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Three Essays on Macroeconomics and Income Inequality

Jhon Jair Gonzalez Pulgarin

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Par

Jhon Jair GONZALEZ PULGARIN

Three Essays on Macroeconomics and Income Inequality

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TABLE OF CONTENTS

Introduction	9
1 Intergenerational trends in educational and income mobility in the United States of America since the 1960s	17
1.1 Introduction	17
1.2 Related Literature	21
1.3 Data Description	23
1.3.1 Overview on the National Longitudinal Survey of Youth (NLSY) . .	24
1.3.2 Educational Attainment	25
1.3.3 Incomes	26
1.3.4 Representativeness of data	28
1.4 Educational mobility	29
1.4.1 Stylized facts	29
1.4.2 Econometric approach	31
1.4.3 Robustness check	34
1.5 Income Mobility	35
1.5.1 Log-Log Correlations	35
1.5.2 Rank-rank correlations	38
1.6 The impact of parents' education on children's income	40
1.7 The reality of the American dream	42
1.8 Conclusions	47
Bibliography	48
Appendix	53
1.A Age distribution of youth and parents	53
1.B Educational Mobility - NLSY79	55
1.C Probit models of intergenerational educational mobility	56
1.D Income distribution of youths	58

TABLE OF CONTENTS

2	Ensuring the Sustainability of the US Pay-As-You-Go System	61
2.1	Introduction	61
2.2	Related Literature	66
2.3	Model	69
2.3.1	Aging, earnings and social mobility	70
2.3.2	Households' decisions	71
2.3.3	Wealth distribution	73
2.3.4	Equilibrium	73
2.4	Calibration	74
2.4.1	Calibration based on external information and assumptions	74
2.4.2	Calibrations based on model's restrictions	79
2.5	Comparison of Steady State Results	81
2.5.1	Demographic and Educational Changes in the Long Run	81
2.5.2	Disentangling the impact of the structural changes	83
2.6	Aggregate and distributional impacts of the PAYG system adjustments	88
2.6.1	Macroeconomic Aggregates	89
2.6.2	Inequalities	94
2.7	Welfare	97
2.8	Conclusion	100
	Bibliography	102
	Appendix	105
2.A	Human capital by age	105
2.B	Data hours worked by age	107
2.C	Data on social mobility	108
2.C.1	Social mobility based on NLSY79	108
2.C.2	Social mobility based on NLSY98	109
2.D	Social mobility: from data to model	110
2.D.1	The transformation of the grid	110
2.D.2	Estimation of the new transition matrix	111
2.E	Numerical method of the approximated solution	113
2.E.1	Approximation of the HLB equations for numerical solutions.	113
2.E.2	Matrices of the linear system.	115
2.F	Decomposition of the PAYG system adjustments	119

2.G	Inequalities within Age	120
3	The Impact of Firing Costs on Wages Across Various Educational Categories	121
3.1	Introduction	121
3.2	Data for Measuring the Effect of the Firing Costs on Wages	125
3.3	Econometric Strategy	127
3.3.1	Average Treatment Effect in Staggered Settings	127
3.3.2	Implementation	129
3.3.3	Discussion on the Assumptions	133
3.4	The Model	134
3.4.1	Description of the Model	134
3.4.2	Effects of the Firing Costs	138
3.5	Calibration of the General Equilibrium Model	142
3.5.1	Benchmark Calibration	143
3.5.2	Matching the United States Labor Market	145
3.6	Conclusions	149
	Bibliography	151
	Appendix	153
3.A	Wages and Employment Protection	153
3.B	Further Details of the Data Set	155
3.B.1	Five Educational Categories	155
3.C	Evolution of the Wages Pre and Post Treatment	159
3.D	Characteristics of the Selected States	159
3.E	Complete Estimates	163
3.F	Complete Solution to the Model	167
3.F.1	Finding $J(\bar{m}, \eta)$	169
3.F.2	The Effect of the Firing Costs	171
3.G	Deriving the Expression for $\frac{dw}{dF}$	177
3.H	Determining the Effects of Firing Costs on $m_c(\eta)$	178
3.I	Calibration of the General Equilibrium Model	178
	Concluding remarks	181

INTRODUCTION

This thesis examines the intergenerational income mobility, the sustainability of the pensions system and the labor protection policies in the United States (the US). Despite covering seemingly different topics, they are all analyzed under the scope of the income and wealth inequalities using macroeconomic tools. Furthermore, the role of the education emerges as a crucial determinant across all three chapters, shaping the results. The link between education, income and wealth inequalities is indeed fundamental. Particularly, chapter one explores how changes in the evolution of the educational attainment impact intergenerational income mobility and thus, inequalities. It highlights that the evolving educational system can either mitigate or exacerbate income inequality. On the other hand, chapter two suggests that increasing educational attainment can accentuate wealth inequalities through a saving effect. Finally, chapter three presents the education as a key variable that influences the effect of increasing labor protection policies on wages.

These topics are economically and socially relevant. Indeed, income inequality, as measured by the share of income owned by the top 1%, has soared over the past decades in the United States (Chancel & Piketty, 2021), and there has also been an increase in the wage gap across educational categories (Acemoglu & Autor, 2011). Consequently, education policies have emerged as a mean to counteract these trends. In this regard, policies aimed at increasing access to higher education and lower the tuition fees have been implemented, e.g.: affirmative action policies, the educational loan system, student debt relief, and others (Dill, 2022). The growing significance of these issues underpins the focus of chapter one in this thesis, which seeks to address questions such as: does increased places at the universities ensure higher access and improve intergenerational mobility? How does income inequality relate to intergenerational mobility? Is income mobility lower or higher among the youths with highly educated parents? Are rising educational levels perpetuating social elites?

To address income inequality effectively, it is crucial to revisit the core discussion surrounding intergenerational income mobility and its relationship with educational attainment. There remains ambiguity in research findings regarding this link. One long lasting belief suggests that the center of the attention should be focused on the progres-

sion in the educational attainment across generations, as a key to escaping poverty and reducing income disparities. Schools can play an important role in compensating for initial social and environmental inequalities. However, if the educational system fails to provide equal opportunities to all the students, social inequalities might be reinforced rather than reduced.

The concept of income mobility is also rooted on the perception of the "American dream": Americans might be more willing to support higher inequality if this means that they can reach their dreams with hard work, or at least their children will be able to climb the income ladder (the prospects of upward mobility) (Alesina, Stantcheva, & Teso, 2018). However, evidence suggests that countries with higher inequality are those with lower levels of intergenerational mobility (Corak, 2006). This disparity might be explained by the "inequality of opportunity": increases in income inequality translates into lower mobility because of an unequal distribution of opportunities for economic advancement among children (Corak, 2013a).

The joint work with Ekkehard Ernst, François Langot and Rossana Merola, presented in chapter one, measures the evolution of the intergenerational income and educational mobility and whether the access to all the opportunities offered by the American economy has become more open over time. We provide estimates for the intergenerational income elasticities, rank-rank income correlations and educational-income transition matrices. To do this, we use the two cohorts of the National Longitudinal Survey of Youth (1979, 1997) administered by the Bureau of Labor Statistics of the United States. We find that since the 1980s educational mobility, both upward and downward, has increased. This suggests that the American system manages to give the same educational opportunities to all children regardless the education level of their parents. We also find that the impact of the income rank of parents without a university degree is very low on the income rank of their children. However, for children having parents graduated from college, high parental income enables them to insure against intergenerational income fall, thus generating a correlation between parents' and children's income.

This thesis also addresses the latent issue of the pensions sustainability in the United States. Chapter two looks into the necessary reforms to countervail the effects of the aging population on the sustainability of the pension system in an economy with increasing levels of education among the population. It also explores whether the rising educational attainment can mitigate the strain on the pension system. Indeed, the increase in life expectancy at 65 years old, from 14.5 years in 1960 to 21.5 years in 2100, has placed

significant pressure on the dependency ratio, which is expected to surge from 21.6% in 2010 to 38.6% in 2060. Consequently, ensuring pension sustainability has become a priority on the political agenda. Concurrently, there has been an increasing trend in the levels of education among the population, as discussed in chapter one. Therefore, might this increasing trend in educational attainment affect the effectiveness of the instruments implemented to ensure pension sustainability? Research findings suggest the existence of a link between education and savings, that can ultimately increase income and wealth inequality across age generations (see e.g. Bernheim and Scholz (1993) and Bernheim, Garrett, and Maki (2001)).

The second chapter analyzes all the ingredients explained in the previous paragraph. In particular, this chapter, a joint work with Xavier Fairise, François Langot and Alexandre Popier, introduces a heterogeneous agent model that allows to understand the sustainability of the pensions system in the context of an increasing life time expectancy, and a lowering dependency ratio. We explore various reform options, including adjustments to income tax rates, pension levels, and retirement age. In particular, the policy experiments analyzed are: *(i)* increasing the revenues of the Social Security system by increasing the contribution rate, *(ii)* reducing the expenses of the Social Security by reducing pensions, or even *(iii)* raising the retirement age in order to simultaneously increase the revenues and reduce the expenses. Additionally, we take into account the evolution of the educational attainment and the average career development linked to employment experience, distinguishing between the labor market of graduates and that of non-graduates.

Chapter two finds that variations in the income tax and pensions rates increase distortions in the labor supply, resulting in reduced work-related remuneration. These adjustments also tend to increase the probability for the youths to be financially constrained. However, the distortions in the labor supply vanish when increasing the retirement age, but this raises the problem of the optimal sharing of time allocation between working and leisure over the life-cycle. The increase in the level of education does not generate significant effects on the sustainability of the fiscal budget, even if it allows a significant increase in GDP. Adjustments via tax increases or pension reductions make the wealth inequalities to increase, which are higher when raising the retirement age.

Finally, the last chapter of this thesis, addresses how variations of regulations in employment protection across different states in the US affect wage differentials between educational categories. These effects appear to be influenced by the level of education of the workers. Labor market policies play a determinant role on intergenerational in-

come mobility but they might also amplify the documented labor income gaps across various educational categories. On one hand, employment policies that point to increase the skills of the workers, allow them to easily change for better jobs, augmenting their earnings prospects, increasing income mobility and reducing intra wage inequality. On the other hand, existing skill gaps among the population has created an skill premium that has driven the dynamics of between wage inequalities.

The evolution of the college-wage premium, a measure of the returns to education, has shown a fluctuating trend in the United States. During the period namely the "Great Compression," wage inequality reduced due to a combination of a high demand for less skilled labor during the wartime, wage-fixing approaches, and a steep increase in the supply of highly educated workers (Goldin & Margo, 1992). However, despite this wage convergence, particularly in the manufacturing sector, the college/high school wage premium has been rising over the past decades (Blanchard & Katz, 1992).¹ Indeed, State-level time series data on total pre-tax wage and salary income, reveals divergent trends across educational categories in the United States from 1977 to 1997. Individuals with some college, college and greater than college education have seen steep increases in wages from the beginning of the 1980's to 1997, while those with only lower or high school education have experienced significant decreases or stagnation from 1977 to 1997. These within-wage inequalities can be the result of changes in the returns to skills or changes on wage-fixing institutions. Furthermore, structural reforms, changes in unionization or in collective bargaining, might also influence wage structure (Katz & Autor, 1999). Recent trends underline the role of technology as the primary driver of the increased wage inequality (Acemoglu & Autor, 2011).

