition rates, depending on whether asylum policies are perceived as immigration enforcement or a humanitarian issue.

likely to accept refugees from contiguous allies. In a recent paper, Jackson and Atkinson (2019) find that countries contending over issues related to ideology are more likely to admit their rivals' refugees than countries contending over other issues.

We build on these results and estimate a gravity-type equation relating asylum outcomes to a series of norm and interest-based variables. Specifically, we estimate the following equation:

$$Asylum_{ijt} = Norms'_{it}\alpha + Interests'_{ijt}\beta + Covariates'_{ij}\gamma + \delta_i + \theta_j + \mu_t + \nu_{ijt}, \quad (3.1)$$

where  $Asylum_{ijt}$  is a measure of country  $j$ 's policy with respect to asylum seekers from  $i$  in year  $t$ ;  $Norms_{it}$  is a vector of normative variables capturing humanitarian conditions in the sending country; they include the intra-national conflict score and the political terror scale;  $Interests_{ijt}$  is a vector of interest-based variables capturing diplomatic relations between countries  $i$  and  $j$ ; they include the index of voting similarity in the UN General Assembly and an indicator variable that takes the value 1 if countries  $i$  and  $j$  are linked by a free trade agreement;  $Covariates_{ij}$  is a vector of time-invariant bilateral variables, including distance, contiguity, common language, colonial ties and common religion;<sup>18</sup>  $\delta_i$  and  $\theta_j$  are origin and destination fixed effects that control for time-invariant country-specific characteristics;<sup>19</sup>  $\mu_t$  are year fixed effects that control for common trends in migration and asylum patterns;  $\nu_{ijt}$  is a time-varying bilateral random error.

Following what has become customary in the trade literature, we estimate equation (3.1) by Poisson Pseudo-Maximum Likelihood whenever the dependent is a measure of flows. We discuss the advantages of this estimator over ordinary least squares further below. When the dependent variable is the share of approved applications (recognition rates), we use OLS. Table 3.2 shows the main results.

In columns (1) and (2), the dependent variable is the number of processed demands, which as shown previously is highly correlated with the number of asylum seekers.<sup>20</sup> Because displaced persons first enter the host country and only afterwards apply for asylum, receiving states have limited control over the type of applicants it receives.<sup>21</sup> There is evidence that less generous asylum policies have the potential to curb refugee inflows. Hatton (2009) shows that policies that restrict the access to the territory and introduce tougher criteria in the processing of applications reduce the number of asylum seekers. It is less clear that such policies also allow governments to influence the type of asylum seekers they host. Given governments' limited room for maneuver, international tensions should matter only insofar as they were internalized by the asylum seekers

<sup>18</sup>In specifications that include dyadic fixed effects, these bilateral covariates are dropped to avoid multicollinearity.

<sup>19</sup>Unlike in standard gravity-equations, we set these fixed effects to be time-invariant. Allowing for time-varying fixed effects would not allow us to estimate the coefficients on normative variables, as these are origin-specific. Moreover, we find that time-varying origin and destination fixed effects, together with country-pair fixed effects, explain almost 98% of the variation in the interest-based variables.

<sup>20</sup>Using the number of filed demands instead of the number of processed applications produces similar point estimates. The results are available upon request.

<sup>21</sup>Displaced persons can also access the EU through UNHCR's resettlement schemes. Specifically, displaced persons apply for refugee status while still in the origin or first asylum country and relocate to the EU once their demand has been approved. Yet, this procedure is not very common. Resettled refugees accounted for less than 7% of the total number of asylum seekers granted protection in the EU in 2018.

Table 3.2: Normative and Interest-Based Determinants of Asylum Policies

Dependent variable	Processed applications		Positive decisions		Recognition rates	
	(1)	(2)	(3)	(4)	(5)	(6)
<i>Interest-based factors</i>						
UN affinity score index	−0.004 (0.005)	−0.006 (0.005)	−0.014* (0.008)	−0.015* (0.008)	−0.065** (0.027)	−0.047* (0.027)
Regional trade agreement	0.008 (0.221)	0.032 (0.221)	−0.850*** (0.283)	−0.875*** (0.259)	−2.031* (1.075)	−3.169*** (1.060)
<i>Norm-based factors</i>						
Conflict magnitude score	0.147*** (0.049)	0.143*** (0.050)	0.301*** (0.063)	0.298*** (0.063)	2.222*** (0.368)	2.161*** (0.374)
Political terror scale	0.306*** (0.062)	0.294*** (0.060)	0.432*** (0.090)	0.434*** (0.088)	2.980*** (0.477)	2.881*** (0.478)
R-squared	0.727	0.868	0.809	0.903	0.325	0.443
Observations	33,381	33,354	19,687	17,249	19,745	19,471
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Specifications in columns (1) through (4) are estimated by PPML. Specifications in columns (5) through (6) are estimated by OLS. The sample includes all bilateral asylum seeker flows for which we observe at least one positive value during the sample period. In columns (3) through (6), the sample is restricted to bilateral flows with a positive number of asylum seekers. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

themselves. The coefficients in columns (1) and (2) are small and statistically insignificant. This suggests that neither measure of bilateral tensions is salient enough to affect asylum seekers' choice of destinations.

In sharp contrast, the coefficients on both norm-based factors are positive and highly significant: the number of asylum applications rises, on average, by 16%  $((e^{0.147} - 1) \times 100)$  and 36%  $((e^{0.306} - 1) \times 100)$  for a one-unit increase in the conflict score and in the political terror scale, respectively. The results are robust to including dyadic fixed effects, as demonstrated in column (2). These effects are consistent with Hatton (2016)'s and Neumayer (2005b)'s finding that political oppression and violence in the country of origin are important determinants of asylum migration to Europe.

In columns (3) and (4), we re-estimate equation (3.1) using the number of approved applications as the dependent variable. In contrast to asylum seeker flows, the number of approved applications can be directly affected by governmental policy. Strategic interests are expected play a more important role. The coefficients on interest-based variables are negative and statistically significant. An increase in the UN voting affinity index of 10 percentage points corresponds to a drop in the number of approved applications of 13%  $(\times(e^{-0.014 \times 10} - 1) \times 100)$ , significant at 10%. Similarly, free trade agreements are associated with a decrease of 57%  $(e^{-0.850} - 1) \times 100)$ , significant at 1%. The coefficients on the norm-based variables are positive and highly significant. In column (4), we

add dyadic fixed effects. The point estimates change only marginally.

The last two columns of Table 3.2 show the results when the dependent variable is the recognition rate. Better diplomatic relations are associated with lower acceptance rates: increasing the voting index by 10 percentage points decreases recognition rates by 0.65 percentage points, while free trade agreements are associated with a reduction of 2 points. Worse humanitarian conditions in the origin country raise recognition rates by 2 and 3 percentage points with a one-unit increase in the conflict score and political terror scale, respectively. The results are robust to controlling for dyadic effects. The effect of UN voting is slightly smaller and significant at 10%, while the effect of free trade agreements is larger and highly significant.

Table 3.11 in Appendix 3.7.3 reports results from additional robustness checks. Column (1) shows the estimates from the baseline specification. One concern about the previous results is that recognition rates depend on the number of asylum claims. If governments face budgetary constraints, a higher number of applications will mechanically translate into lower acceptance rates. We do not find evidence that this affects our results. In column (2) we condition on the number of applications from the sending country and in column (3) we control for the total number of applications filed in the destination country. The point estimates are extremely similar to those in the baseline specification.<sup>22</sup> Another issue is related to the effects of the European Migrant Crisis. In column (4), we show estimates for the pre-crisis period (1999-2014). The coefficients on UN voting are not affected by the change of sample; the effect of free trade agreements is, on the other hand, smaller and less significant.

The relevance of foreign policy concerns may also depend on the status of individual states on the international scene. To test this hypothesis, in columns (5) and (6) we estimate equation (3.1) separately for EU-15 countries and the new member states. The point estimates are mainly significant for the older, richer member-states. Lastly, governments' ability to use asylum policies as an instrument of foreign policy may also depend on the salience of humanitarian crises in the origin countries. In columns (7) and (8) we estimate equation (3.1) only for countries of origin with no internal conflicts and limited political violence. In columns (9) and (10), we replicate the analysis for countries experiencing conflict and extensive political violence. While the results are not conclusive, the coefficients on interest-based variables seem more robust for countries experiencing less internal violence, which is consistent with the hypothesis that countries have more room for maneuver when humanitarian conditions are less salient to a wider public.

### 3.3.3 International Incidents and Asylum Recognition Rates

The analysis in the preceding section comes with several caveats. First, the interest-based variables exhibit relatively little within-pair variation over time. For instance, only 22.5% of the country pairs in the sample experienced a change in the trade agreement variable from 1999 to 2017. Second, the EU forms a trading bloc, which prevents individual member states from directly negotiating with

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<sup>22</sup>Interestingly, we find that recognition rates are positively correlated with the number of applications from the sending country, but negatively correlated with the total number of applications in the receiving country.

Table 3.3: International Incidents and Asylum Policies

Dependent variable	Processed applications		Positive decisions		Recognition rates	
	(1)	(2)	(3)	(4)	(5)	(6)
Number of conflicts	0.012 (0.008)	0.021* (0.011)	0.021** (0.011)	0.042* (0.022)	0.387*** (0.133)	0.436*** (0.163)
Number of agreements	-0.006** (0.003)	-0.008*** (0.003)	-0.009** (0.004)	-0.010** (0.004)	-0.087*** (0.033)	-0.079** (0.038)
R-squared	0.714	0.856	0.778	0.870	0.316	0.432
Observations	33,127	33,127	19,572	17,178	19,620	19,358
Origin FE	Yes	Yes	Yes	Yes	Yes	Yes
Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Specifications in columns (1) through (4) are estimated by PPML. Specifications in columns (5) through (6) are estimated by OLS. The sample includes all bilateral asylum seeker flows for which we observe at least one positive value during the sample period. In columns (3) through (6), the sample is restricted to bilateral flows with a positive number of asylum seekers. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

other nations. This limits the ability of trade treaties to capture changes in bilateral relationships over time. Third, there is evidence that voting patterns in the UN assembly are affected by prospects of material gains (Dreher, Nunnenkamp, and Thiele, 2008; Dreher and Jensen, 2013). This would be a source of measurement error that could bias our coefficients. In this section we consider an alternative measure of interstate rivalries based on the occurrence of international incidents.

In order to study the relationship between international events and asylum policies, we estimate equation (3.1) using the number of episodes of conflict and cooperation as the explanatory variables. The results are shown in Table 3.3, which follows the same structure as Table 3.2. The dependent variable in the first two columns is the number of applications, in columns (3) and (4) the number of approved applications and in columns (5) and (6) the recognition rate. Regressions of flows are estimated by PPML, while regressions of shares by OLS. Columns (1), (3) and (5) include origin, destination and year-specific fixed effects, as well as bilateral covariates. Column (2), (4) and (6) report results that include bilateral fixed effects.