Alongside the steep increase in the college/wage premium, the United States also experienced a well-documented rise in firing costs during the period 1977-1997 (Autor, 2003). In effect, several exceptions to the the employment-at-will policy were introduced across states during this period. The employment-at-will policy allows employers to discharge or retain employees at will, with or without cause, without being inherently unlawful. There are three main exceptions to the employment-at-will: the implied contract, the public policy and the "good faith" exception. In chapter three, I analyze whether the variations to the employment-at-will and the wage trends are related. In particular, I analyze how cross states variations of adopted exceptions to the employment-at-will policy, affect wages of

1. For a comprehensive historic revision of the research evolution on wage determinants see Katz and Autor (1999).

individuals with different levels of education in the United States. It is observed that increasing employment protection may prompt firms to lower their dismissal threshold, potentially leading to reduced average job productivity and lower wages. Furthermore, the arrival of idiosyncratic shocks may be higher for the less and highly educated workers due to deteriorating labor market conditions and high volatility, respectively.

In chapter three, I construct a panel using a variety of data sources such as the Current Population Survey, the Bureau of Economic Analysis surveys, the Employment Survey of the Bureau of Labor Statistics and data from Autor (2003). The panel contains information at the state level on wages for individuals with different educational levels, states adopting exceptions to the employment-at-will, GDP, employment and other covariates. This allows to provide empirical evidence of the link between firing costs and wages by estimating different econometric models. Secondly, I estimate the average treatment effect of implementing these regulations on wages across different educational categories, using recent quasi-experimental methods that extend the difference-in-difference framework to staggered settings with heterogeneous treatment effects. Additionally, I offer theoretical explanations of the empirical results.

I find that the Average Treatment Effect of rising firing costs shows a negative effect on wages within selected states. The extent of these effects varies depending on the level of education, with estimations revealing a particularly strong negative effect for individuals with greater than college education and for high school dropouts. From a theoretical point of view, firing costs have a detrimental impact on equilibrium wages for incumbent workers. The results suggest a negative effect of increasing employment protection regulation on the top and the bottom of the wages across various educational levels. The role of the idiosyncratic shocks emerges as an dominant explanatory factor in the theoretical findings.

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INTERGENERATIONAL TRENDS IN EDUCATIONAL AND INCOME MOBILITY IN THE UNITED STATES OF AMERICA SINCE THE 1960s

Joint with F. Langot, E. Ernst and R. Merola

1.1 Introduction

Social cohesion in the United States of America (the US) has long been based on the idea that all economic opportunities are accessible to everyone (this is the iconic "rags-to-riches American dream"). From this perspective, social mobility is a prerequisite for sustaining "American-style" society, which is the guarantee that everyone can access any remuneration based on their merits (Alesina et al., 2018).¹ The credibility of this American-style society is, therefore, based on there being effective "prospects of upward mobility" (Benabou & Ok, 2001).²

In this chapter, we measure whether, over time, access to all opportunities offered by the American economy has become more open and, hence, enhanced social mobility. We contribute to the literature by analysing the role of educational mobility in the economic

1. "America has always been a land of opportunity, a land where, if you work hard, you can get ahead." B. Clinton, 1995. The typical answer recorded in Economic Mobility Project (2009) when Americans are asked to explain what mean "The American dream" is "Being able to succeed regardless of the economic circumstances in which you were born." This view then leads the lower income individuals to not ask for large redistributive policies because they expect that they or their children, climb the income ladder ((Corak, 2013b)).

2. Upward income mobility is defined as the strictly positive probability of ending up in the top 25 per cent of earnings, even when parents have an income in the bottom half of the income distribution Chetty, Hendren, Kline, and Saez (2014a).

mobility process.³ So far the evidence is scarce, as we discuss in section 2.

We believe that this is a relevant topic to analyse, since social mobility – in terms of income and education – tends to correlate negatively with inequality and poverty. Common wisdom says that countries with higher income inequality tend to have lower intergenerational income mobility, which is supported by findings by Chetty, Hendren, Kline, and Saez (2014b). The relationship between social mobility and inequality has even been given its own name – the "Great Gatsby Curve" (for example, Corak (2013b); Blanden (2013)). Educational mobility also plays a key role. Using the Global Database of Intergenerational Mobility, Narayan et al. (2018) find that countries that have higher educational mobility are characterized by higher growth, and lower inequality and poverty.

We analyse intergenerational education and income mobility in the US, for children born between 1957 and 1964 and between 1980 and 1984, using the 1979 and 1997 versions of the National Longitudinal Survey of Youth (NLSY).⁴ Chetty et al. (2017) argue that it is essential to have data available that establishes a link between parents and children, to fully understand the evolution of social mobility. The NLSY provides valuable information on the links between parents and children, which therefore allows us to understand intergenerational social mobility.

We show that total mobility, defined as the sum of upward and downward mobility, has remained stable for cohorts born between 1957 and 1964, and has significantly increased for those born between 1980 and 1984. This suggests that making universities more accessible in the 1960s had an impact on upward educational mobility in the US.⁵ Across the period we examine, the probability that a child whose parents have had a tertiary education will attain a bachelor's degree has an inverted U shape. This shows there was a break in the social reproduction of the elite (Bourdieu, 1984). For example, having at least one parent with a bachelor's degree accounts for 70 per cent of the probability that a child born between 1957 and 1964 will graduate, but the parents' contribution declines to less than 60 per cent for children born between 1980 and 1984. In other words, cohorts

3. The literature distinguishes between absolute and relative mobility. Absolute mobility measures whether society's education, income and general living standards have increased; this is often measured by the percentage of people who have a higher income than their parents. Relative mobility refers to the likelihood that children will move from their parents' rank in the social hierarchy. In this chapter, we focus on relative mobility.

4. Intergenerational social mobility refers to children's ability to attain a higher social status than their parents OECD (2018).

5. These findings are consistent with, and extend, the results of Hilger (2015). Hilger estimates that educational mobility strongly increased between the 1930s and the 1970s, and slightly declined after the 1980s.

who have a parent with a bachelor’s degree have had 3.5 times more chances to attain a bachelor’s degree than those whose parents have not had a tertiary education, if they were born between 1957 and 1964, but only 2.25 times more chances if they were born between 1980 and 1984.

Intergenerational educational mobility is the sum of downward mobility and upward mobility. In the US, intergenerational educational mobility has risen since the 1960s, and our results point out that upward education mobility is the stronger force at work. However, low-educated parents have also been able to invest more in their children’s education, which has led to an increase in their children attaining a higher education, because the number of higher education places has risen. This rise in places is a necessary condition: after the children of higher-educated parents have been registered at universities, the increased number of university places leaves more opportunities for the rest.

Since education tends to be a strong predictor of lifetime earnings, the increase in educational mobility could also induce an increase in income mobility in the US. We test this in the second part of the chapter, by analysing how income mobility has evolved. We compute intergenerational income elasticity (IGE), which is the elasticity of a child’s income with respect to their parents’ income.⁶ We show that IGE is continuously decreasing, suggesting that income mobility of cohorts born between 1957 and 1984 has been increasing. These results are consistent with those for educational mobility, for which upward mobility has also been increasing significantly.

However, changes to IGE, as a measure of income mobility, can be affected by changes to intergenerational inequality. In our sample, income inequality among youths has declined over the period we examine, while income inequality among parents has risen. This has led to a significant decline in the relative income inequality between youths and parents. Therefore, even if the correlation between children’s and parents’ incomes remains stable over the period, IGE mechanically declines, driven by the reduction in the relative income inequality between youths and parents. The declining IGE supports the idea that income mobility in the US is rising. However, this rise is misleading as it is only driven by the increase in income inequalities among parents.

To isolate income mobility from changes to income inequality, we use an alternative measure of income mobility: the rank-rank correlation. This measures the association between parents ranking in the income distribution and their children’s ranking in the

6. Intergenerational mobility can be measured in relative or absolute terms. According to Chetty et al. (2014a), IGE is an indicator of relative mobility. IGE is obtained by running a regression of the logarithm of the child’s income on the logarithm of the parents’ income (log-log estimate).

income distribution when they are adults.⁷ Chetty et al. (2014a) show that rank-rank correlations and IGE estimates are closely related; the rank-rank correlation can be viewed as the IGE estimate, but without the effect of shifting relative inequalities. The rank-rank correlation decreases only slightly over time, which points to a modest increase in income mobility. Our results are similar to those of Chetty et al. (2014a), showing that, overall, the rank-rank intergenerational correlation has not changed. IGE decreased only for cohorts between 1971 and 1993, because of increasing income inequality.

We subsequently test whether parental education has an impact on children's income. We find that parents' income has a greater impact on children's income when parents are highly educated. This result is consistent with the view that highly educated parents invest more in their children and send them to better quality schools, leading to their children having higher cognitive skills and completing more years of schooling, which ultimately affects the children's earnings (Blanden, Gregg, and Macmillan, 2007; Keane and Wolpin, 2001; Daruich and Kozlowski, 2020). However, we also find that the income of parents with no college degree has a very small impact on the income ranking of their children, and that income differences among parents with no college degree do not explain the income positions of their children.

Our results highlight that, even in a society where people - in principle - can move upwards, the perpetuation of privileges creates "stickiness" at the top of the distribution. This is because wealthy students are more likely to have access to the most prestigious colleges.⁸ Chetty, Friedman, Saez, Turner, and Yagan (2020) argue that most students at Ivy League colleges come from families in the top 1.0 per cent of the income distribution, while only 3.8 per cent of the students come from the bottom quintile of the income distribution. Sandel describes this as: "American higher education is like an elevator in a building that most people enter on the top floor" (Sandel, 2017).

Finally, we use matrices of mobility to analyse upward mobility – the combination of educational and income mobility. While we show that upward mobility has risen, we also observe that downward mobility has declined over the same period, which points to the perpetuation of elites. We conclude that, by the end of the 1980s, the American system

7. The measure of intergenerational income mobility, in relative terms, is based on the correlation between the ranking of children's and parents' incomes. This is obtained by performing a regression of the percentile rank of a child in the income distribution of children and the percentile rank of their parents in the income distribution of parents. The slope of this regression reflects the association between the income distribution of children and their parents.

8. The New York Times has published comprehensive information on the correlation between parental income and the university that their children attend (Aisch, Buchanan, Cox, & Quealy, 2017).

has successfully improved educational opportunities for children from low-income families, by increasing the number of university seats. However, society has also developed an elite, which is wealthy and well educated. For those born to this elite, their family's status has a strong impact on their welfare and that of future generations.