Regression in columns (1) and (2) provide some evidence that international tensions are correlated with the number of processed applications, although the point estimates are not always significant. Each additional conflict increases the number of claims by 1.2% (insignificant), while each episode of cooperation decreases the number of claims by 0.6% (significant at 5%). The point estimates do not change in a significant way once we add dyadic fixed effects, although they are slightly more significant. Unlike UN voting or free trade agreements, which are perhaps not salient enough to a wider audience, the effects of international events appear to be consistent with asylum seekers sorting across destinations based on existing international rivalries.<sup>23</sup>

<sup>23</sup>An alternative hypothesis is that refugee flows cause an increase in the number of international incidents. To test

In columns (3) and (4) we show the results when the dependent variable is the number of refugees. For each additional conflict and agreement, the number of approved asylum applications changes by roughly +2% and -1%, respectively. Both coefficients are significant at the 5% level. The point estimates are larger once we include dyadic fixed effects and remain significant at conventional levels. Together, the results in columns (1) through (4) imply that recognition rates correlate positively with the number of conflicts and negatively with the number of agreements. As shown in columns (5) and (6), the coefficients have the expected sign, are highly significant and robust to controlling for pair-specific fixed effects.

International incidents vary in terms of importance. We exploit the fine classification in the GDELT database to estimate how asylum outcomes correlate with different types of events. Specifically, we distinguish between verbal and material conflicts or agreements. The results are reported in Table 3.12 in Appendix 3.7.3. The coefficients on verbal and material conflicts are not significant in any of the regressions using flows as the dependent variable. They are significantly correlated, however, with recognition rates. These are estimated to increase by 0.41 and 0.34 percentage points with each additional verbal and material dispute. Only the effect of verbal conflicts is significant. Concerning interstate cooperation, the coefficients on verbal agreements are negative and statistically significant in all regressions. The coefficients on material cooperation are positive in the flow regressions and negative in the share regressions, but never statistically significant. The evidence suggests that our relationship is mainly driven by verbal incidents.

Finally, Table 3.13 in Appendix 3.7.3 reports additional robustness checks. Column (1) shows the coefficients in the baseline specification. In columns (2) and (3), we condition on the number of applications from the sending country and from all other countries. The point estimates are only marginally affected. In column (4), we estimate our regression for the pre-crisis period. The coefficients we obtain are similar in magnitude to those in the baseline specification. In columns (5) and (6), we run our regression for the EU-15 countries and the new member states separately. Consistent with our results in the previous section, we obtain significant coefficients only for the richer and larger states in the EU. An additional concern is that the geographic coverage of the GDELT is biased in favor of the largest countries. For instance, France, Germany and Great Britain are each referenced at least 1,000 times in the database (Great Britain has more than 4000 entries). By contrast, the remaining EU countries have an average of 150 entries. In column (7), we restrict the sample to France, Germany and the United Kingdom. The point estimates are less significant but have the expected sign and are of the same order of magnitude. In columns (8) and (9) we test the sensitivity of our estimates to different definitions of international events. In column (8) we include minor events, while in column (9) we consider all government-affiliated entities. The coefficients are not significantly altered. In column (10), we allow for time-varying origin and destination fixed effects. The coefficients have the right sign, although they are slightly smaller in absolute terms and less significant.

This section documents a robust relationship between different measures of interstate tensions

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this, we drop from the event matrix incidents involving refugees. We find that this does not affect our results.

and asylum policies. In particular we show that, conditional on humanitarian conditions in the origin country and a strictly positive number of asylum demands, EU countries are more likely to admit refugees from “non-partner” than from “partner” states. Of course, we do not claim that this relationship is causal. The relationship between norms, interests and asylum policies is more complex than modeled here.<sup>24</sup> Humanitarian conditions in the sending countries may themselves generate international tensions and amplify the effect on recognition rates. Asylum policies can also heighten tensions, especially when prominent dissidents are granted asylum. That being said, we argue that such considerations do not weaken our argument, but reinforce the idea of a close relationship between asylum policies and interstate relations.

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<sup>24</sup>In Appendix 3.7.2, we discuss the evolution of asylum policies in Germany with respect to Turkish asylum seekers. The example highlights the complicated nature of the relationship between asylum policies and international tensions.

### 3.4 Gravity Model and Estimation

In this section we briefly describe a canonical model of international trade that delivers a gravity equation. We then discuss the estimation method we adopt to study the relationship between asylum policies and trade flows.

#### 3.4.1 Gravity Equation

A host of models micro-found gravity equations. Demand-side models use CES preferences with either national product differentiation (Anderson, 1979), monopolistic competition (Krugman, 1979) or CET production (Baier and Bergstrand, 2001) to derive gravity equations. Supply-side models build on comparative advantage (Eaton and Kortum, 2002) or firm heterogeneity (Chaney, 2008).<sup>25</sup> In what follows, we briefly present a demand-side micro-foundation of the gravity equation, based on Anderson and Van Wincoop (2003). The economy consists of  $N$  countries indexed by  $i$ .

*Production.* The model builds on the Armingtonian assumption that every country is the unique producer of a variety.  $i$  can therefore be used to index both countries and the variety they produce. Labor is the only factor of production and the production technology features constant returns to scale. Markets are assumed to be competitive, which means that workers are paid their marginal product ( $w_i = p_i$ ).

*Consumption.* Consumers have identical, homothetic preferences that are described by a CES utility function, with  $\sigma$  denoting the elasticity of substitution between goods. Consumers maximize utility subject to their budget constraint. Solving this optimization problem yields an expression for each country  $j$ 's nominal expenditure on goods produced in country  $i$ .

*Trade Costs.* We follow a long established tradition in the international trade literature and assume that trade costs take the iceberg form: for one unit of a variety produced in  $i$  to reach consumers in  $j$ ,  $\tau_{ij} - 1 > 0$  additional units need to be shipped. Assuming competitive markets, the price of variety  $i$  in country  $j$  will simply be  $p_{ij} = \tau_{ij}p_i$ .

*Gravity equation.* Plugging the expression for prices into the expenditure function delivers the following gravity equation:

$$X_{ij} = S_i M_j \tau_{ij}^{1-\sigma}, \quad (3.2)$$

where  $S_i = a_i^{\sigma-1} w_i^{1-\sigma}$  and  $M_j = X_j P_j^{\sigma-1}$ .  $a_i$  is a measure of the quality of country  $i$ 's products,  $X_j$  is country  $j$ 's total expenditure and  $P_j$  the dual price index in  $j$ . This equation corresponds to Head and Mayer (2014)'s definition of structural gravity.<sup>26</sup> Bilateral trade flows can be decomposed into an origin-specific term ( $S_i$ ), a destination-specific term ( $M_j$ ) and a term capturing bilateral frictions ( $\tau_{ij}^{1-\sigma}$ ).

<sup>25</sup>See Head and Mayer (2014) for a review of the recent literature on the gravity equation.

<sup>26</sup>Specifically, country  $j$ 's expenditure on goods produced in country  $i$ ,  $\pi_{ij} = \frac{X_{ij}}{X_j}$ , can be expressed in the multiplicatively separable form:  $\pi_{ij} = \frac{S_i \phi_{ij}}{\Phi_j}$  where  $\Phi_j = \sum_k S_k \phi_{kj}$ . In our case  $\phi_{ij} = \tau_{ij}^{1-\sigma}$  and  $S_i = a_i^{\sigma-1} w_i^{1-\sigma}$ .

### 3.4.2 Estimation

*Asylum policies and trade costs.* We make the assumption that asylum policies are correlated with international trade flows only through their effect on the iceberg trade costs.<sup>27,28</sup> Specifically, we posit that trade costs take the following form:

$$\tau_{ij} = \exp(\delta \text{Asylum}_{ij} + \mathbf{Z}'_{ij}\mu + \varepsilon_{ij}), \quad (3.3)$$

where  $\text{Asylum}_{ij}$  is our measure of asylum policies,  $\mathbf{Z}_{ijt}$  is a vector of bilateral covariates and  $\varepsilon_{ij}$  is the bilateral error term.

*Econometric specification.* Making the time dimension explicit and plugging equation (3.3) into equation (3.2), we obtain the following gravity equation that we take to the data:

$$X_{ijt} = S_{it}M_{jt} \exp\left((1 - \sigma)(\delta \text{Asylum}_{ijt} + \mathbf{Z}'_{ijt}\mu + \varepsilon_{ijt})\right) \quad (3.4)$$

*Theory-consistent estimation.* Estimation of equation (3.4) that is consistent with the theory requires adequate controls for the origin and destination-specific terms in the gravity equation. One possible solution was proposed by Anderson and Van Wincoop (2003). They use market clearing conditions to derive implicit solutions for these terms, which they then substitute into the gravity equation. The resulting equation is estimated by nonlinear least squares, minimizing the sum of squared errors.<sup>29</sup> A more simple method, that goes back to Harrigan (1996), consists of controlling for  $S_{it}$  and  $M_{jt}$  through an appropriate set of fixed effects. In what follows, we use this second method and include origin and destination-specific time-varying fixed effects in all specifications.

*Estimator.* One straightforward solution to estimating equation (3.4) is to log-linearize it and perform ordinary least squares. This method, however, raises several issues. First, by taking logs we exclude from the regression zero trade flows, which has the potential to generate systematic selection bias. Second, in the presence of heteroskedasticity, Silva and Tenreyro (2006) show that OLS estimates of gravity equations are biased. We therefore estimate equation (3.4) by Poisson pseudo-maximum likelihood (PPML). This estimator is robust to both the presence of zero trade flows and heteroskedastic errors, as demonstrated in Silva and Tenreyro (2006) and Head and Mayer (2014).<sup>30</sup> As a robustness check, we also estimate equation (3.4) using a multinomial

<sup>27</sup>Of course, this is an extreme assumption. Higher asylum rates may reflect a worsening humanitarian crisis, such as a war or civil unrest, in which productive capital gets destroyed. If, as a result, production costs increase in the origin country, higher recognition rates may also be correlated with trade flows through the origin-specific term. We discuss how we address this issue further below.

<sup>28</sup>We remain agnostic about the exact mechanisms through which recognition rates correlate with trade costs. Higher recognition rate, by increasing the size of ethnic business and social groups, could reduce contracting and informational costs and promote trade (Rauch and Trindade, 2002). Higher recognition rates may also signal higher tensions and reduce trade flows.

<sup>29</sup>Head and Mayer (2014) build on Anderson and Van Wincoop (2003) to propose a simpler algorithm. They first estimate the cost parameters for an initial value of the multilateral resistance terms. They then use a contraction mapping algorithm to find fixed points that they use to update the multilateral resistance terms. The procedure is iterated until the estimates stop changing.

<sup>30</sup>An advantage of using PPML is that the dependent variable does not have to follow a Poisson distribution, nor does it have to be an integer for the PPML estimator to be consistent (Gourieroux, Monfort, and Trognon, 1984). In

pseudo-maximum likelihood (MPML) estimator (Eaton, Kortum, and Sotelo, 2012). This estimator also yields unbiased estimates in the presence of heteroskedasticity. Moreover, because the independent variable is expressed as a trade share, lower weights are attributed to countries that trade significantly more and might have different asylum policies as a result.

*Discussion.* In addition to making minimal assumptions on the structure of gravity and its ease of implementation, controlling for the origin and destination-specific terms through fixed effects has another advantage in our framework. Including time-varying origin-specific fixed effects allows us to control for humanitarian conditions in sending countries. The coefficient on asylum policies will therefore not be confounded by factors related to the destruction of productive capacities in the origin. Similarly, by including time-varying destination-specific fixed effects we control for the general policy towards refugees in the receiving country. The coefficients we estimate will thus not be confounded by institutional differences across EU countries.