1.2 Related Literature

Analysing intergenerational mobility is crucial to understand economic inequalities, as intergenerational mobility is an indicator of the extent to which children can succeed regardless of their family background.

People who believe that opportunities are unequally distributed, and high income can buy better education, are less keen to accept current income disparities. Perception of equal opportunities is crucial for social stability and cohesion (Balestra & Ciani, 2022).

One strand of the literature analyses the impact of educational mobility on economic mobility. So far, there is scarce empirical evidence on this subject, but the literature does point out that the impact varies between regions. In Latin America, education has a strong impact on economic mobility (Torche, 2014). In contrast, Assaad and Saleh (2018) and Binzel and Carvalho (2017) show that educational mobility in Jordan and Egypt respectively has not increased income mobility, which suggests that the educational pathway plays a limited role in economic mobility.

Becker, Duke Kominers, Murphy, and Spenkuch (2018) develop a theoretical model that predicts that, under certain circumstances, there are strong complementarities between parents' and children's education.⁹ This implies that societies develop a highly educated elite, whose members have high mobility but not "across the endogenously determined class boundaries" (Becker et al., 2018, p. 9). Therefore, a family's initial status has a strong impact on the welfare of its future generations. These theoretical predictions are consistent with observed data in OECD countries. Throughout OECD countries, high parental educational attainment has a positive influence on the likelihood that their children will complete tertiary education or an advanced research programme (OECD, 2017).¹⁰

9. If there is high elasticity between parents' and children's human capital and between children's earnings and their parents' investments in human capital, the relationship between parents' and children's human capital will be convex, leading to high returns on human capital investments. The complementarities of parents' and children's human capital imply that parents have a strong influence on the human capital of their children.

10. In OECD countries, on average, children whose parents have a tertiary degree are 55 per cent likely

Another strand of the literature analyses how intergenerational mobility has evolved. Narayan et al. (2018) provide an overview of intergenerational mobility around the world and compare income and educational mobility in developing and developed countries. Focusing on the US, Autor (2014) stresses the importance of measuring whether mobility for children born before and after the historic rise of US inequality has appreciably changed. Related to this, Davis and Mazumder (2024) document a sharp decline in income mobility for cohorts born around 1960, compared with those born in the 1940s. The reason for this trend is that most of those born around 1960 entered the labour market after the large increase in inequality, which started in the early 1980s; those born in the 1940s entered the labour market before this inflection point.

However, Chetty et al. (2014a) reach different conclusions. They find that mobility has not changed since the 1970s. A lacking trend for intergenerational mobility contrasts with the increasing income inequality observed in recent decades, since inequality and mobility are negatively correlated (this is the Great Gatsby Curve we discussed in the Introduction). One explanation for this is that the increase in inequality has been driven by the extreme upper tail, and there is little correlation between mobility and inequality in the extreme upper tail, while the correlation between inequality and mobility is driven primarily by "middle-class" inequality (Piketty and Saez, 2003; Chetty et al., 2014b).

In the same vein as Chetty et al. (2014a), Lee and Solon (2009) argue that intergenerational mobility has not changed. They say that estimates are imprecise due to an inefficient use of data. Chetty et al. (2017) argue that a lack of data to establish a link between parents and their children prevents researchers from fully understanding how income mobility has evolved in the US.

Ayasse, Myers, Schmidt, and Schwam (2016) provide an analysis of the American dream in different US states. They define the "American dream" as the probability that youths will end up in the national fifth quintile of the income distribution, given that their

to obtain a tertiary degree themselves ('immobility at the top'), whereas this likelihood is 20 per cent for children whose parents do not have a tertiary degree ("upward mobility"). Using comparable data, immobility at the top and upward mobility are, respectively, 55 per cent and 25 per cent in the US; 62 per cent and 17 per cent in France; 60 per cent and 33 per cent in Norway; and 65 per cent and 25 per cent in the UK. This represents a 30 percentage point (pp) gap in the US and a 45 pp gap in France. In the US, 19 per cent of people aged 30 to 44 years old whose parents have not had a tertiary education (2012, 2015) have completed tertiary type A or an advanced research programme. The equivalent proportions are 16 per cent in France, 33 per cent in Norway and 25 per cent in the UK. In contrast, in the US, 56 per cent of people aged 30 to 44 years old (2012 or 2015) with at least one parent who has a tertiary education degree have completed tertiary type A or an advanced research programme. The equivalent proportions are 62 per cent in France, 61 per cent in Norway and 64 per cent in the UK (OECD, 2017). This represents a 37 percentage point (pp) gap in the US and a 46 pp gap in France.

parents were in the national first quintile of the income distribution. The probabilities range from 0.0408 for South Carolina to 0.19 for North Dakota. After three generations, the probabilities range from 0.123 for Georgia to 0.344 for North Dakota.

The The Pew Charitable Trusts (2012) finds that younger generations of Americans have higher earnings than their parents had at the same age, although there is some persistence in income position. For example, 43 per cent of adults whose parents' income was in the bottom quintile of the income distribution remained in the bottom quintile, while 40 per cent of adults whose parents' income was in the top quintile of the income distribution remained in the top quintile. Despite this persistence, this research also shows that educational attainments push people out of the immobility trap. For example, 47 per cent of adults whose parents' income was in the bottom quintile of the income distribution remain in the bottom quintile if they do not have a college degree, but only 10 per cent remain in the bottom quintile if they attain a college degree. Meanwhile, an adult whose parents' income was in the top quintile is more likely to remain in the top quintile if they have a bachelor's degree than if they do not (51 per cent compared with 25 per cent).¹¹

1.3 Data Description

Before discussing data on educational attainments and income trends, in this section we give a short overview of the historical context for education attainments and evolution of global trends in the US.

Educational mobility in the US is a result of the educational system, which has undergone a big transformation. Over the last century, American universities have increased seats and the proportion of youths who go to college has dramatically increased.

American universities were initially conceived to preserve the values of Protestantism. They were marked by religious idealism, and this influenced the type of students who colleges accepted. For example, the 300 students who attended Harvard during the administration of Dunster and Chauncy, between 1642 and 1672, were mainly English

11. Stockhausen (2021) computed absolute and relative income mobility for youths in West Germany and the US who were born between 1955 and 1975. He finds that the share of youths who earn more than their parents (absolute mobility) amounts to 67 per cent in West Germany and 60 per cent in the US. In terms of relative income mobility, 66 per cent of West German youth and 50 per cent of American youths whose parents were in the lowest quartile manage to end up in the highest quartile. West Germany exhibits a lower estimated IGE than the US (0.299 and 0.483 respectively), suggesting higher income mobility in West Germany. Combining the two measures (absolute and relative income mobility) Stockhausen (2021) shows that 56 per cent of West German youths and 52 per cent of American youths who have higher income than their parents have ended up in one higher income quartile at least.

exiles or their sons; sons of ministers and magistrates; sons of the gentry; and sons of college-educated fathers (Geiger, 2016). This situation remained unchanged during the late nineteenth and early twentieth centuries. During the 1950s, the American university system was influenced by the ideas of James Bryant Conant who, citing Thomas Jefferson, referred to social mobility as an essential feature of a classless society in the US. Conant (1940) pointed out that the education system has a role to provide people with opportunities to develop their skills and improve their chances for social mobility.

The spread of Conant's ideas, together with demographic growth and public reforms, may explain why the percentage of adults aged 25 to 29 years old with at least a bachelor's degree increased: in 1940, 5 per cent had a bachelor's degree or higher, while in 1976, 24 per cent had a bachelor's degree or higher. By 2015, this percentage had risen to 36 per cent (see Census website).

1.3.1 Overview on the National Longitudinal Survey of Youth (NLSY)

The primary purpose of the NLSY is to collect data on young people's experiences of the labour force, attachment to the labour market and investment in education and training. The NLSY shows how different socioeconomic variables have evolved for people who were 14 to 22 years old in the first round of the 1979 version (BLS, 2019a) or 12 to 17 years old in the first round of the 1997 version (BLS, 2019b).¹²

In 1979, the NLSY79 surveyed 12,686 young men and women who were born between 1957 and 1964. This sample was interviewed annually from 1979 to 1994, and biennially thereafter. Data are now available from round 1 in 1979 through to round 28 in 2018. The initial cohort of NLSY97 was 8,984 young men and women who were divided into two subsamples:

1. A cross-sectional sample of 6,748 respondents who were born between 1980 and 1984. The subsample was designed to represent people living in the US during the initial survey round.
2. A supplemental sample of 2,236 respondents who were born between 1980 and 1984. The subsample was designed to overrepresent Hispanic, Latino and Black people living in the US during the initial survey round.

12. See Appendix 1.A for more details on how the NLSY cohorts are distributed.

The NLSY97 cohort has so far been surveyed 19 times; it is now interviewed biennially. Data are now available from round 1 in 1997/98 through to round 19 in 2019/2020, and from a COVID-19 supplement in 2021, which asked respondents how the COVID pandemic was affecting their health and employment.¹³ Our study characterizes individuals by their educational attainment and income 30 years after they were born, and by the educational attainment and income of their parents during the corresponding rounds of the NLSY97.¹⁴

1.3.2 Educational Attainment

In our study, we define a "skilled individual" as an NLSY respondent who has more than 15 years of schooling or more than 3 years of college education (this is the number of years needed to attain a bachelor's degree). If a respondent has less schooling, we define them as "unskilled." If a respondent's mother, father or both parents have the number of years of schooling that was needed to attain a bachelor's degree in 1979 or 1997, we define them as "skilled." For each NLSY79 respondent, we compare their educational attainment at age 30 with the educational attainment of their parents. For this information, we use data recorded in 1979, because parents were more than 30 years old in that year and, therefore, had already made education investment decisions.

We consider similar procedures for youths in the NLSY97. In this case, we compare the educational attainment of respondent at age 30 with that achieved by their parents before 1997.

Educational attainment of youths. We observe youths 30 years after their birth. If they have enough years of schooling to attain a bachelor's degree, we define them as "skilled children." Otherwise, we define them as "unskilled children." For example, to calculate whether youths born in 1957 are skilled or unskilled, we use information from the variable R24454 labelled HGCREV87. This asks youths this question from the 1979 survey: "What is the highest grade completed as of May of survey year 1987?" Cohorts

13. While it could be possible to analyse the upward mobility in education by race and gender, the data may be insufficient for statistical precision. Even if it was possible to carry analyse the NLSY97 data by race and gender, it would be impossible to analyse the NLSY79, because multiple steps would be needed to compute family income.

14. In our study, we check that parents are at least 30 years old, hence they have fewer incentives to invest in their education beyond this age. See Appendix 1.A for the age distribution of youths and parents.

born in other years were asked a similar question.¹⁵ The answers to this question range from 0 to 20 years of schooling or 8 or more years of college education. We consider a respondent "skilled" if they have more than 15 years of schooling or more than 3 years of college education.

For years 2010, 2011, 2013 and 2015, we use the variable `cv_hgv_ever_edt_year` to compute the level of education that NLSY97 respondents have attained. We use a similar methodology to compute the educational attainment of NLSY97 respondents.

Educational attainment of parents. We define the father or the mother of the respondent as a "skilled parent" if they have more than 15 years of schooling or more than 3 years of college education.

We use the variables `hgc_father_1979` and `hgc_mother_1979` to compute indicators of education for the mother and father of each NLSY79 respondents. These variables provide information on the number of years of education a parent has attained. Similarly, we use the variables `cv_hgc_bio_dad_1997` and `cv_hgc_bio_mom_1997` to obtain information about the level of education that the mother and father of each NLSY97 respondent has attained.

In NLSY79 and NLSY97 these variables range from zero years of schooling through to eight years of college education.

1.3.3 Incomes

Youths' incomes in NLSY79 and NLSY97. For each of the birth cohorts, we use the pre-tax income from wages and salaries to define the income of youths when they are 30 years old (variable `R35590`, questions 13 to 15). For years 1987 to 1994, we use the variable `Trunc_Revised_year` to obtain the total pre-tax income from salary, wages, commissions or tips in the past calendar year. For years 2010, 2011, 2013 and 2015 for NLSY97, we use the variable `T75456` labelled `YINC_1700_year` to obtain the total pre-tax income from salary, wages, commissions or tips. In the case of the NLSY79, the available data is truncated at the top of the income distribution. Data administrators employed various truncation methods during different periods. Specifically, between 1979

15. Using the NLSY79, we compute the education completed by youth respondents in 1987, 1994 and 1996 for those born in 1957, 1964 and 1965 respectively. Similarly, the NLSY97 allows us to compute the education completed by youth respondents in 2010, 2013 and 2015 for those born in 1980, 1983 and 1987, respectively. Because of data availability, we cannot compute the education of youth respondents in 1995, 2012 or 2014, and use 1996, 2013 and 2015 respectively instead.

and 1984, incomes exceeding \$75,000 were truncated to \$75,001, and from 1985 to 1988, values above \$100,000 were truncated to \$100,001. Subsequently, different algorithms were implemented. For the NLSY97, topcoding of income variables is applied to 2% of the reported values, and these values are replaced by the mean of the high values.¹⁶

Parents' income (NLSY79). Variable `tnfi_trunc_1979` is the total pre-tax family income in the past calendar year. We use this variable as a proxy for parents' income in 1979. This variable provides information about the different sources of income of household members who are related to the respondent by blood or marriage. We use data only for youths living with their parents at the time of the survey. We extract the possible income that youths are contributing to the family income variable, leaving what is mainly parents' income. We use the variable `R0173700` labelled `hhi-2` (version of household record from screener) to identify any youth respondents who are married or have children and delete them from the sample. Out of 12,686 NLSY79 respondents, we identify 8,838 youth respondents living with their parents. To distinguish the parents' and youths incomes, parents answer questionnaire A and youth answer a shorter, more limited questionnaire.¹⁷ The household income is based on the information provided by parents.

We extract the youths' income from the net family income variable using two types of variables:

1. The variable `R01554` labelled `S21Q02A`, which is the total salary and wage income of each youth in the past calendar year. This variable excludes youths who are 18 years old or older, have a child, are enrolled in college, are married, are living outside the parents' home or have served in the military services in the past calendar year.
2. The variable `R01691` labelled `INCOME-24` for the other youths, who do not meet any of the previous criteria.

Parents' incomes in NLSY97. For the NLSY97, we have precise information about parents' income, so we can directly compare it with children's income.¹⁸ We use the

16. For the US CPI see IMF data

17. If the youth is 18 years old or older, has a child, is enrolled in college, is married or is living outside the parents' home, they answer a more complex questionnaire about their income. For more information, see Table 1 on the NLSY79 website (<https://www.nlsinfo.org/content/cohorts/NLSY79>).

18. This information is not available for 2001.

variable R1204500 labelled `cv_income_gross_yr_1997`, which is a proxy indicator of family income in 1997.¹⁹ This variable provides information on the gross household income in the past calendar year.

1.3.4 Representativeness of data

To generate our sample, we apply several restrictions to the NLSY data. To check if our sample is representative of the American population, we compare our observations with summary statistics computed using the Current Population Survey (CPS).

Table 1.1 shows that education and race of youths are homogenized in the CPS and the NLSY, but the proportion of female youths is lower in the NLSY79 than in the CPS. The proportion of educated youths is similar in the NLSY79 and the CPS, but quite different in the NLSY97. The proportion of educated people increases more steeply in the NLSY97 than in the CPS. Finally, the earnings distribution of youths in the NLSY is similar to the CPS. We conclude that our sample is representative of youths aged 30 years in the US.

Table 1.1 – **Characteristics and earnings of the youth: a comparison between CPS and NLSY data**

Variable	CPS 1987-1994	NLSY79 1987-1994	CPS 2010-2013	NLSY97 2010-2013
Male	53.38	61.20	52.60	54.43
Female	46.62	38.80	47.40	45.57
Non Black	91.05	89.16	89.07	88.51
Black	8.95	10.84	10.93	11.49
L Educated	74.41	76.29	63.95	51.26
H Educated	25.59	23.71	36.05	48.74
Income				
Av	35,165.48	37,123.56	39,432.70	38,009.00
P25	18,423.78	21,109.88	19,387.95	20,000.00
P50	31,400.87	34,226.88	32,011.00	32,761.15
P75	47,127.06	48,936.55	49,906.80	50,000.00
Obs	17,257	1,726	8,648	1,517

The NLSY data are weighted.

19. This variable is computed by combining several components. For more information, see Income NLSY1997.

Table 1.2 compares parents' income distributions in our sample (this data is extracted from the NLSY79 and the NLSY97) with CPS data. Our data from the NLSY97 is comparable with the CPS (this shows our data are representative of the US population) but our data from the NLSY79 is not. These differences are no surprise, as Jo (2006) has already shown that the NLSY97 and CPS do not represent the same population.

Table 1.2 – **Parents' income (in US \$): a comparison of CPS and NLSY data**

	1987		1988		1988		1990		1991		1992		1993		1994	
	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY
Av.	42,709	66,504	40,647	62,439	39,972	63,358	41,114	64,860	42,294	68,901	42,715	58,124	43,660	70,403	44,825	69,131
SD	31,428	43,304	29,463	38,279	28,189	37,503	30,647	36,943	31,399	38,504	31,621	33,579	31,599	43,014	32,504	43,036
P25	20,310	30,045	19,580	33,808	19,185	35,972	19,432	40,447	19,992	39,407	20,973	33,269	20,831	40,543	21,501	37,798
P50	36,355	55,584	34,750	58,212	34,788	55,877	35,042	61,010	35,906	64,584	36,313	52,476	37,887	66,643	39,288	59,682
P75	57,687	94,643	54,574	82,027	54,474	81,538	55,372	79,087	56,256	96,110	56,884	74,620	59,193	95,276	60,080	90,517
Obs	19,113	189	23,037	225	23,141	225	21,405	252	21,839	233	22,236	208	23,137	206	23,497	188

Table 1.3 – **Parents' Income: Comparison Between CPS and NLSY97 Data**

	2010		2011		2012		2013	
	CPS	NLSY	CPS	NLSY	CPS	NLSY	CPS	NLSY
Av.	48,882	47,049	50,173	51,542	51,296	47,402	50,137	48,688
SD	53,391	47,095	53,477	51,339	54,025	35,710	46,102	42,813
P25	21,735	16,301	22,733	21,403	23,562	24,052	22,851	23,806
P50	38,036	33,961	39,518	40,130	39,337	41,889	39,255	37,988
P75	59,082	63,847	60,546	64,209	62,474	65,452	62,333	63,314
Obs	25,716	408	25,528	345	26,046	390	26,441	374

1.4 Educational mobility

1.4.1 Stylized facts

One way to measure the evolution of educational mobility between different cohorts is to construct mobility matrices between parents without a bachelor's degree and children with a bachelor's degree. These 2×2 matrices are used to measure how the probability of attaining a bachelor's degree, given the family's educational background, has evolved.²⁰

20. The matrix of educational mobility is $\begin{bmatrix} N_{uu} & N_{us} \\ N_{su} & N_{ss} \end{bmatrix}$, where u denotes the state "unskilled" and s the state "skilled". Therefore, for example, the probability of obtaining a bachelor's degree for a child with parents without a bachelor's degree is $N_{us}/(N_{uu} + N_{us})$.

Panel (a) in Figure 1.1 shows how the probability of a child attaining a bachelor’s degree if their parents do not have a bachelor’s degree has evolved (upward educational mobility). In 25 years, the probability has more than doubled, so we conclude that upward mobility has clearly increased since the end of the 1980s. Panel (b) in Figure 1.1 shows the probability of a child not attaining a bachelor’s degree despite their parents having a bachelor’s degree (downward educational mobility). In 25 years, the probability has more than halved, so we conclude that downward mobility has greatly diminished. Finally, panel (c) in Figure 1.1 shows that total educational mobility (this is the share of upward and downward mobility in all intergenerational transitions) in the US has increased since the late 1980s. This underlines the strong force of upward mobility, which dominates the reduction in downward mobility.

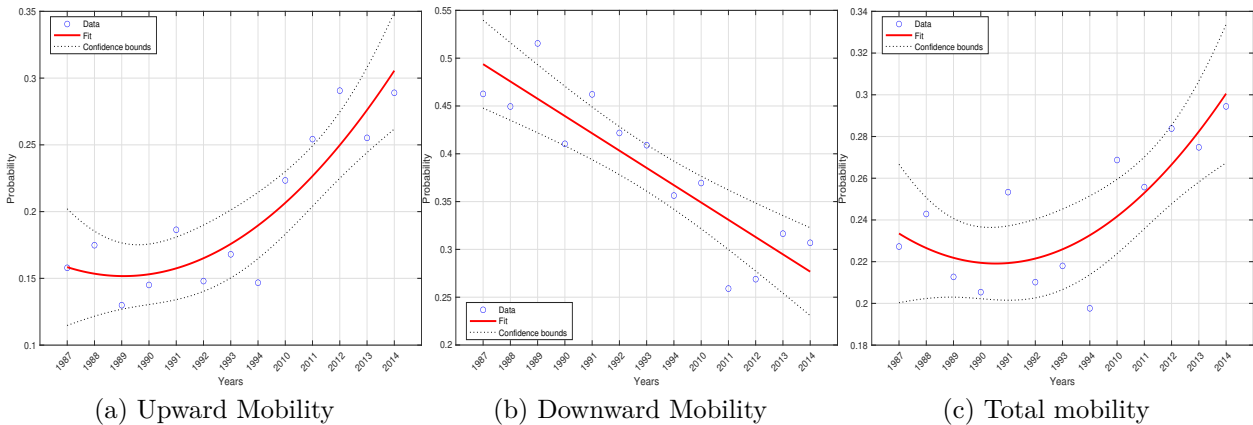


Figure 1.1 – Mobility in Educational Attainment - 1987-2014.