Equally important, in our baseline specification we also include country-pair specific fixed effects. We thus effectively control for all geographic, cultural, historical and political determinants of trade flows that are time-invariant.<sup>31</sup> This is particularly important in our context as asylum seekers are likely to sort across destinations based on factors that are unobserved to the researcher. Insofar as these factors are time-invariant, they will be absorbed into our fixed effects.

The estimated coefficient on asylum policies,  $(1 - \sigma)\delta$ , should, nevertheless, not be interpreted as a causal effect. We cannot rule out the existence of time-varying bilateral confounding factors. If anything, we rationalize the negative coefficient we document in the next section as being (at least partly) an artifact of the correlation between asylum policies and international tensions. Furthermore, trade patterns themselves can determine asylum policies. States, as rational agents, may refuse to grant refugee status to asylum seekers from trade partners in an effort not to antagonize them.<sup>32</sup>

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addition, the PPML has another advantage over OLS. Specifically, the estimated fixed effects end up corresponding to their theoretical counterparts (Fally, 2015).

<sup>31</sup>Felbermayr and Toubal (2010) construct a measure of cultural proximity using votes in the Eurovision Song Contest and show that it is positively associated with trade flows over time. Nunn and Treffer (2014) review the literature studying institutional differences as a source of comparative advantage in international trade.

<sup>32</sup>Martin, Mayer, and Thoenig (2008) show that countries that trade more are less likely to engage in war. However, the probability of militarized interstate disputes is higher when countries trade more with the rest of the world, as bilateral dependence on a given trade partner is lower.

## 3.5 Asylum Policies and Trade Flows

In this section we present evidence of a statistically significant and negative correlation between asylum policies and international trade. We also show that our findings are robust across a variety of specifications and investigate the main mechanisms that could explain the patterns we document.

### 3.5.1 Baseline Results

Table 3.4 displays our baseline results when estimating equation (3.4). In columns (1) and (2), we report results for European imports, while in columns (3) and (4) the dependent variable is the aggregate exports to the rest of the world. All regressions include time-varying importer and exporter fixed effects. This allows us to control for humanitarian conditions in the origin (the “push” factors) and economic conditions in the destination (the “pull” factors). We also include time-invariant dyadic fixed effects. As already mentioned, all bilateral determinants of trade and asylum policies that do not change over time (i.e. historical or cultural proximity) are absorbed by these fixed effects.

Column 1 shows that asylum recognition rates are *negatively* correlated with European imports. A 10 percentage point increase in recognition rates is associated with a decline in imports of 0.5%. The point estimate is significant at 5%. In column 2, we investigate how the number of admitted refugees correlates with trade flows. In this specification, we also control for the total number of asylum demands. We find that doubling the number of refugees decreases European imports from the rest of the world by 1.4%.<sup>33</sup> An important result is that asylum policies are only correlated with (aggregate) import flows. Columns (3) and (4) show that the coefficients on recognition rates and the number of refugees are never significant for European exports.

Overall, we find a negative correlation between asylum policies and imports. This result contrasts with the evidence in Parsons and Vézina (2018). While they demonstrate a positive effect of Vietnamese refugees in 1975 on exports in 1995, we focus on the contemporaneous correlation between asylum policies and trade flows. Insofar as asylum policies capture countries’ attitudes towards other states, the patterns we document are consistent with the findings in the trade and international conflict literature. Michaels and Zhi (2010) show that following the French opposition to the war in Iraq and the decline of France’s favorability rating in the US, export impediments from France to the US rose by 14 percentage points, whereas the effect for export impediments from the US to France was smaller. Similarly, Fuchs and Klann (2013) show that Chinese imports from other countries experienced a temporary decline following official visits of the Dalai Lama.

We further investigate the persistence of these effects in Table 3.14 in Appendix 3.7.3. Specifically, we re-estimate equation (3.4) using the lagged values of the number of refugees as the independent variable.<sup>34</sup> The coefficient on the one-period lagged number of refugees is half the

<sup>33</sup>The size of the sample increases significantly in the refugee specification as we also include bilateral pairs with no filed claims. We do not find evidence that this biases our results. Estimating equation (3.4) for observations with a non-missing recognition rate produces similar coefficients.

<sup>34</sup>The results are similar if we use the lagged values of the recognition rates. We do not report them to save space,

Table 3.4: Asylum Policies and International Trade Flows

Dependent variable	Trade flows			
	European imports		European exports	
	(1)	(2)	(3)	(4)
Recognition rate	−0.049** (0.024)		0.012 (0.017)	
$\ln(1+\text{Refugees})$		−0.014** (0.006)		−0.006 (0.005)
$\ln(1+\text{Asylum seekers})$		0.001 (0.005)		−0.007* (0.004)
Regional trade agreement	−0.133 (0.164)	0.109 (0.085)	0.569*** (0.094)	0.252* (0.145)
Exporter $\times$ Year FE	Yes	Yes	Yes	Yes
Importer $\times$ Year FE	Yes	Yes	Yes	Yes
Importer $\times$ Exporter FE	Yes	Yes	Yes	Yes
# Observations	19,091	64,903	22,467	76,285

Notes: All specifications are estimated by Poisson Pseudo-Maximum Likelihood. The sample includes bilateral trade flows between EU countries and the rest of the world from 1999 to 2017. Recognition rates are computed as the share of asylum seekers who are granted refugee status. The variable  $\ln(\text{Refugees})$  is the log of the number of refugees plus one.  $\ln(\text{Asylum Seekers}_{ijt})$  is the log of total number of asylum seekers plus one. The number of observations differ across columns because observations with a number of asylum seekers equal to 0 are discarded in columns 1 and 3. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

non-lagged estimate and no longer significant. The two-period lag is even smaller, while the three-period lag becomes positive, albeit non-significant. The correlation between asylum policies and imports is therefore not persistent and survives for two to three years at most. Surprisingly, the effect becomes significant for exports when we use a two-year lag. This may reflect delayed retaliation or the destruction of trading networks due to the initial reduction in imports.

Table 3.15 in Appendix 3.7.3 reports results from several robustness checks. In Panel A, we show estimates when we use a Multinomial PML estimator. The dependent variable is in this case the market share (i.e. bilateral flows divided by total expenditure,  $X_{ij}/X_j$ ). The coefficient on recognition rates is negative, significant at 10% and only marginally smaller (column 1). The coefficient on the log of the number of refugees is not statistically significant at conventional levels, but is of the same order of magnitude as in the baseline specification. Using exports as the dependent variables produces coefficients that are not significant. In Panel B, we also include pair-specific time trends that control for unobserved linear bilateral evolutions in diplomatic relations. The results are only marginally affected. In Panel C, we estimate our specifications excluding the years 2015–2017. Humanitarian conditions worsened during this period in many countries in the Middle East, leading to massive inflows of asylum seekers in Europe which might be correlated with changes in

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but are available upon request.

diplomatic relations. The results in Panel C demonstrate that our results are not driven by the European Migrant Crisis. Finally, we show that the relationship between refugees and trade flows is robust to alternative measures of refugees. In Panel D, we use the hyperbolic sine transformation of the number of refugees (MacKinnon and Magee, 1990).<sup>35</sup> Our point estimates in columns (2) and (4) are close to the ones obtained in the baseline specification.

### 3.5.2 Results by Industry

A related issue is whether the relationship between asylum policies and trade varies across different types of products. To test this hypothesis, we use Rauch (1999)’s classification of goods into homogeneous, reference-priced and differentiated.<sup>36</sup> We also use the SITC codes to classify different types of trade flows and study how they correlate with asylum policies.

As Figure 3.2A illustrates, from 1999 to 2017 the EU exported predominantly differentiated goods. 86% of trade flows leaving Europe consisted of differentiated goods, albeit there was some variation across countries.<sup>37</sup> The share of trade in differentiated goods is much smaller for imports, with almost 50% of trade being in homogeneous and reference-priced products. Once again, there was significant variation across states, as shown in Figure 3.2B. These import and export shares are relatively stable across time. The export shares for differentiated goods increased marginally from 1999 to 2017, while the import shares for differentiated goods were slightly smaller than average in the mid 2010s (Figure 3.6 in Appendix 3.7.4).

Rauch and Trindade (2002) argue that “commodities that do not possess reference prices are taken to be sufficiently differentiated that prices cannot convey all the information relevant for international trade”. This has several implications. First, search frictions are likely higher for differentiated goods, implying a greater difficulty to find alternative suppliers. This means that trade exchanges in differentiated goods are likely to be stickier even in the context of deteriorating bilateral interstate relations (i.e. higher recognition rates) than trade in homogeneous goods. Second, the existence of a larger diaspora (i.e. higher recognition rates) may help mitigate informational costs, which are more prevalent for trade in differentiated goods. These considerations lead us to conjecture that the correlation between asylum policies and trade flows should “more negative” for homogeneous goods than for differentiated products.

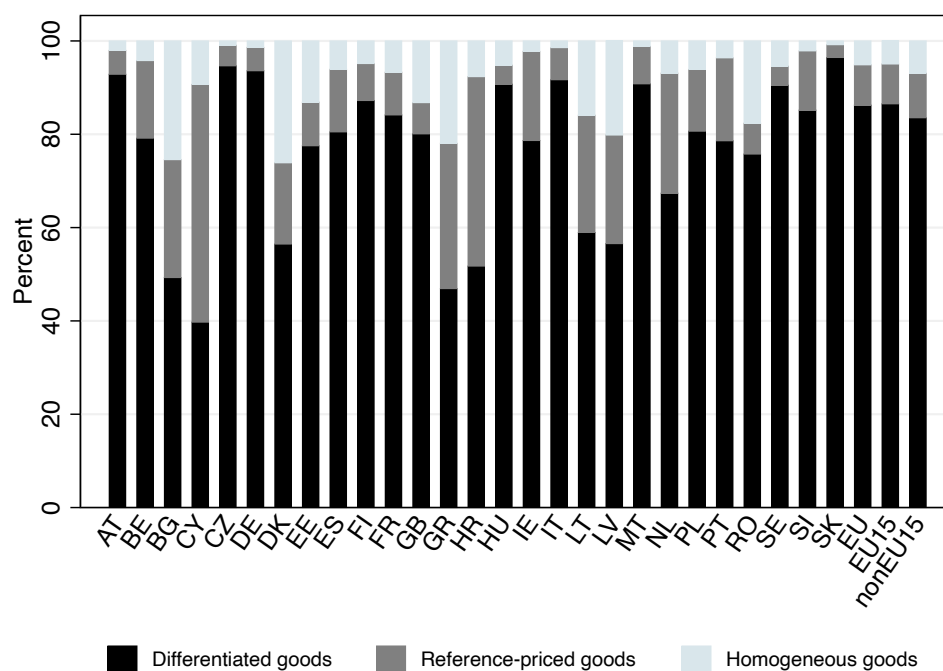
We report tests of this hypothesis in Panel A of Table 3.5. Each row shows the results from a different regression in which the dependent variable is trade flows in either homogeneous, reference-priced or differentiated goods. The first three columns use the recognition rate as our measure of asylum policies, while in the last three columns we use refugee flows. All specifications include

<sup>35</sup>For any variable  $x$ , the hyperbolic sine transformation is expressed as  $\ln(x + (x^2 + 1)^{\frac{1}{2}})$ . This function is well defined when  $x$  takes the value 0.