Note: (i) Children are observed 30 years after their date birth, which implies that observations are between 1987 and 2014. (ii) In panels (a) and (c), the estimated equation is $Pr_t = a + bt + ct^2 + \varepsilon_t$, whereas in panel (b) it is $Pr_t = a + bt + \varepsilon_t$. The OLS estimated coefficients are $\{0.1642^{***}; -0.009; 0.0015^{**}\}$ in panel (a), $\{0.51^{***}; -0.018^{***}\}$ in panel (b), and $\{0.24^{***}; -0.0103; 0.0011^{**}\}$ in panel (c). * $p < 10\%$, ** $p < 5\%$ and *** $p < 1\%$ levels.

Panel (a) in Figure 1.1 shows the evolution of the probability of obtaining a bachelor’s degree for a child with parents without a bachelor’s degree, i.e. upward mobility. We conclude that upward mobility has clearly increased since the end of the 1980s. The probability has multiplied by more than 2 in 25 years. Panel (b) in Figure 1.1 shows the evolution of downward mobility, that is the probability that a child does not attain a bachelor’s degree despite his/her parents have at least a bachelor’s degree. We conclude that downward mobility has greatly diminished (divided by more than 2 in 25 years).

Finally, panel (c) in Figure 1.1 shows that educational mobility (the share of upward and downward educational mobility in all intergenerational transitions) has increasing in the United States since the end of the 1980s. This last result underlines the strong force of the upward mobility, that dominates the reduction in the downward mobility.

1.4.2 Econometric approach

We aim to distinguish the effect that two factors may have on the observed increase in upward educational mobility:

1. Universities opening up to the entire population, which has made it more likely that youths will attain a bachelor's degree or a higher degree.
2. A favorable family context since children in higher socioeconomic backgrounds are more exposed to regular educational activities at home (Clarke & Thevenon, 2022).

To achieve this aim, we estimate the following regression:

$$Y_{i,j,k} = \alpha_{j,k} + \beta_{j,k}X_{i,k} + \varepsilon_{i,j,k} \quad (1.1)$$

where $Y_{i,j,k}$ is a binary variable that is equal to 1 if the youth respondent i is skilled (i.e. has at least a bachelor degree), he/she is born in cohort j , for each NLSY versions $k \in \{NLSY79, NLSY97\}$; $X_{i,k}$ is a binary variable that is equal to 1 if either the mother or the father of the respondent i has a bachelor degree in the NLSY versions k ; finally, $\varepsilon_{i,j,k}$ are the residuals. Therefore, for each version of the survey, $\alpha_{j,k}$ is the probability of becoming skilled for a youth born in year j , conditionally to have unskilled parents, while $\beta_{j,k}$ gives the marginal increase of the probability for a youth born in cohort j to become skilled induced by parents being skilled.

Table 1.4 – **Education Transition for Different Birth Cohorts - NLSY79.**

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\beta_{j,k}$	0.379*** (0.0467)	0.376*** (0.0437)	0.355*** (0.0451)	0.445*** (0.0421)	0.351*** (0.0423)	0.430*** (0.0404)	0.423*** (0.0448)	0.497*** (0.0433)
$\alpha_{j,k}$	0.158*** (0.0158)	0.175*** (0.0166)	0.130*** (0.0144)	0.145*** (0.0147)	0.186*** (0.0164)	0.148*** (0.0143)	0.168*** (0.0158)	0.147*** (0.0162)
Observations	986	1030	1061	1144	1041	1084	1000	837
Adjusted R^2	0.136	0.133	0.129	0.186	0.114	0.175	0.154	0.231

Notes: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.4 presents OLS estimates for Equation (1.1) for different birth cohorts, using the NLSY79. For example, a child of unskilled parents born in 1958 has a probability of being skilled equal to 17.5% ($\alpha_{1958,NLSY79}$). Having skilled parents has a marginal impact that causes the probability to rise by 37.6 pp ($\beta_{1958,NLSY79}$). Therefore, the probability that a youth born in 1958 will be highly educated, regardless of their parents' educational attainment, is $\alpha_{1958,NLSY79} + \beta_{1958,NLSY79} \times P_{s,p} = 26.88\%$ where $P_{s,p} = 24.963\%$ is the share of skilled individuals in the population of parents.²¹

Table 1.5 – Education Transition for Different Birth Cohorts - NLSY97.

Year of birth (j)	1980	1981	1982	1983	1984
$\beta_{j,k}$	0.407*** (0.0394)	0.487*** (0.0337)	0.441*** (0.0348)	0.428*** (0.0343)	0.404*** (0.0357)
$\alpha_{j,k}$	0.223*** (0.0190)	0.254*** (0.0182)	0.291*** (0.0193)	0.255*** (0.0180)	0.289*** (0.0188)
Observations	838	961	968	989	983
Adjusted R^2	0.155	0.209	0.169	0.167	0.142

Note: $k = NLSY97$. Robust standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.5 presents OLS estimates for Equation (1.1) using the NLSY97. The results show that the coefficients $\alpha_{j,k}$ are higher than those obtained for the NLSY79. On average, we observe an increase in educational mobility, mostly driven by universities opening up to all. Table 1.5 shows that the probability of a youth achieving a higher degree than their parents has significantly increased, from 15.7 per cent in the NLSY79 to 26.2 per cent in the NLSY97. The marginal effect of the family context has remained unchanged - the differences between zero and the NLSY79 average estimate (0.41) and the NLSY97 average estimate (0.43) are not statistically different.

Information in Table 1.4 and Table 1.5 allows us to track how educational transition between youths and their parents has evolved.

Figure 1.2 panel (a) shows how much the probability that a child born to unskilled parents will attain a bachelor's degree has increased. Rather than being a continual change, this increase results from a significant change in educational opportunities that began in the late 1980s. The average age to attain a bachelor's degree is 22 years, and the schooling duration to attain this degree is four years. This means that, when we observe a child at 30 years old, they were enrolled in their bachelor's degree 11 years earlier (between

21. See the Appendix 1.A for the evolution of the share of skilled individuals in the population of parents.

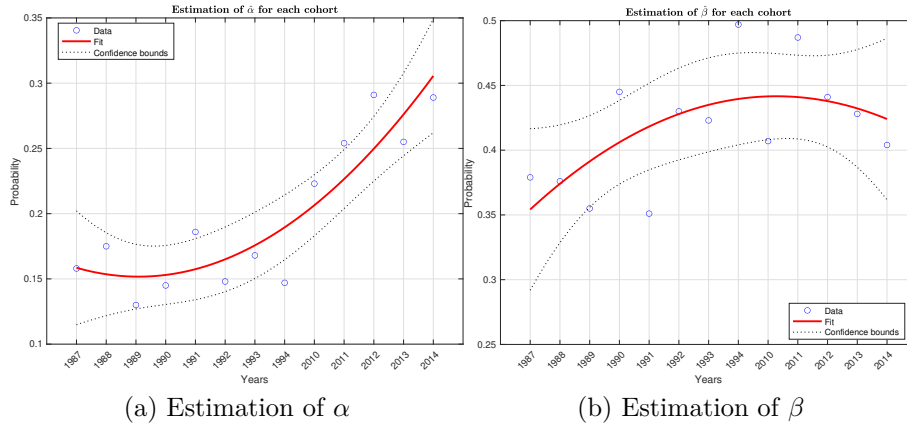


Figure 1.2 – **Mobility in educational attainment between 1987 and 2014**

Note: (i) Estimation of α : the probability that a youth will become skilled, having unskilled parents. (ii) Estimation of β : the impact that having skilled parents has on the probability that a youth will become skilled. (iii) Children are observed 30 years after their date birth, leading the observations to range between 1987 and 2014. (iv) In the panels (a) and (b), the estimated equation is $\theta_t = a + bt + ct^2 + \varepsilon_t$ for $\theta \in \{\alpha, \beta\}$. In the panel (a), the estimated coefficients are $\{0.166^{***}; -0.009; 0.0015^{**}\}$ and, in the panel (b), they are $\{0.331^{***}; 0.0236^{**}; -0.0012\}$. * $p < 10\%$, ** $p < 5\%$ and *** $p < 1\%$ levels.

1977 and 1986 for the NLSY79 cohorts and between 1990 and 1994 for the NLSY97 cohorts). Therefore, upward educational mobility in the US has largely increased since the late 1980s. Figure 1.2 panel (b) shows that the marginal impact that having skilled parents has on the probability of obtaining at least a bachelor’s degree has evolved with an inverted U shape. For youth born in 1958, the parents-children correlation is 0.36. It reaches its maximum (0.56) for those born in 1965 and then declines to 0.40 (close to the initial correlation) for those born in 1984. The situation between 1987 and 1996 contrasts with the situation after 2010. For the first subsample (1987 to 1996), parents having higher education had an increasing impact on the probability that their children would attain at least a bachelor’s degree. For the second subsample (2010 onwards), this impact declined. Figure 1.2 panel (a) suggests that, after intergenerational educational mobility significantly declined, having broader access to American universities has significantly improved educational mobility for children from low-income families, as their educational attainments that increased since the late 1980s. This turning point coincides with the end of Ronald Reagan’s presidential term, so it is likely that the increase in educational mobility results from changes in the US educational system driven by the report "A Nation at Risk" (1983) (The National Commission on Excellence in Education 1983). Figure 1.2

panel (b) shows that, for children with highly educated parents, after 2010 downward mobility marginally increased or stagnated.

1.4.3 Robustness check

Previous research (Carneiro, Meghir, & Parey, 2013) has found that the level of education of the mother plays a central role in the educational attainment of her children. This points to a need to analyse the educational transition between mothers and children. Therefore, we re-estimate Equation (1.1) for both versions of the survey $k \in \{NLSY79, NLSY97\}$ (see Table 1.6 1.7). X_{ik} now takes the value of 1 if the mother of the respondent i has at least a bachelor's degree.

Table 1.6 – **Education Transition (Youth-Mothers) for Different Birth Cohorts - NLSY79.**

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\beta_{j,k}$	0.434*** (0.0634)	0.327*** (0.0617)	0.397*** (0.0638)	0.472*** (0.0554)	0.321*** (0.0602)	0.453*** (0.0539)	0.469*** (0.0594)	0.532*** (0.0585)
$\alpha_{j,k}$	0.193*** (0.0157)	0.218*** (0.0164)	0.158*** (0.0142)	0.177*** (0.0143)	0.220*** (0.0155)	0.182*** (0.0138)	0.197*** (0.0152)	0.200*** (0.0162)
Observations	1093	1125	1186	1296	1171	1238	1132	951
Adjusted R^2	0.096	0.055	0.079	0.124	0.049	0.107	0.107	0.131

Note: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The estimation results show that coefficients α and β are identical to those obtained when we assume that either the mother or the father or both have a bachelor's degree. We conclude that changes in educational mobility between generations is robust to alternative measures of parents' education.

Table 1.7 – **Education Transition (Youth-Mothers) for Different Birth Cohorts - NLSY97.**

Year of birth (j)	1980	1981	1982	1983	1984
$\beta_{j,k}$	0.402*** (0.0452)	0.438*** (0.0386)	0.417*** (0.0379)	0.481*** (0.0362)	0.393*** (0.0397)
$\alpha_{j,k}$	0.265*** (0.0194)	0.311*** (0.0185)	0.337*** (0.0194)	0.282*** (0.0178)	0.330*** (0.0189)
Observations	814	942	944	967	961
Adjusted R^2	0.119	0.134	0.127	0.174	0.109

Note: $k = NLSY97$. Robust standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

1.5 Income Mobility

1.5.1 Log-Log Correlations

To track the evolution of income mobility in the United States between 1987 and 2015, we follow Solon (1999). We regress the log income from wages and salaries ($Y_{i,j,k}$) of each youth i reported 30 years after their birth cohort j on the log income of their parents ($X_{i,j,k}$) reported when the youth is 18 years old. We run this regression for both versions k of the NLSY, i.e. for $k \in \{NLSY79, NLSY97\}$. IGE is the most widely used measure of intergenerational economic mobility. It captures the statistical connection between parents' income and the income of their children in later life: $\frac{dE[\log(Y_{i,j,k})|X_{i,j,k}=x]}{d\log(x)}$. To estimate the IGE, we estimate the regression shown in equation (1.2) (Chetty et al., 2014a).

$$\log(Y_{i,j,k}) = \omega_{j,k} + \kappa_{j,k} \log(X_{i,j,k}) + e_{i,j,k} \quad (1.2)$$

where $\kappa_{j,k}$ is the IGE. It gives a measure of *relative mobility* by estimating the income gaps (in log) between children born to high-income families and those born to low-income families. $\omega_{j,k}$ is a constant. It may be interpreted as "minimum income," as it is the income (in log) of children whose parents have \$1 income.

Table 1.8 – IGE for Different Birth Cohorts - NLSY79

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\kappa_{j,k}$	0.263* (0.101)	0.235 (0.130)	0.404** (0.126)	0.171* (0.0824)	0.233*** (0.0623)	0.170* (0.0713)	0.211 (0.125)	0.158 (0.0859)
$\omega_{j,k}$	7.286*** (1.110)	7.667*** (1.417)	5.882*** (1.412)	8.431*** (0.896)	7.675*** (0.670)	8.492*** (0.759)	7.959*** (1.377)	8.459*** (0.929)
Observations	189	225	225	252	233	208	206	188
Adjusted R^2	0.034	0.021	0.067	0.017	0.041	0.013	0.026	0.013

Note: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.8 shows that IGE values range from 0.158 to 0.404, for children born between 1957 and 1964. The average estimated IGE value is 0.23. This means that, for NLSY79 respondents, a 10 per cent increase in parents' income is associated with an average 2.3 per cent rise in children's income.

Table 1.9 shows that IGE values are lower for youths born between 1980 and 1983 than for those born between 1957 and 1964. The values range from 0.085 and 0.204; the

Table 1.9 – IGE for Different Birth Cohorts - NLSY97

Year of birth (j)	1980	1981	1982	1983
$\kappa_{j,k}$	0.0853* (0.0379)	0.204*** (0.0541)	0.114** (0.0422)	0.128** (0.0458)
$\omega_{j,k}$	9.408*** (0.385)	8.089*** (0.569)	9.104*** (0.441)	8.822*** (0.469)
Observations	408	345	390	374
Adjusted R^2	0.012	0.036	0.012	0.014

Note: $k = NLSY97$. Robust standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

average estimated IGE value is 0.13. This means that, for NLSY97 respondents, a 10 per cent increase in parents’ income is associated with an average 1.3 per cent rise in children’s income.

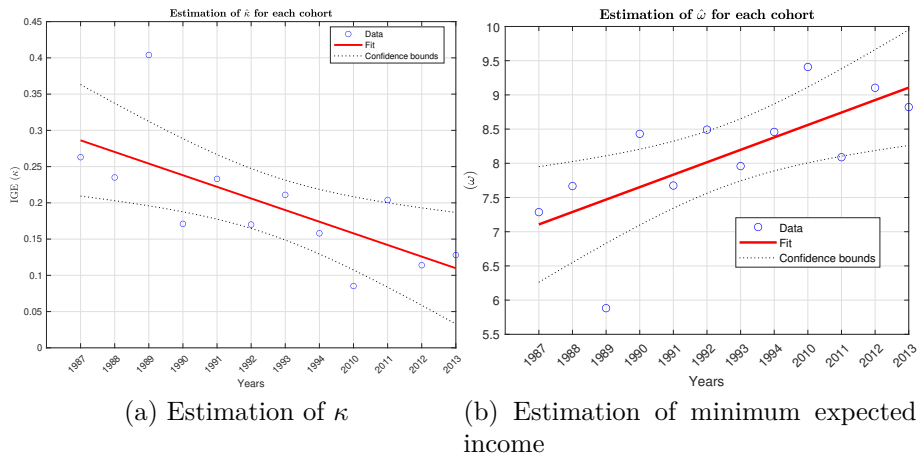


Figure 1.3 – Intergenerational elasticity (κ)

Note: (i) Children’s income is observed 30 years after their date birth (1957-1964 and 1980-1983), which implies that observations are between 1987 and 2013. (ii) In panels (a) and (b), the estimated equation is $\theta_t = a + bt + \varepsilon_t$ for $\theta \in \{\kappa, \omega\}$. In the panels (a) and (b) the estimated coefficients are respectively $\{0.3022^{***}; -0.0160^{**}\}$ and $\{6.924^{***}; 0.1817^{**}\}$. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The evolution of IGE across the cohorts gives us information about income mobility trends (see Figure 3). We observe that IGE is continuously decreasing, as the estimated slope of the IGE trend is negative. This means that the income mobility of cohorts born between 1957 and 1984 has been increasing. These results are consistent with the results on educational mobility, which also point to a significant increase in upward mobility. As Chetty et al. (2014a) point out, IGE depends on two components: an indicator of

income mobility ρ and an indicator of the relative income inequalities between youths and parents. More precisely, see equation (1.3) below:

$$IGE = \rho \frac{\sigma_{\log(Y)}}{\sigma_{\log(X)}} \quad \text{with } \rho = \text{corr}(\log(Y), \log(X)) \quad (1.3)$$

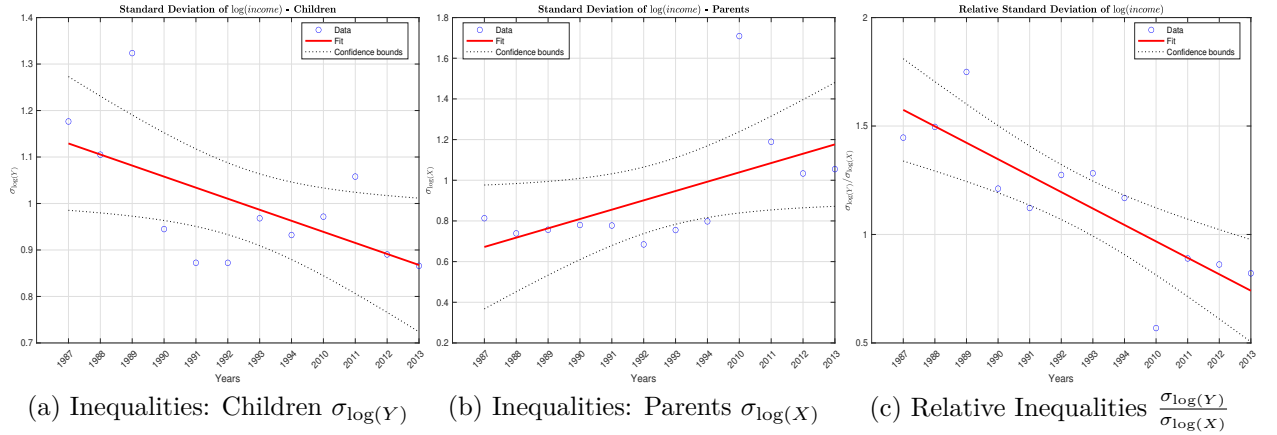


Figure 1.4 – **Income inequalities between 1987 and 2014**

Note: (i) Children are observed 30 years after their date birth, leading the observations to be between 1987 and 2014. (ii) In all panels, the estimated equation is $\theta_t = a + bt + \varepsilon_t$ for $\theta \in \left\{ \sigma_{\log(Y)}, \sigma_{\log(X)}, \frac{\sigma_{\log(Y)}}{\sigma_{\log(X)}} \right\}$. The estimated coefficients are $\{1.152^{***}; -0.0237^{**}\}$, $\{0.6261^{***}; 0.045^{**}\}$ and $\{1.6501^{***}; -0.0757^{***}\}$ respectively. * $p < 10\%$, ** $p < 5\%$ and *** $p < 1\%$ levels.

Equation (1.3) shows that, if income inequality among children ($\sigma_{\log(Y)}$) decreases relative to income inequality among parents ($\sigma_{\log(X)}$), IGE declines if all other things are equal. Therefore, IGE can be affected by changes to the relative size of intergenerational inequality. Figure 1.4 panel (a) shows that income inequality among youths has declined over the period, while panel (b) shows that income inequality among parents has risen over the same period. This has led to a significant decline in relative income inequality, which is illustrated in panel (c). Therefore, even if the correlation between children’s and parents’ income ρ remains stable over the period, IGE mechanically declines due to a reduction in relative inequalities $\frac{\sigma_{\log(Y)}}{\sigma_{\log(X)}}$.

This highlights that the rise in income inequality, largely documented in the US, has a direct impact on IGE, which is a measure of intergenerational mobility. In particular, when IGE in the US is decreasing, it may suggest that income mobility is rising; however, this result is driven only by widening income disparities among parents. This generates

greater income mobility, even if children and parents occupy the same position in the income distribution of their respective peers. Another limitation of using IGE to measure intergenerational mobility is that IGE is sensitive to extreme values in the distribution, especially at the bottom of the distribution where the log function magnifies the shape (Chetty et al., 2014a). Therefore, in subsection 5.2 we compute the rank-rank correlation, to isolate income mobility from relative changes in income inequality between parents and children.

1.5.2 Rank-rank correlations

Estimating the rank-rank correlation between parents' and youths' incomes is an alternative procedure to analyse intergenerational income mobility (see Equation (1.4)).

$$P_{i,j,k}^c = \tilde{\omega}_{j,k} + \tilde{\kappa}_{j,k} P_{i,j,k}^p + \varepsilon_{i,j,k} \quad (1.4)$$

where $P_{i,j,k}^c$ is the income percentile of children i born in j and registered in survey k , and $P_{i,j,k}^p$ is the income percentile of the youth's parents. In this case, $\tilde{\kappa}$ is the slope coefficient once we regress youth income percentiles on parents' income percentiles for each birth cohort in both versions k of the NLSY. Therefore, for each youth i , $\tilde{\kappa}$ measures the impact (correlation) that their parents' income position - relative to other parents of the same cohort - has on their income position - relative to other youths in the same cohort when they are 30 years old. A strong correlation between the income position of parents and youths suggests low income mobility, as the income position of a youth at age 30 years is greatly influenced by the income of their parents some years earlier.