<sup>36</sup>Both homogeneous and reference-priced goods have reference prices. The only difference is that the latter are traded on organized exchanges.

<sup>37</sup>Bulgaria, Cyprus and Greece exhibited export shares in differentiated goods lower than 50%, while the exports of differentiated goods exceeded 90% for Austria, the Czech Republic, Germany, Hungary, Italy, Malta, Sweden and Slovakia.

(A) EU Exports to the Rest of World



(B) EU Imports from the Rest of the World

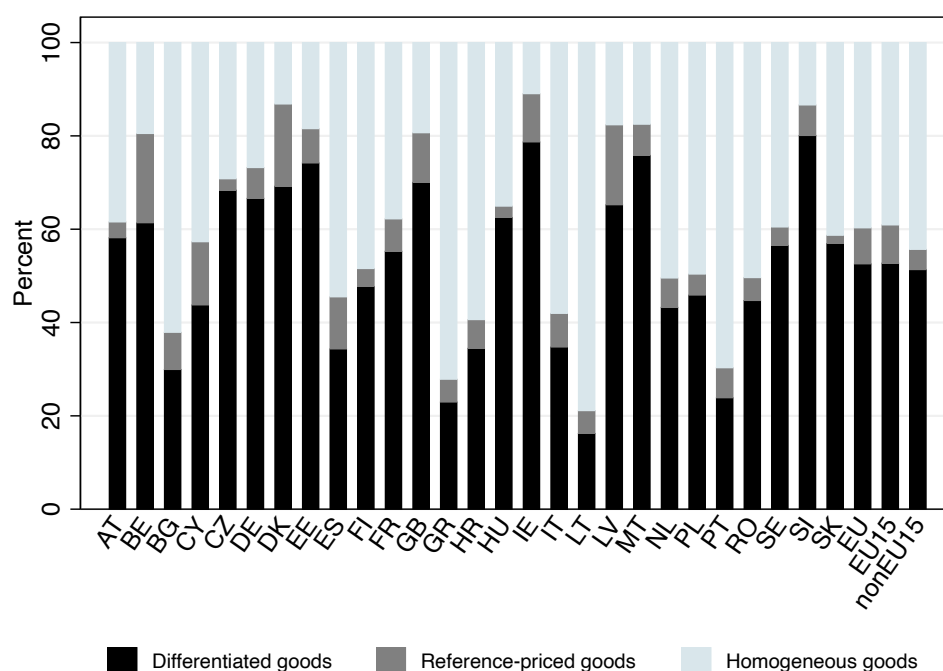


Figure 3.2: National Trade Shares for Different Categories of Goods

Notes: This figure shows the share of aggregate imports and exports for different categories of products. We use Rauch (1999)'s classification of goods into differentiated, reference-priced and homogeneous.

Table 3.5: Asylum Policies and European Imports by Industry

Independent Variable	Recognition rate			ln(1+Refugees)		
	Coef.	Std. Err.	Obs.	Coef.	Std. Err.	Obs.
Types of goods	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Rauch classification</i>						
Homogeneous goods	-0.303***	(0.073)	11,822	-0.033**	(0.016)	29,020
Reference-priced goods	-0.061	(0.038)	13,632	-0.018	(0.011)	34,568
Differentiated goods	0.031	(0.038)	16,616	-0.005	(0.011)	44,810
<i>Panel B: SITC Industries</i>						
Food, live animals (SITC 0)	0.027	(0.027)	15,390	-0.005	(0.007)	41,829
Beverages and tobacco (SITC 1)	0.061	(0.076)	9,067	-0.003	(0.016)	24,338
Crude materials, inedible, except fuels (SITC 2)	-0.113**	(0.049)	15,378	-0.005	(0.010)	37,643
Mineral fuels, lubricants and related materials (SITC 3)	-0.117	(0.072)	7,432	-0.016	(0.014)	16,422
Animal and vegetable oils, fats and waxes (SITC 4)	-0.401***	(0.151)	6,073	-0.057**	(0.023)	13,492
Chemicals and related products, n.e.s. (SITC 5)	-0.009	(0.039)	12,328	-0.023	(0.015)	31,676
Manufactured goods classified chiefly by material (SITC 6)	-0.043	(0.040)	15,780	-0.023***	(0.009)	41,424
Machinery and transport equipment (SITC 7)	-0.047	(0.050)	16,453	-0.006	(0.010)	44,261
Miscellaneous manufactured articles (SITC 8)	0.033	(0.029)	16,146	0.000	(0.008)	44,276
Not classified elsewhere (SITC 9)	-0.006	(0.520)	4,917	0.096	(0.092)	11,195

Notes: All coefficients are estimated by Poisson Pseudo-Maximum Likelihood. All specifications include time-varying origin and destination-specific fixed effects, as well as time-invariant dyadic fixed effects. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

time-varying importer and exporter fixed effects, as well as dyadic fixed effects. The estimator is PPML.

Consistent with our hypothesis, we find a large and significant correlation between recognition rates and imports of homogeneous goods: an increase of 10 percentage points in recognition rates is associated with a 3.5% decrease in homogeneous product imports. The coefficient is significant at 1%. We find a similar effect for refugee flows: doubling the number of refugees corresponds to a 3.3% decrease in imports. The coefficients for reference-priced goods, while negative, are smaller and not significant at conventional levels. The results for differentiated goods are not robust, the point estimates changing sign from one specification to the other. Replicating the results for exports does not produce robust coefficients, as shown in Table 3.6.

If, conditional on the set of fixed effects, recognition rates contain information on changes in international relations, then the negative coefficients we find for imports could be driven by firms and state-owned companies reducing their purchases from rival countries or by consumer boycott. In a recent study, Pandya and Venkatesan (2016) show that American consumers reduced their spending on French-sounding products after the French government's decision to oppose the US over the invasion of Iraq. While the available data do not allow us to distinguish between these two channels, we provide tentative evidence by re-estimating equation (3.4) at the industry-level.

The results of these regressions are displayed in Panel B of Table 3.5 for European imports. Out of ten industries, we find negative coefficients for six of them in both regressions with recognition rates and refugees flows as the independent variables. The largest effect is observed for animal and vegetable oils, fats and waxes (SITC 4). We also find statistically significant coefficients on recognition rates for crude materials, inedible, except fuel (SITC 2) and on refugee flows for manufactured goods (SITC 6). Fuchs and Klann (2013) show that the Dalai Lama effect is due in

Table 3.6: Asylum Policies and European Exports by Industry

Independent Variable	Recognition rate			ln(1+Refugees)		
	Coef.	Std. Err.	Obs.	Coef.	Std. Err.	Obs.
Types of goods	(1)	(2)	(3)	(4)	(5)	(6)
<i>Panel A: Rauch classification</i>						
Homogeneous goods	0.201*	(0.107)	14,101	-0.052*	(0.028)	29,879
Reference-priced goods	0.032	(0.034)	19,097	0.014	(0.010)	48,496
Differentiated goods	-0.032	(0.029)	21,662	-0.012	(0.007)	64,140
<i>Panel B: SITC Industries</i>						
Food, live animals (SITC 0)	0.039	(0.036)	19,795	-0.008	(0.008)	51,436
Beverages and tobacco (SITC 1)	0.012	(0.091)	16,138	0.019	(0.020)	39,767
Crude materials, inedible, except fuels (SITC 2)	0.054	(0.044)	18,590	0.006	(0.012)	44,391
Mineral fuels, lubricants and related materials (SITC 3)	0.039	(0.112)	15,535	0.007	(0.025)	36,263
Animal and vegetable oils, fats and waxes (SITC 4)	0.323***	(0.102)	11,433	-0.000	(0.023)	23,068
Chemicals and related products, n.e.s. (SITC 5)	0.045	(0.027)	20,620	0.005	(0.008)	57,385
Manufactured goods classified chiefly by material (SITC 6)	-0.006	(0.033)	21,007	-0.003	(0.007)	59,735
Machinery and transport equipment (SITC 7)	-0.028	(0.028)	21,606	-0.013*	(0.007)	64,630
Miscellaneous manufactured articles (SITC 8)	-0.033	(0.022)	21,273	-0.004	(0.006)	61,495
Not classified elsewhere (SITC 9)	-0.555	(0.400)	6,646	-0.171*	(0.101)	15,922

Notes: All coefficients are estimated by Poisson Pseudo-Maximum Likelihood. All specifications include time-varying origin and destination-specific fixed effects, as well as time-invariant dyadic fixed effects. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

great part to a reduction in exports of machinery and transport equipment (SITC 7). We also find negative coefficients for this industry, although the effects are not statistically significant. Most importantly, the coefficients for food, live animals (SITC 0), beverages and tobacco (SITC 1) and miscellaneous manufactured articles (SITC 8) are positive (but not significant). This would suggest that consumer boycott could have played only a limited role, and most of the effect was driven by changes in the purchasing patterns of private firms and state-owned companies. The results for exports are less robust, and rarely significant, as shown in Panel B of Table 3.6.

To sum up, the results presented in this section are consistent with our hypothesis that, after controlling for the origin and destination component, asylum policies reflect bilateral tensions that show up in their negative correlation with international trade flows. In particular, we only find a strong relationship for trade in homogeneous goods, for which it is arguably easier to find alternative suppliers in international markets. The lack of a strong correlation for trade in differentiated goods may be due to positive network effects offsetting the impact of interstate conflict.

## 3.6 Conclusion

This chapter builds on previous work in the political science literature and estimates a robust relationship between asylum policies in the EU and international tensions. In particular, we find that greater similarity in voting patterns in the UN General Assembly and free trade agreements are associated with a lower probability that an asylum seeker will be granted refuge. We also show that international incidents affect recognition rates. Episodes of interstate conflict lead to higher recognition rates, while interstate cooperation typically lowers refugee admission rates. Even though our analysis stresses political economy considerations, it does not deny the importance of humanitarian conditions. In fact, we confirm previous findings that conflict and political terror in the countries of origin lead to higher recognition rates. Our argument is that conditional on humanitarian conditions in the sending country, EU member states are more prone to admitting refugees from rival than from friendly countries.

The analysis carried out in this chapter also highlights the likelihood that international tensions confound the relationship between asylum policies and international trade flows. We document a negative, robust and statistically significant relationship between trade flows and asylum policies, even after controlling for humanitarian conditions in the origin, general asylum policies in the destination and country-pair characteristics that do not vary over time. In particular, we find that higher recognition rates (or higher refugees flows) are associated with lower levels of European imports from the rest of the world. We also demonstrate that the effect is driven mainly by trade in homogeneous goods. Equally important, this effect is not persistent and disappears in less than three years. Exports appear to be less sensitive to contemporaneous asylum policies.

We acknowledge that the evidence presented in this article relies mostly on correlations and we encourage caution in interpreting our results in a causal way. If anything, the relationship between international trade and asylum policies is a complex one and a causal effect may go in both directions. Second, linking asylum data to firm-level data would permit testing additional channels that may be operating and achieve a better understanding of how firms adjust to changes in asylum policies. We hope our research will prompt future inquiries along these lines.

## 3.7 Appendix

### 3.7.1 Data Description

#### 3.7.1.1 Data Sources

Variable	Source	Sample	Notes
Trade Flows	BACI: International Trade Database at the Product-Level (Gaulier and Zignago, 2010)	Trade flows between 27 European countries (Belgium and Luxembourg are aggregated and the UK is included) and 145 non-European countries from 1999 to 2017.	The data set provides information on trade-flows at the product level for nearly all countries from 1999 to 2017. Values are reported in thousands of dollars and have not been deflated. In our final sample, we only keep countries that are independent political entities.
Asylum Statistics	Eurostat (Eurostat, 2018)	Asylum seeker and refugee flows from 145 countries in 27 European states from 1999 to 2017.	The data sets provide information on the yearly number of asylum demands and first-instance decisions by citizenship. We drop intra-European flows.
Conflict in the country of origin	Center for Systemic Peace - Major Episodes of Political Violence (Marshall, 2018)	167 countries observed from 1999 to 2017.	The data set records major episodes of political violence and conflict at the national level. The events covered are international violence and warfare, civil violence and warfare and ethnic violence and warfare. Our measure of conflict is the sum of magnitudes of all societal and interstate episodes of violence.

Variable	Source	Sample	Notes
Political Terror Scale (PTS)	Freedom House (Gibney et al., 2018)	195 countries observed from 1999 to 2017.	The PTS is a measure of political violence and terror in a given country. It ranges from 1 (countries with a secure rule of law) to 5 (countries with generalized violations of civil and political rights). The data set compiles three indices from three different sources: the yearly reports of Amnesty International, the reports on Human Rights Practices of the U.S. State Department and the World Reports of Human Rights Watch. Our PTS variable is the average of these indices.
UN Voting Similarity	Voeten et al. (2009)	Bilateral affinity indices between 27 European countries and 145 non-European countries from 1999 to 2017.	This data set contains dyadic affinity scores, computed as the probability that two states vote in the same way in the UN General Assembly.
Events	GDELT (Leetaru and Schrod, 2013)	The sample contains international events involving 27 European countries and 145 non-European countries from 1999 to 2017.	The GDELT database contains international events reported in newspapers and classified either as verbal or material conflict or as verbal or material cooperation.
Distance and other gravity variables	Head et al. (2010)	Bilateral distance and other gravity variables between 27 European countries and 145 non-European states from 1999 to 2017.	The data set contains data on the geographic distance between states, as well as other gravity-related variables: contiguity, common official language, common religion, colonial ties, WTO membership as well as GDP and population levels.

### 3.7.1.2 Event Data

The international event data set was downloaded from the GDELT Project’s website (the data can be accessed at <https://www.gdeltproject.org/>).<sup>38</sup> The database references more than 200 million geolocated reports of events from 1979 to the present. International incidents are grouped into several classes and categories, as defined in the Conflict and Mediation Event Observations (CAMEO) framework. The main classes and categories are summarized in the table below.

News reports concerning the events in the data set set come from various English-speaking international sources and are coded using the Textual Analysis by Augmented Replacement Instructions (TABARI) software. The TABARI algorithm analyses the lead sentence of a news report. For example, a report that starts with the sentence, “The US imposes economic sanctions on Russia”, will be recorded in the following way. The US is coded as the lead actor and Russia is coded as the actor being affected by the lead actor’s decision. The class of the event is “Material Conflict”, the category “Reduce Relations” and the sub-category “Impose embargo, boycott, or sanctions”. Daily news reports are recorded from April 2013 to December 2017. From January 2006 to March 2013, the data set contains monthly reports while from 1999 to 2005 there are only yearly records.

In order to create the event database, we run four Python scripts. The first script downloads the zip files from the GDELT website and unzips them. The second script trims the original data set by keeping only those observations in which at least one of the actors is a EU Member State and saves it as a csv file. The third script further trims the data set by dropping observations with missing actors and those in which at least one actor is a supra-national entity (i.e. the EU as a whole, the Balkans, the African Union). We only keep events for which both the lead actor and the destination actor are national entities. We then collapse the data set at the yearly level, such that the resulting csv file contains yearly dyadic pairs, each member corresponding to a national entity. Finally, the fourth script creates two data sets, the former containing events classified as “Verbal and Material Conflict”, and the latter containing “Verbal and Material Cooperation” events.

Table 3.7: Event Classes and Categories in the GDELT Database

Verbal Cooperation	Material Cooperation	Verbal Conflict	Material Conflict
Make public statement	Engage in material cooperation	Demand	Exhibit force posture
Appeal	Provide aid	Disapprove	Reduce relations
Express intent to cooperate	Yield	Reject	Coerce
Consult	Investigate	Threaten	Assault
Diplomatic Cooperation		Protest	Fight
			Unconventional mass violence

Notes: Each event type contains several subcategories. More information can be found on the GDELT project’s website.

<sup>38</sup>For a more in-depth discussion of the GDELT database, see Leetaru and Schrodtt (2013).

### 3.7.1.3 Missing Recognition Rates

One important concern about the analysis carried out in this paper is related to the high frequency of missing recognition rates. For more than 75% of the bilateral pairs in our data set (61,418 out of 81,567), we cannot compute recognition rates. This is due to the unavailability of asylum data and the presence of a significant number of zero asylum seeker flows. In this section, we discuss the determinants of missing values and how this affects our results.

Several European countries do not report asylum statistics in a given year in our sample: Belgium in 2002 and 2007, Bulgaria from 1999 to 2001, Croatia from 1999 to 2011, Cyprus from 1999 to 2002, the Czech Republic from 1999 to 2001, Germany in 1999 and 2000, Denmark in 2002, Estonia from 1999 to 2002, Spain in 1999 and 2000, Great Britain from 1999 to 2001, Greece from 1999 to 2002, Hungary from 1999 to 2001, Ireland from 2000 to 2002, Italy from 1999 to 2007, Latvia from 1999 to 2001, Lithuania from 1999 to 2001, Malta from 1999 to 2002, the Netherlands in 2007, Poland from 1999 to 2001, Portugal in 1999, Romania in 1999 and 2000, Slovenia from 1999 to 2001 and Slovakia from 1999 to 2002. This type of non-reporting generates 12,402 missing recognition rates. There are 269 other cases of missing data, in which a government does not report the number of applications from a specific sending country. This implies that non-reporting accounts for only 20% of the missing recognition rates in our sample, the remaining 80% being due to zero asylum seeker flows.

As the graph below illustrates, missing recognition rates due to data unavailability were more likely during the first years covered in our sample, when the lack of asylum statistics accounted for almost 80% of missing values. Starting with 2003, this becomes less of an issue and the vast majority of missing recognition rates can be imputed to zero asylum seeker flows.

In the table below, we estimate a linear probability model that expresses the conditional probability of missing asylum data as a function of interest-based, norm-based and bilateral covariates. It is noteworthy to mention that the sample probability of missing data is 15.53%. In column (1), we present results from an OLS regression that does not include any fixed effects. We find that voting similarity, conflicts in the sending country and sharing a common religion increase the probability of missing data, while free trade agreements, distance and colonial ties are negatively associated with this probability. These results are not affected by the estimation method: using a Probit model produces similar coefficients, as demonstrated in column (3). The evidence, however, suggests that the results are driven by the new member states, which were more likely not to report data in the beginning of our sample period. These states were also more likely to vote in a similar fashion with the rest of the world than EU-15 countries, less likely to have a free trade agreement, were located closer to sending countries (the new member states form a contiguous eastern bloc within the EU) and were less likely to share colonial ties with other countries. Also, internal conflicts in sending countries appear to have been of a greater magnitude from 1999 to 2001, which corresponds to the period when missing data were more likely. In column (2), we re-estimate the linear probability model including origin and destination fixed effects, as well as year fixed effects. There are fewer significant coefficients, and those that remain significant have a small effect on

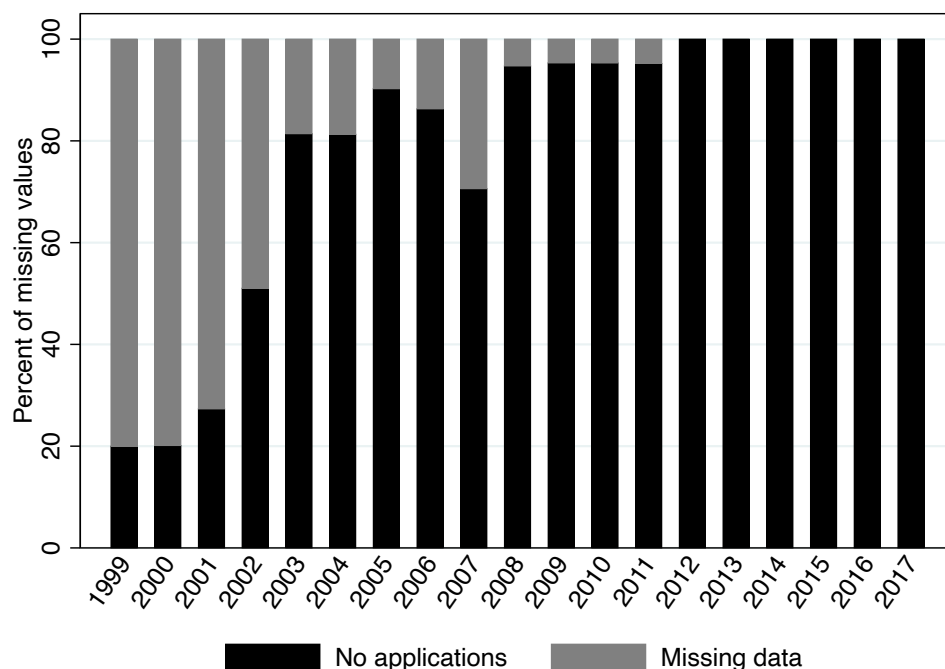


Figure 3.3: Sources of Missing Recognition Rates

the probability of missing data. An increase in the voting affinity index of 10 percentage points increases the probability by 1 percent, while regional trade agreements reduces it by 2.3 percent.

We believe data unavailability to be less of an issue in our study. When a country does not report data, recognition rates are marked as missing for all bilateral pairs that include it and are excluded from regressions. Selection bias is likely to occur if countries systematically sort into reporting and non-reporting based on unobservable, time-varying characteristics. To test whether this is a source of concern for us, we re-estimated our regressions for the 2008-2017 period, when data availability was less of an issue. All of our results carry through.