Figure 1.5 shows that the rank-rank correlation decreases slightly over time; the negative slope is significant at 10 per cent. This suggests that the effect of parents' income position on the income position of their children has declined slightly.

Table 1.10 and Table 1.11 report OLS estimates of the rank-rank correlation. Children whose parents are at the bottom of the income distribution have income in the 40th percentile ($\tilde{\omega}$ in panel (b) in Figure 1.5), and this rank remains stable over time. Figure 1.5 panel (a) shows that, on average for all NLSY79 cohorts, a 1 pp increase in parents' rank is associated with a 0.24 pp increase in children's mean rank, while on average for all NLSY97 cohorts, a 1 pp increase in parents' rank is associated with a 0.21 pp increase in children's rank. Given that the rank-rank correlation is a good approximation of the ρ

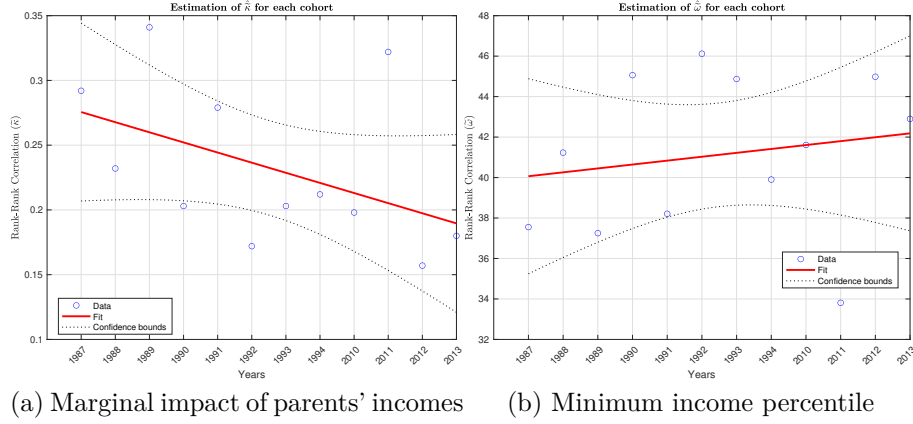


Figure 1.5 – Rank correlation

Note: (i) Children's income is observed 30 years after their date birth (1957-1964 and 1980-1983), which implies that observations are between 1987 and 2013. (ii) In panels (a) and (b), the estimated equation is $\theta_t = a + bt + \varepsilon_t$ for $\theta \in \{\tilde{\kappa}, \tilde{\omega}\}$. In panels (a) and (b) the estimated coefficients are respectively $\{0.2833^{***}; -0.0078^+\}$ and $\{39.872^{***}; 0.192\}$. $^+ p < 0.1, ^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$.

coefficient of IGE,²² we can deduce that the largest part of the shift in income mobility, which IGE captures, is determined by changes to income inequality, while a small part of the shift is explained by changes to the link between parents' and children's income ranks.

Table 1.10 – Rank-rank correlations for different birth cohorts - NLSY79

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\tilde{\kappa}_{j,k}$	0.292 ^{***} (0.0812)	0.232 ^{**} (0.0835)	0.341 ^{***} (0.0755)	0.203 [*] (0.0802)	0.279 ^{***} (0.0729)	0.172 [*] (0.0787)	0.203 [*] (0.0961)	0.212 [*] (0.0823)
$\tilde{\omega}_{j,k}$	37.55 ^{***} (5.081)	41.23 ^{***} (5.115)	37.25 ^{***} (5.284)	45.06 ^{***} (4.984)	38.21 ^{***} (4.657)	46.12 ^{***} (4.777)	44.87 ^{***} (5.765)	39.90 ^{***} (4.954)
Observations	189	225	225	252	233	208	206	188
Adjusted R^2	0.075	0.044	0.101	0.029	0.066	0.022	0.030	0.036

Note: $k = NLSY79$. Robust standard errors in parentheses. $^* p < 0.05, ^{**} p < 0.01, ^{***} p < 0.001$

22. The coefficient of the rank-rank correlation is approximately proportional to ρ . If we denote ρ_P the rank-rank correlation, with P_X (P_Y) the percentile rank in the income distribution X (Y), then $\rho_P \approx \gamma\rho$, with γ a constant. Therefore, IGE combines the rank-rank correlation with the ratio of standard deviations of income across generations.

Table 1.11 – Rank-rank correlations for different birth cohorts - NLSY97

Year of birth (j)	1980	1981	1982	1983
$\tilde{\kappa}_{j,k}$	0.198*** (0.0522)	0.322*** (0.0554)	0.157** (0.0538)	0.180*** (0.0536)
$\tilde{\omega}_{j,k}$	41.61*** (3.195)	33.81*** (3.528)	44.98*** (3.342)	42.90*** (3.104)
Observations	408	345	390	374
Adjusted R^2	0.039	0.102	0.022	0.028

Note: $k = NLSY97$. Robus standard errors in parentheses
 * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

1.6 The impact of parents’ education on children’s income

The section 1.4 shows that all children now have a better chance of attaining a university degree, regardless of their parents’ education level. We now test whether parents’ education has an impact on children’s income. To test this idea, we estimate the model shown in Equation (1.5):

$$Q_{i,j,k}^c = \tilde{\omega}_{j,k} + \tilde{\kappa}_{j,k}^{ls} Q_{i,k}^{p,ls} + \tilde{\kappa}_{j,k}^{hs} Q_{i,k}^{p,hs} + \varepsilon_{i,j,k} \quad (1.5)$$

where $Q_{i,j,k}^c$ is the income quartile of children i born in j and registered in survey k , and $Q_{i,k}^p$ is the income quartile of the youth’s parents in survey k , that is in 1979 (NLSY79) or in 1997 (NLSY97).²³ More precisely, $Q_{i,k}^{p,hs}$ is the income quartile of highly educated parents, while $Q_{i,k}^{p,ls}$ is the income quartile of low-educated parents.

Equation (1.5) allows us to distinguish the impact of parents’ income rank has on the children’s income rank conditionally on the parents’ educational attainment ($\tilde{\kappa}_{j,k}^{ls}$ and $\tilde{\kappa}_{j,k}^{hs}$).

Tables 1.12 and Table 1.13 report OLS estimates for Equation (1.5). Results reported in Tables 1.12 and in Table 1.13 show that the impact of parents’ incomes on children’s incomes is lower when parents do not have college degrees than when they are college graduates. Over all cohorts, the average value measuring the effect of the impact of parents’ income on children’s income is $\tilde{\kappa}^{ls}$ is 0.118 if parents are unskilled, whereas it is

23. We restrict our analysis to mobility across quartiles because the number of observations is too few observations to robustly estimate based on percentiles.

Table 1.12 – Impact of parents’ educational attainment on the rank-rank correlations for different birth cohorts - NLSY79

Yeath of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\tilde{\kappa}_{j,k}^{ls}$	0.200* (0.0841)	0.118 (0.0771)	0.270*** (0.0777)	0.0514 (0.0753)	0.151 (0.0784)	0.0752 (0.0798)	0.00759 (0.0822)	0.111 (0.0811)
$\tilde{\kappa}_{j,k}^{hs}$	0.316** (0.104)	0.272* (0.118)	0.383*** (0.0895)	0.177 (0.0934)	0.364*** (0.0803)	0.239* (0.0950)	0.285** (0.105)	0.189 (0.103)
$\tilde{\omega}_{j,k}$	2.019*** (0.232)	2.237*** (0.226)	1.978*** (0.233)	2.530*** (0.213)	2.082*** (0.217)	2.356*** (0.221)	2.556*** (0.230)	2.158*** (0.223)
Observations	189	225	225	252	233	208	206	188
Adjusted R^2	0.052	0.033	0.073	0.011	0.080	0.033	0.081	0.012

Note: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.13 – Impact of parents’ educational attainment on the rank-rank correlations for different birth cohorts - NLSY97

Yeath of birth (j)	1980	1981	1982	1983
$\tilde{\kappa}_{j,k}^{ls}$	0.176** (0.0553)	0.203*** (0.0593)	0.0253 (0.0529)	0.0345 (0.0557)
$\tilde{\kappa}_{j,k}^{hs}$	0.236*** (0.0621)	0.364*** (0.0548)	0.154* (0.0619)	0.214*** (0.0645)
$\tilde{\omega}_{j,k}$	2.076*** (0.151)	1.816*** (0.154)	2.438*** (0.148)	2.324*** (0.145)
Observations	408	345	390	374
Adjusted R^2	0.040	0.105	0.024	0.050

Note: $k = NLSY97$. Robus standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$\tilde{\kappa}^{hs} = 0.266$ if parents are skilled. This difference is statistically significant at 5 per cent level. The impact of the income rank of parents without a university degree is very low on the income rank of their children, which indicates that a low parental income is not relevant in explaining the income positions of children.

Our results suggest that the American system is giving more opportunities than in the past, to children from low-income families whose parents have not graduated from college. Meanwhile, children whose parents have college degrees and high income are protected against intergenerational income fall. Therefore, there is a correlation between the income of parents and their children.

Our results are consistent with the view that the more money a family has, the more likely their children will have access to the most prestigious colleges and the best earning outcomes. As Chetty et al. (2020) points out, Ivy League colleges predominantly enroll students from high-income families ("reproduction of elites").

Our results also align with those of Becker et al. (2018) and The Pew Charitable Trusts (2012). On the one hand, American society has developed a highly educated elite, whose members have high mobility but not, as Becker et al. (2018, p. 9) describe: "across the endogenously determined class boundaries". Therefore, for those born in this elite, their family position has a strong impact on the social rank of them and their future generations. On the other hand, making universities open to all, by increasing the number of places, has created new opportunities for children from low-income families to attain a higher education, which pushes them out of the immobility trap. As The Pew Charitable Trusts (2012) states, adults whose parents are in the bottom quintile of the income distribution are much more likely to remain at the bottom themselves if they do not attain a college degree, while those who do attain a college degree are more likely to move out of the bottom quintile.

1.7 The reality of the American dream

Another way to measure the proportion of Americans who can realize the American dream is to compute the transition matrices that describe intergenerational mobility. As we are interested in a combination of educational mobility and earnings mobility, we combine information on children's educational attainment - conditionally on their parents' educational attainment - with information on earning mobility. In this way, we compute the earnings quartiles for parents and children with and without a bachelor's degree (see

Table 1.14 for the NLSY79 cohorts and Table 1.15 for the NLSY97 cohorts).²⁴

This information tells us the probability that the income of a child who is a college graduate, and the income of a child who is not a college graduate, will be in one of the four quartiles, conditional on their parents' income rank and education (see Equation 1.6).

$$p_{ij,i'j'} = \Pr(\text{Child: degree} = D_i \ \& \ \text{earning} = Q_j \mid \text{Parent: degree} = D_{i'} \ \& \ \text{earning} = Q_{j'}) \quad (1.6)$$

where $D_x \in \{\text{College degree, No College degree}\}$ for $x = i, i'$ and $Q_y \in \{Q1, \dots, Q4\}$ for $y = j, j'$.