More worrisome is the high number of zero asylum seeker flows. In the absence of a strictly positive number of applications, recognition rates cannot be computed and remain unobserved (there is no reason to assume that recognition rates would be zero if a positive number of applications were filed). The selection bias could potentially arise from asylum seekers sorting across destinations based on unobservable characteristics. In columns (4) through (6) of the table below, we estimate the probability of observing null asylee flows as a function of interest-based, norm-based and bilateral variables, conditional on data being available. The sample probability of no flows, conditional on data availability, is 70.75%. Column (4) reports estimates from a linear probability model with no fixed effects. Better inter-state relations, as measured by a higher voting affinity index and by the presence of trade agreements, are associated with a higher probability of zero flows, while worse humanitarian conditions in the country of origin reduce it. A larger distance, the absence of a common language and colonial ties increase the probability of zero flows, which is consistent with

Table 3.8: Determinants of Missing Recognition Rates

	Probability missing			Probability zero flow		
	(1) OLS	(2) OLS	(3) Probit	(4) OLS	(5) OLS	(6) Probit
<i>Interest-based factors</i>						
UN voting affinity Index	0.004*** (0.000)	0.001*** (0.000)	0.004*** (0.000)	0.001 (0.001)	0.001*** (0.000)	0.001*** (0.000)
Regional Trade Agreement	-0.156*** (0.004)	-0.023*** (0.004)	-0.230*** (0.005)	0.025** (0.011)	0.007 (0.006)	0.043*** (0.005)
<i>Norm-based factors</i>						
Conflict magnitude score	0.009*** (0.002)	0.000 (0.001)	0.009*** (0.001)	-0.027*** (0.004)	-0.013*** (0.002)	-0.014*** (0.001)
Political Terror scale	-0.001 (0.002)	-0.000 (0.002)	-0.001 (0.002)	-0.104*** (0.005)	-0.027*** (0.002)	-0.137*** (0.002)
<i>Gravity covariates</i>						
log(Distance)	-0.017*** (0.005)	0.001 (0.002)	-0.020*** (0.002)	0.209*** (0.009)	0.121*** (0.007)	0.240*** (0.004)
Contiguity	-0.014 (0.035)	0.003 (0.013)	-0.003 (0.016)	0.180** (0.071)	0.004 (0.019)	0.229*** (0.026)
Common language	0.007 (0.007)	0.002 (0.005)	0.007 (0.006)	-0.166*** (0.024)	-0.141*** (0.007)	-0.189*** (0.009)
Colonial ties	-0.021** (0.010)	-0.001 (0.006)	-0.027*** (0.008)	-0.322*** (0.029)	-0.115*** (0.009)	-0.356*** (0.012)
Common religion	0.037*** (0.010)	0.002 (0.006)	0.034 (0.005)	0.156*** (0.019)	0.055*** (0.009)	0.197*** (0.010)
Origin & Destination FE	No	Yes	No	No	Yes	No
Year FE	No	Yes	No	No	Yes	No

Notes: In columns (1) through (3), the dependent variable is an indicator variable that takes the value 1 for bilateral pairs with missing values. In columns (4) through (6), the dependent variable is an indicator variables that takes the value 1 for bilateral pairs zero flows. The sample used in columns (4) through (6) includes only bilateral pairs for which asylum data is available. For the Probit regressions, we report marginal effects calculated at the sample mean. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

higher relocating costs for asylum seekers in these cases. Contiguity and common religion have both a positive and significant coefficient. The marginal effects from a Probit regression are of a similar magnitude, as shown in column (6). In column (5), we estimate a linear probability model with origin, destination and year fixed effects. Most coefficients remain significant, although they are lower.

### 3.7.2 Case Study: Turkish Refugees in Germany

During the period we study, Germany received the highest number of asylum seekers in the EU. One third of the total number of asylum applications in Europe were filed in Germany. Most of asylum seekers originated from war-torn countries, like Syria, Afghanistan and Iraq. Prior to the European Migrant Crisis, however, the third largest group of asylum seekers in Germany were from Turkey. In this section, we examine the evolution of German recognition rates for Turkish asylum seekers and the diplomatic relationship between the two countries.

In the early 2000s, more than 10,000 Turkish citizens claimed asylum in Germany every year. The numbers decreased significantly over the next ten years, reaching an all-time minimum in 2015 when only 450 applications were recorded. Since then, the number has exploded, exceeding 10,000 demands in 2017. These fluctuations most certainly reflect Turkey's internal tensions. The economic crisis of 2001 might be responsible for the impressive number of asylum claims from 2001 to 2003, while subsequent economic growth may explain the sharp reduction in applications. The recent surge in the number of demands followed the failed coup d'état of 2016, which resulted in a series of arrests and purges of political opponents. Recognition rates also varied considerably during this period, ranging from 5% in the mid-2000s to 33% in 2017.

Germany's current relationship with Turkey can at best be described as tense. Germany is one of the most vocal opponents to Turkey's accession to the European Union, a recurrent bone of contention between the two countries.<sup>39</sup> Germany also hosts more than 3 million persons of Turkish descent, half of them having the right to vote in Turkish elections. It is for this reason that Turkish politicians often organize rallies in Germany, at times in defiance of German authorities.<sup>40</sup> Tensions between the two countries heightened after the failed coup of 2016 and the arrest by Turkish authorities of several German human rights activists. (Reference click here.)

The Figure below illustrates the evolution of quarterly recognition rates from 2008 to 2018. Because these numbers may be correlated with general changes in asylum policies, we also show relative recognition rates, defined as the ratio between the individual rate and the acceptance rate averaged across all countries origin. We find that the two series are highly correlated, with a coefficient of correlation of 0.86. This means that higher recognition rates correspond to a greater chance of being granted asylum relative to asylum seekers from other countries.

The shaded areas correspond to quarters in which recognition rates were higher than the average. While the evidence we provide here is anecdotal, the spikes in acceptance rates happen to coincide with periods of mounting tensions between the two countries. In 2009, recognition rates for Turkish

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<sup>39</sup>Negotiations between Turkey and the EU began in 2005, more than 18 years after Turkey first applied for EU membership. Negotiations stalled five years later after France and Germany officially expressed their opposition to Turkey joining the EU. In addition to government officials, a vast majority of Germans also oppose Turkey's accession to the EU. (Reference click here.)

<sup>40</sup>In a 2014 speech in Cologne, Turkish Prime Minister Tayyip Erdogan addressed 16,000 Turks commending them to integrate but not to assimilate. (Reference click here.) In 2016, a German court prohibited the now-President Erdogan from addressing supporters during a rally in Cologne. (Reference click here.) In June 2017 the German Government did not allow the Turkish President to hold a speech in front of supporters in the run-up to the constitutional referendum. (Reference click here.)

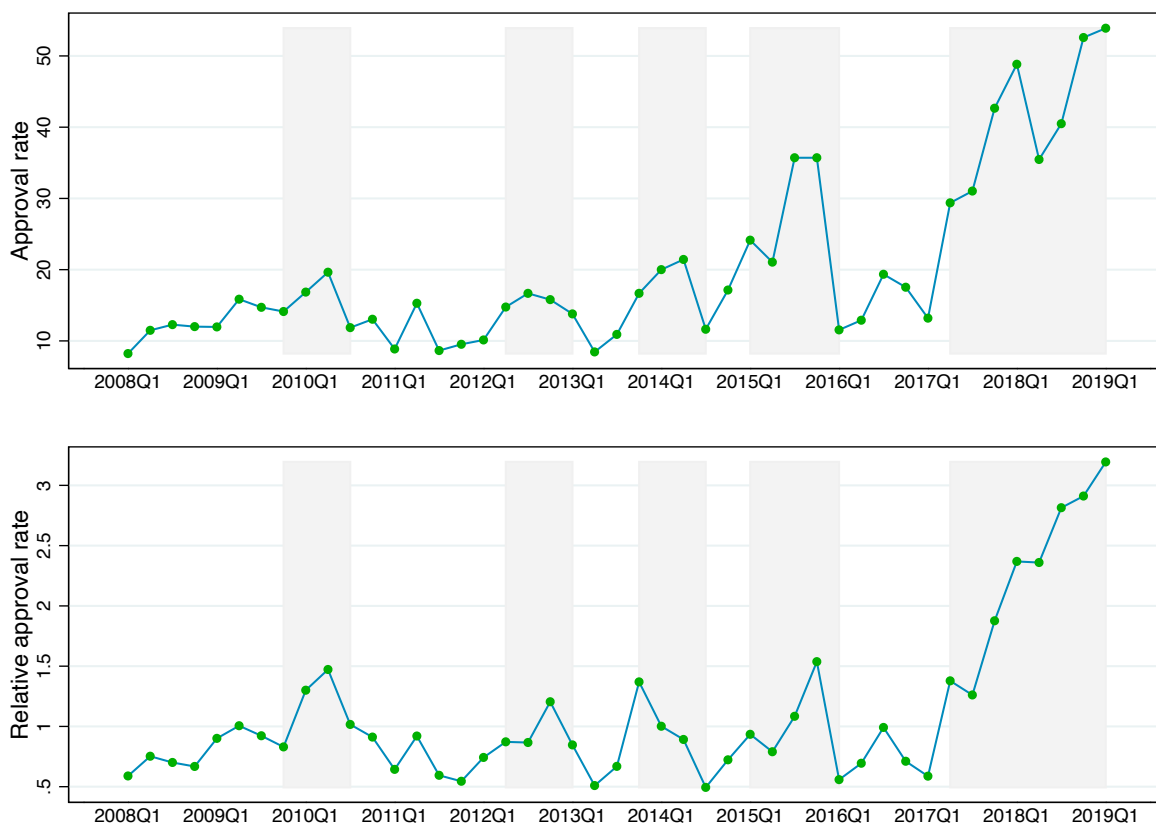


Figure 3.4: Recognition Rates for Turkish Asylum Seekers in Germany

refugees started increasing and peaked in mid-2010. At the same time, the newly established CDU-FDP coalition Government defined the general lines for EU’s “enlargement policy” which provides only a “privileged partnership” for Turkey.<sup>41</sup> (Reference click here.)

Recognition rates declined and remained relatively low for the next two years, before surging in late 2012 and again in late 2013 and early 2014. Tensions with Germany regained in intensity in 2013 following criticism of the Turkish government for its harsh treatment of protesters and Germany’s renewed opposition to Turkey’s EU accession. After meeting his Turkish counterpart, German Foreign Minister Guido Westerwelle had to admit that “You can’t deny the tensions,” while at the same time affirming Germany’s dedication to work towards achieving better relationship with Turkey. (Reference click here.) 2016 marked a new milestone in German-Turkish relations, with the German Parliament adopting a resolution recognizing the Armenian genocide of 1915. The vote came in at a most delicate time, with the German government seeking to appease Turkish officials in a bid to arrive at an agreement regarding the influx of refugees arriving from the Middle East. (Reference click here.) Recognition rates dropped in early 2016, but were on the rise again, as

<sup>41</sup>Tensions between the two countries became so tangible that two days before the planned visit of chancellor Angela Merkel in Turkey in April 2010, the Turkish Prime-Minister Erdogan complained of Germany’s display of “so much hatred towards Turkey”. (Reference click here.)

tensions renewed over Germany's ban on president Erdogan addressing supporters and the purges that occurred following the failed coup of July 2016. ([Reference click here.](#))

Of course, the tensions between Germany and Turkey are intrinsically related to the latter's treatment of political dissidents. As argued above, the deterioration of the rule of law in Turkey, together with arrests of human rights activists, are responsible for both heightened tensions and an increase in recognition rates. We therefore do not claim a causal effect of interstate tensions on recognition rates. Instead, we highlight the complex relationship between refugee acceptance rates, international tensions and human rights violations.

## 3.7.3 Additional Tables

Table 3.9: List of Countries

<b>Panel A: Non-EU countries (145)</b>			
Afghanistan	Djibouti	Lesotho	Saint Vincent and the Grenadines
Albania	Dominica	Liberia	Sao Tome and Principe
Algeria	Dominican Republic	Libya	Saudi Arabia
Angola	Ecuador	Macedonia (FYR)	Senegal
Argentina	Egypt	Madagascar	Seychelles
Armenia	El Salvador	Malawi	Sierra Leone
Australia	Equatorial Guinea	Malaysia	Singapore
Azerbaijan	Eritrea	Maldives	Somalia
Bahamas	Ethiopia	Mali	South Africa
Bahrain	Fiji	Mauritania	Sri Lanka
Bangladesh	Gabon	Mauritius	Sudan
Barbados	Gambia	Mexico	Suriname
Belarus	Georgia	Moldova (Republic of)	Swaziland
Belize	Ghana	Mongolia	Syrian Arab Republic
Benin	Grenada	Morocco	Taiwan
Bhutan	Guatemala	Mozambique	Tajikistan
Bolivia	Guinea	Myanmar	Tanzania, United Republic of
Bosnia and Herzegovina	Guinea-Bissau	Namibia	Thailand
Botswana	Guyana	Nauru	Togo
Brazil	Haiti	Nepal	Trinidad and Tobago
Burkina Faso	Honduras	New Zealand	Tunisia
Burundi	India	Nicaragua	Turkey
Cabo Verde	Indonesia	Niger	Turkmenistan
Cambodia	Iran	Nigeria	Uganda
Cameroon	Iraq	North Korea	Ukraine
Canada	Israel	Oman	United Arab Emirates
Central African Republic	Jamaica	Pakistan	United States of America
Chad	Japan	Panama	Uruguay
Chile	Jordan	Papua New Guinea	Uzbekistan
China	Kazakhstan	Paraguay	Venezuela
Colombia	Kenya	Peru	Vietnam
Comoros	Korea (Democratic People's Republic)	Philippines	Yemen
Congo (Republic of the)	Korea (Republic of)	Qatar	Zambia
Congo (Democratic Republic of the)	Kuwait	Russian Federation	Zimbabwe
Costa Rica	Kyrgyzstan	Rwanda	
Côte d'Ivoire	Laos	Saint Kitts and Nevis	
Cuba	Lebanon	Saint Lucia	
<b>Panel B: EU countries (27)</b>			
Austria	Estonia	Italy	Romania
Belgium (with Luxembourg)	Finland	Latvia	Slovakia
Bulgaria	France	Lithuania	Slovenia
Croatia	Germany	Malta	Spain
Republic of Cyprus	Greece	Netherlands	Sweden
Czech Republic	Hungary	Poland	United Kingdom
Denmark	Ireland	Portugal	

Notes: The sample includes all non-European countries that sent at least one asylum seeker from 1999 to 2007.

Table 3.10: Summary of Events

Event	Frequency	Percent	Event	Frequency	Percent
<b><i>Conflict</i></b>	<b>11783</b>	<b>-</b>	<b><i>Cooperation</i></b>	<b>91413</b>	<b>-</b>
<i>Verbal Conflict</i>	<i>7456</i>	<i>63.28%</i>	<i>Verbal Cooperation</i>	<i>86764</i>	<i>94.91%</i>
Demand	683	9.16%	Make public statement	6267	7.22%
Disapprove	2794	37.47%	Appeal	3321	3.83%
Reject	928	12.45%	Express intent to cooperate	6205	7.15%
Threaten	547	7.34%	Consult	51832	59.74%
Protest	866	11.61%	Diplomatic cooperation	10706	12.34%
Unclassified	1638	21.97%	Unclassified	8433	9.72%
<i>Material Conflict</i>	<i>4327</i>	<i>36.72%</i>	<i>Material Cooperation</i>	<i>4649</i>	<i>5.09%</i>
Exhibit force posture	52	1.20%	Engage in material cooperation	917	19.72%
Reduce relations	926	21.40%	Provide aid	947	20.37%
Coerce	1180	27.27%	Yield	1690	36.35%
Assault	417	9.64%	Investigate	571	12.28%
Fight	884	20.43%	Unclassified	524	11.28%
Unconventional mass violence	7	0.16%			
Unclassified	861	19.90%			

Table 3.11: Normative and Interest-Based Determinants of Asylum Policies – Robustness Checks

Dependent variable	Recognition rate									
	(1) Baseline	(2) Asylum seekers from origin	(3) Asylum seekers from all countries	(4) 1999-2014	(5) EU-15	(6) New member states	(7) No conflict in origin	(8) Limited political violence	(9) At least some conflict in origin	(10) Extensive political violence
<i>Panel A: No dyadic fixed effects</i>										
<i>Interest-based factors</i>										
UN affinity score index - important votes	-0.065** (0.027)	-0.066** (0.027)	-0.065** (0.027)	-0.072*** (0.027)	-0.058** (0.029)	-0.158** (0.069)	-0.032 (0.030)	-0.005 (0.063)	0.021 (0.055)	-0.074** (0.029)
Regional trade agreement	-2.031* (1.075)	-2.014* (1.071)	-1.989* (1.072)	-0.639 (1.286)	-2.590** (1.218)	1.569 (2.293)	-1.774 (1.193)	-3.740** (1.888)	-0.614 (3.899)	-0.397 (1.343)
<i>Norm-based factors</i>										
Conflict magnitude score	2.222*** (0.368)	2.170*** (0.363)	2.215*** (0.369)	1.845*** (0.333)	1.962*** (0.404)	3.276*** (0.823)		-13.220 (9.616)	0.993** (0.478)	1.999*** (0.366)
Political terror scale	2.980*** (0.477)	2.853*** (0.472)	2.948*** (0.475)	2.043*** (0.501)	2.800*** (0.497)	3.075** (1.302)	1.569*** (0.560)	-0.555 (2.121)	4.408*** (0.936)	4.177*** (0.595)
Adjusted R-squared	0.325	0.326	0.327	0.305	0.337	0.370	0.256	0.224	0.406	0.335
Observations	19,745	19,745	19,745	15,890	15,728	3,999	13,702	2,897	6,043	16,846
<i>Panel B: Dyadic fixed effects</i>										
<i>Interest-based factors</i>										
UN affinity score index - important votes	-0.047* (0.027)	-0.048* (0.027)	-0.047* (0.027)	-0.046* (0.027)	-0.054* (0.029)	-0.091 (0.075)	-0.024 (0.028)	-0.029 (0.065)	0.058 (0.054)	-0.056* (0.029)
Regional trade agreement	-3.169*** (1.060)	-3.175*** (1.054)	-3.132*** (1.057)	-2.365* (1.296)	-3.661*** (1.164)	-0.128 (2.565)	-2.543** (1.165)	-4.772** (1.913)	-0.402 (4.298)	-1.987 (1.341)
<i>Norm-based factors</i>										
Conflict magnitude score	2.161*** (0.374)	2.074*** (0.363)	2.154*** (0.375)	1.769*** (0.334)	1.938*** (0.411)	3.125*** (0.835)		-11.890 (9.886)	0.874* (0.474)	1.978*** (0.371)
Political terror scale	2.881*** (0.478)	2.653*** (0.469)	2.855*** (0.477)	2.150*** (0.501)	2.810*** (0.500)	3.676*** (1.407)	1.460*** (0.566)	-0.952 (2.169)	4.545*** (0.930)	4.005*** (0.601)
Adjusted R-squared	0.443	0.444	0.444	0.434	0.444	0.432	0.394	0.320	0.513	0.451
Observations	19,471	19,471	19,471	15,609	15,579	3,892	13,386	2,596	5,918	16,615

Notes: All regressions are estimated by ordinary least squares. Standard errors, clustered at the dyad level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 3.12: International Incidents and Asylum Policies – Finer Classification of Events

Dependent variable	Processed applications		Positive decisions		Recognition rate	
	(1)	(2)	(3)	(4)	(5)	(6)
Number of verbal conflicts	0.001 (0.024)	0.024 (0.028)	0.031 (0.030)	0.072 (0.050)	0.414** (0.180)	0.442** (0.214)
Number of material conflicts	0.025 (0.041)	0.004 (0.041)	−0.011 (0.045)	−0.014 (0.033)	0.342 (0.226)	0.421* (0.220)
Number of verbal cooperation	−0.007** (0.004)	−0.010*** (0.004)	−0.012** (0.006)	−0.018*** (0.005)	−0.087** (0.037)	−0.080* (0.041)
Number of material cooperation	0.042 (0.027)	0.041 (0.028)	0.043* (0.025)	0.047* (0.025)	−0.116 (0.335)	−0.071 (0.290)
R-squared	0.715	0.856	0.779	0.872	0.316	0.432
Observations	33,127	33,127	19,572	17,178	19,620	19,358
Origin & Destination FE	Yes	Yes	Yes	Yes	Yes	Yes
Dyadic FE	No	Yes	No	Yes	No	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Specifications in columns (1) through (4) are estimated by PPML. Specifications in columns (5) through (6) are estimated by OLS. The sample includes all bilateral asylum seeker flows for which we observe at least one positive value during the sample period. In columns (3) through (6), the sample is restricted to bilateral flows with a positive number of asylum seekers. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 3.13: International Incidents and Asylum Policies – Robustness Checks

Dependent variable	Recognition rate									
	(1) Baseline	(2) Asylum seekers from origin	(3) Asylum seekers from all countries	(4) 1999-2014	(5) EU-15	(6) New member states	(7) France, Germany, United Kingdom	(8) Including minor events	(9) Including all agents	(10) Time-varying fixed effects
<i>Panel A: No dyadic fixed effects</i>										
Number of conflicts	0.395*** (0.132)	0.385*** (0.131)	0.387*** (0.133)	0.501*** (0.193)	0.378*** (0.138)	1.090 (0.868)	0.252* (0.153)	0.277*** (0.102)	0.301*** (0.101)	0.186* (0.113)
Number of agreements	-0.087** (0.034)	-0.092*** (0.034)	-0.083** (0.034)	-0.078* (0.041)	-0.088** (0.035)	-0.237 (0.185)	-0.049 (0.041)	-0.068** (0.030)	-0.082** (0.033)	-0.056* (0.032)
Adjusted R-squared	0.316	0.317	0.317	0.299	0.329	0.351	0.402	0.315	0.314	0.418
Observations	19,620	19,620	19,620	15,791	15,615	3,988	4,675	19,681	19,725	19,306
<i>Panel B: dyadic fixed effects</i>										
Number of conflicts	0.436*** (0.163)	0.413*** (0.155)	0.429*** (0.163)	0.589*** (0.218)	0.392** (0.164)	0.147 (0.874)	0.289 (0.181)	0.307*** (0.124)	0.351*** (0.130)	0.123 (0.117)
Number of agreements	-0.079** (0.038)	-0.074** (0.037)	-0.074* (0.038)	-0.066 (0.045)	-0.060* (0.036)	-0.393 (0.252)	-0.030 (0.043)	-0.058* (0.033)	-0.073** (0.037)	-0.043 (0.029)
Adjusted R-squared	0.432	0.434	0.433	0.428	0.434	0.414	0.458	0.430	0.431	0.546
Observations	19,358	19,358	19,358	15,521	15,473	3,885	4,654	19,417	19,457	19,037

Notes: All regressions are estimated by ordinary least squares. Standard errors, clustered at the dyad level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 3.14: Asylum Policies and International Trade Flows – Results on Persistence

Dependent variable	Trade flows					
	European imports			European exports		
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln(1+\text{Refugees}_{ijt-1})$	-0.008 (0.006)			-0.005 (0.005)		
$\ln(1+\text{Asylum seekers}_{ijt-1})$	-0.005 (0.005)			-0.007* (0.004)		
$\ln(1+\text{Refugees}_{ijt-2})$		-0.001 (0.006)			-0.011* (0.006)	
$\ln(1+\text{Asylum seekers}_{ijt-2})$		-0.003 (0.005)			0.000 (0.004)	
$\ln(1+\text{Refugees}_{ijt-3})$			0.005 (0.007)			-0.010** (0.005)
$\ln(1+\text{Asylum seekers}_{ijt-3})$			-0.003 (0.005)			-0.001 (0.004)
Exporter $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer $\times$ Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
# Observations	60,771	56,622	52,484	61,797	57,659	53,576

Notes: All specifications are estimated by Poisson Pseudo-Maximum Likelihood. The sample includes bilateral trade flows between EU countries and the rest of the world from 1999 to 2017. The variable  $\ln(\text{Refugees})$  is the log of the number of refugees plus one.  $\ln(\text{Asylum Seekers}_{ijt})$  is the log of total number of asylum seekers plus one. The number of observations differ across columns because observations with a number of asylum seekers equal to 0 are discarded in columns 1 and 3. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

Table 3.15: Asylum Policies and International Trade Flows – Robustness Checks

Dependent variable	European imports		European exports	
	(1)	(2)	(3)	(4)
<i>Panel A: Multinomial pseudo-maximum likelihood estimator</i>				
Recognition rate	−0.058*		0.023	
	(0.032)		(0.025)	
ln(1 + Refugees)		−0.011		−0.006
		(0.009)		(0.006)
ln(1+Asylum seekers)		0.008		−0.003
		(0.009)		(0.006)
# Observations	19,091	64,903	22,467	76,285
<i>Panel B: Include pair specific time trends</i>				
Recognition rate	−0.045**		−0.003	
	(0.021)		(0.017)	
ln(1 + Refugees)		−0.013***		−0.000
		(0.004)		(0.004)
ln(1 + Asylum seekers)		0.003		−0.000
		(0.004)		(0.003)
# Observations	19,089	64,898	22,397	76,000
<i>Panel C: Pre-European Migrant Crisis (1999-2014)</i>				
Recognition rate	−0.089***		0.013	
	(0.030)		(0.027)	
ln(1 + Refugees)		−0.019***		−0.005
		(0.007)		(0.005)
ln(1 + Asylum seekers)		0.005		−0.005
		(0.005)		(0.004)
# Observations	15,290	52,560	17,788	61,106
<i>Panel D: Hyperbolic sine transformation</i>				
Refugees		−0.012**		−0.005
		(0.005)		(0.004)
Asylum seekers		0.001		−0.005*
		(0.004)		(0.003)
# Observations		64,903		76,285

Notes: The specifications in Panel A are estimated by Multinomial Pseudo-Maximum Likelihood. All remaining specifications are estimated by Poisson Pseudo-Maximum Likelihood. All specifications include time-varying exporter and importer-specific fixed effects, time-invariant dyadic fixed effects and a free trade indicator variable. Standard errors, clustered at the country-pair level, are reported in parentheses. \* significant at 10%, \*\* significant at 5%, \*\*\* significant at 1%.

## 3.7.4 Additional Figures

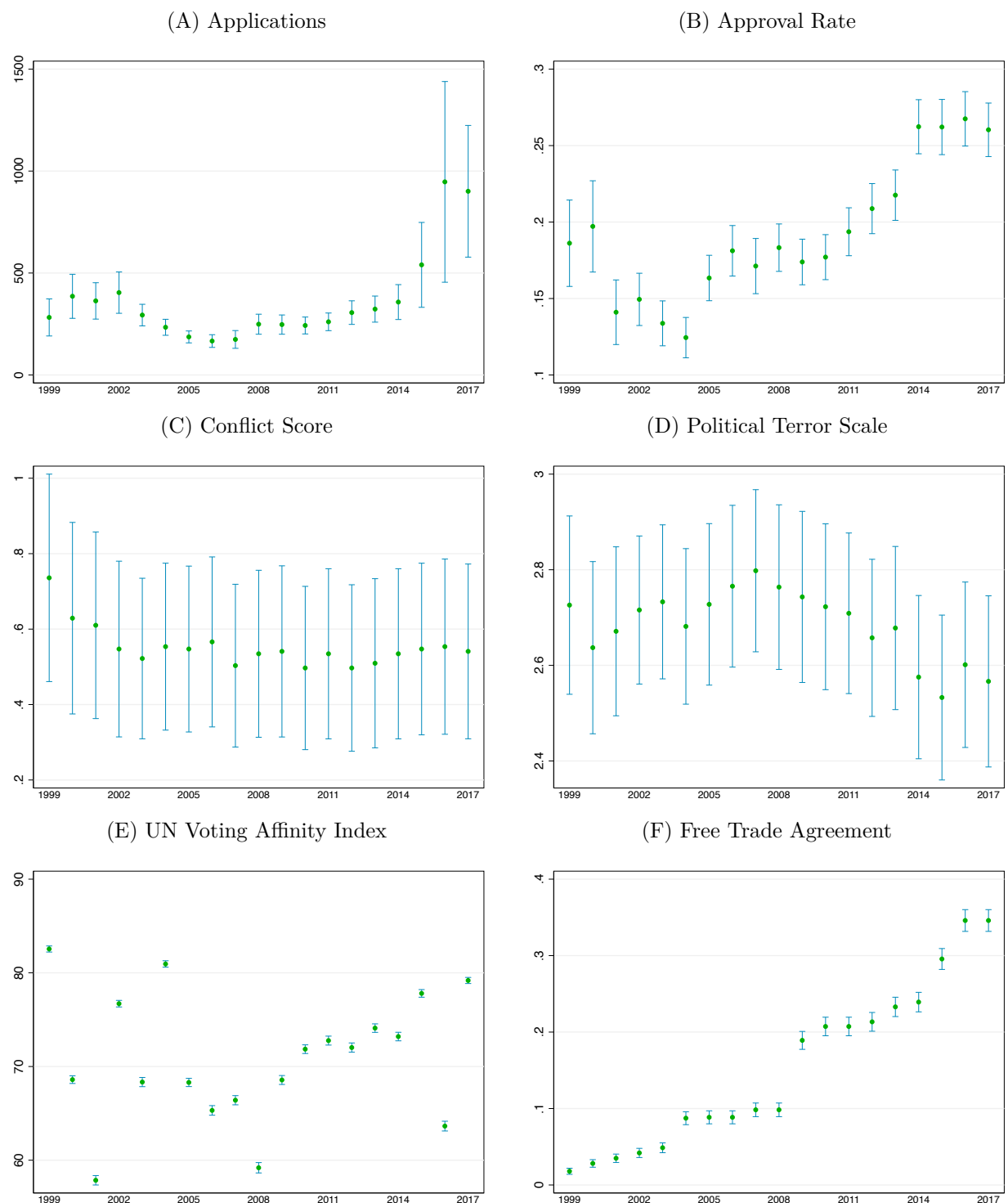
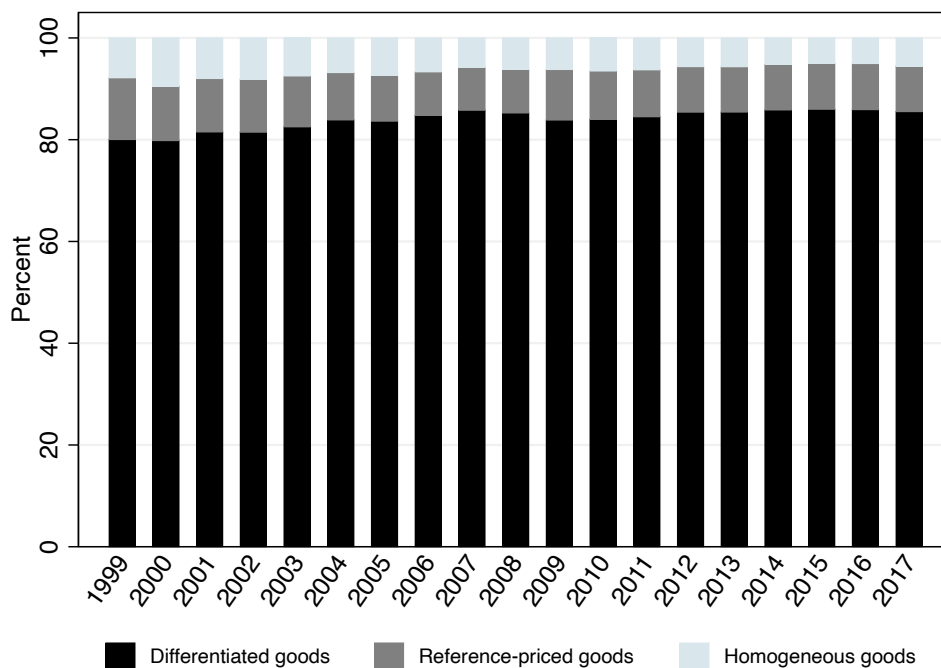


Figure 3.5: Annual Average Statistics

Notes: This figure shows yearly averages and their 95% confidence intervals for a series of variables in our sample.

(A) EU Exports to the Rest of World



(B) EU Imports from the Rest of the World

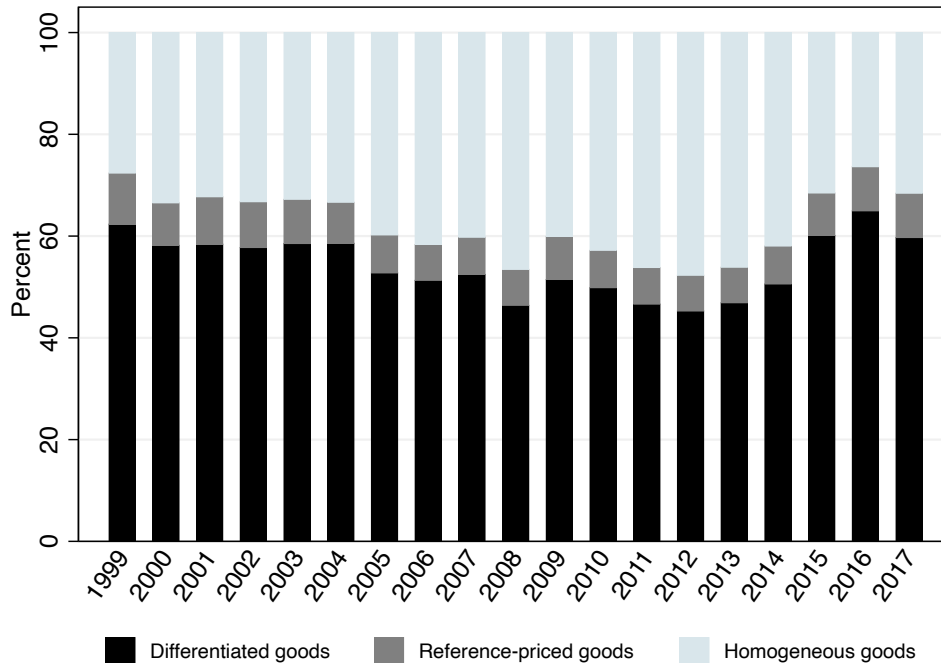


Figure 3.6: Annual Trade Shares for Different Categories of Goods

Notes: This figure shows the share of aggregate imports and exports for different categories of products. We use Rauch (1999)'s classification of goods into differentiated, reference-priced and homogeneous.

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