Table 1.14 – **Intergenerational Mobility — NLSY79**

		Child No College				Child College			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Parent	Q1	0.3273	0.2485	0.1667	0.1545	0.0606	0.0152	0.0182	0.0091
	Q2	0.2312	0.2601	0.2139	0.1705	0.0260	0.0376	0.0405	0.0202
No College	Q3	0.1667	0.2258	0.2151	0.2366	0.0430	0.0323	0.0457	0.0349
	Q4	0.1447	0.1500	0.2184	0.2684	0.0526	0.0684	0.0553	0.0421
Parent	Q1	0.1429	0.1169	0.1818	0.1818	0.0779	0.0649	0.0779	0.1558
	Q2	0.0541	0.0541	0.1622	0.2973	0.0946	0.1757	0.0811	0.0811
College	Q3	0.0658	0.1316	0.1053	0.1842	0.1184	0.1974	0.0921	0.1053
	Q4	0.0563	0.0423	0.1549	0.2113	0.0704	0.0845	0.1972	0.1831

It is particularly interesting to focus on the probability that a child can move from the bottom to the top of the distribution. This means, in other words, the probability that a child – whose parents do not have a college degree and are in the first income quartile for parents without a degree – could attain a college degree and earnings in the top income quartile for children with a college degree. This probability is 0.91 per cent for the NLSY79 (see Table 1.14) and 3.16 per cent for the NLSY97 (see Table 1.15). As the probability has increased more than threefold, it clearly shows that upward mobility has risen over time. We observe that downward mobility has also declined. The probability that a child - whose parents have a college degree and are in the top income quartile

24. To have robust information for each survey, we present the results after we have aggregated all transitions for each survey. Therefore, results related to the NLSY79 aggregate all transitions of children born between 1957 and 1964, and those related to the NLSY97 aggregate all transitions of children born between 1980 and 1984.

Table 1.15 – Intergenerational Mobility — NLSY97

		Child No College				Child College			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Parent	Q1	0.2759	0.2414	0.1552	0.1149	0.0661	0.0603	0.0546	0.0316
	Q2	0.2076	0.1725	0.2018	0.1784	0.0673	0.0673	0.0614	0.0439
No College	Q3	0.1623	0.2068	0.1545	0.1597	0.0890	0.0995	0.0812	0.0471
	Q4	0.1342	0.1178	0.1589	0.2137	0.0877	0.0986	0.0795	0.1096
Parent	Q1	0.0764	0.1083	0.0828	0.0955	0.2484	0.1210	0.1146	0.1529
	Q2	0.0671	0.0470	0.0872	0.1275	0.1812	0.1678	0.1477	0.1745
College	Q3	0.0347	0.0556	0.0903	0.1181	0.1736	0.1597	0.1667	0.2014
	Q4	0.0461	0.0329	0.0329	0.0921	0.1776	0.1316	0.2303	0.2566

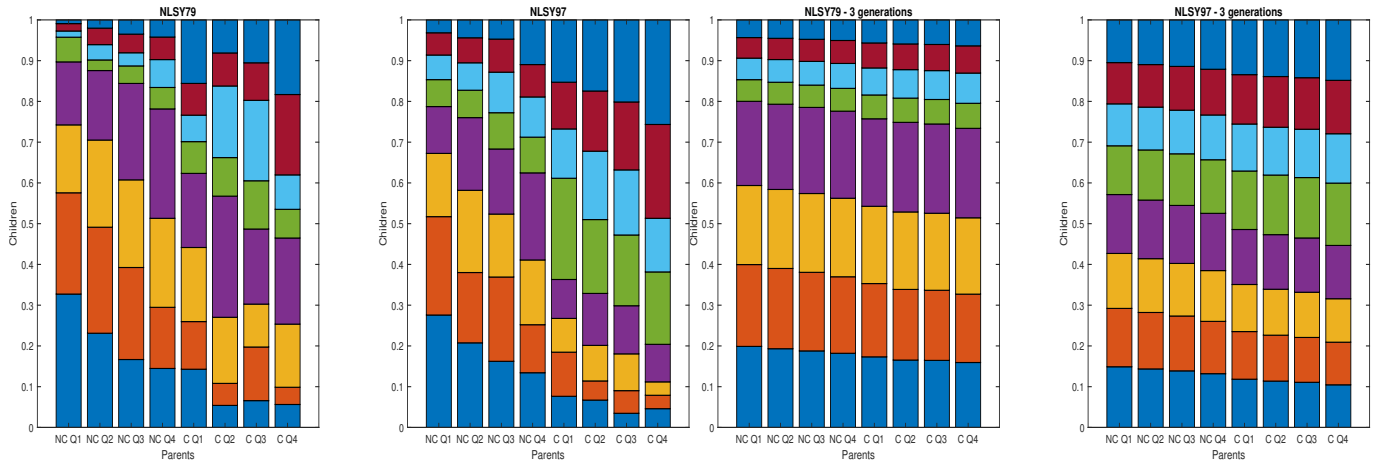
for parents with a degree – does not attain a college degree and has earnings in the first quartile – is 5.63 per cent for the NLSY79 (see Table 1.14) and 4.61 per cent for the NLSY97 (see Table 1.15).

Figure 1.6 panel (a) compares the mobility between parents and children for NLSY79 and NLSY97 cohorts. It shows that cohorts born after 1980 (NLSY97) – after universities became open to all students - have greater upward mobility. For NLSY97 cohorts, panel (a) also suggests that a college degree does not always translate into higher earnings, as the green bars show a large proportion of youths with a college degree are in the bottom of the wage distribution of skilled young workers.

Matrices allow us to analyse an important aspect of mobility, which is the pace at which it occurs. Social fluidity can be apprehended by iterating these matrices for several generations, until the situation of the initial set of parents no longer influences the position in society of subsequent generations of children. Comparing Figure 6 panels (a) and (b) provides an indication of the pace at which an individual may escape from their initial family group.

Figure 1.7 focuses on "extreme mobility," which is:

- the probability that a parent with no college degree, and whose earnings place them at the bottom of the income distribution, will have a descendant (such as a child, grandchild or great grandchild) who attains a college degree and earnings that place them at the top of the income distribution (upward mobility), or
- the probability that a parent with a college degree, and whose earnings place them at the top of the income distribution, will have a descendant who does not attain

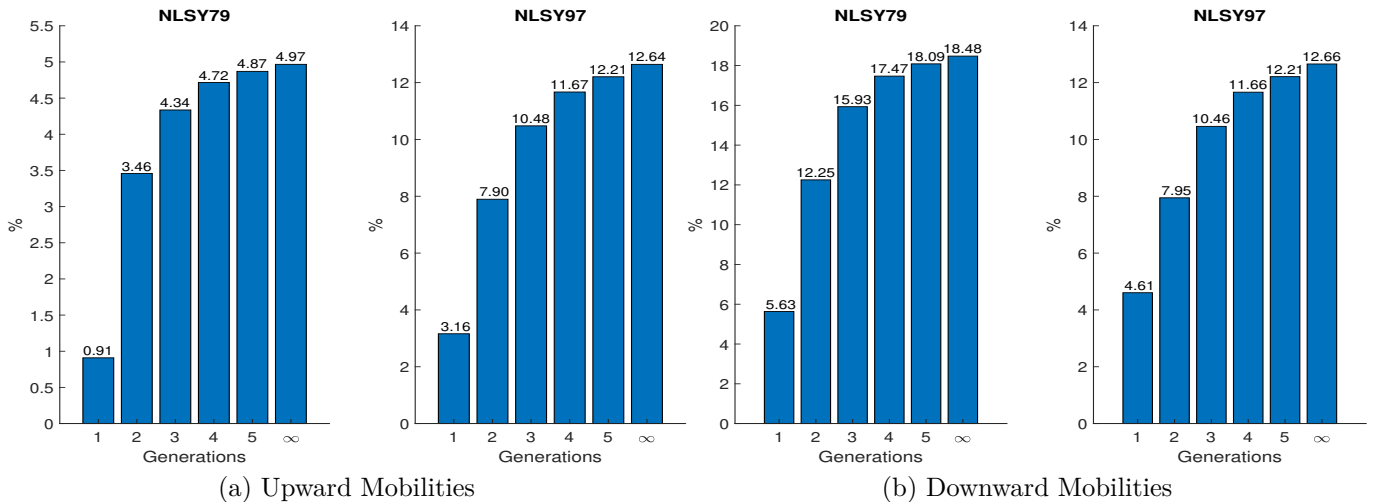


(a) Mobilities Parents-Children (1 generation)

(b) Mobilities Parents-Great Grandchildren (3 generations)

Figure 1.6 – Intergenerational mobility: education and earnings.

Note: Note: (i) blue= No college degree and income in Q1; (ii) orange= No college degree and income in Q2; (iii) yellow= No college degree and income in Q3; (iv) purple= No college degree and income in Q4; (v) green= College degree and income in Q1; (vi) sky blue= College degree and income in Q2; (vii) burgundy= College degree and income in Q3; (viii) dark blue= College degree and income in Q4. Source: NLSY79 & NLSY97.



(a) Upward Mobilities

(b) Downward Mobilities

Figure 1.7 – Mobilities from bottom to the top and from top to the bottom.

Note: Upward mobility: $\Pr(\text{Child with college degree \& earning} = Q_4 \mid \text{Parent with no college degree \& earning} = Q_1)$. Downward Mobility: $\Pr(\text{Child with no college degree \& earning} = Q_1 \mid \text{Parent with college degree \& earning} = Q_4)$. Source: NLSY79 & NLSY97.

a college degree and has earnings that place them at the bottom of the income distribution (downward mobility).

From Figure 1.7 we observe that NLSY97 cohorts, who were born after 1980, have higher upward mobility than NLSY79 cohorts, who were born between 1957 and 1964. Panel (a) shows that upward mobility more quickly converges towards its long-run value for NLSY97 cohorts than NLSY79 cohorts. This implies that, for NLSY97 cohorts, fewer generations are needed before youths escape from the poor education and income situation of the initial parents.

Figure 1.8 confirms this result. It shows the probability that a child will attain a college degree if their parents do not have college degrees rose significantly between the two surveys. Therefore, dependence on the initial conditions is more rapidly forgotten for NLYS97 cohorts and their descendants than for NLSY79 cohorts and their descendants.

In contrast, Figure 1.7 panel (b) shows that downward mobility decreased between NLSY79 and NLSY97. NLSY97 cohorts experience lower downward mobility, and downward mobility converges more slowly towards its long-run value for them than for NLSY79 cohorts. This finding is consistent with the effect of broadening access to university after the 1980s, which has given a greater proportion of youths access to higher education and, therefore, caused upward mobility to rise.

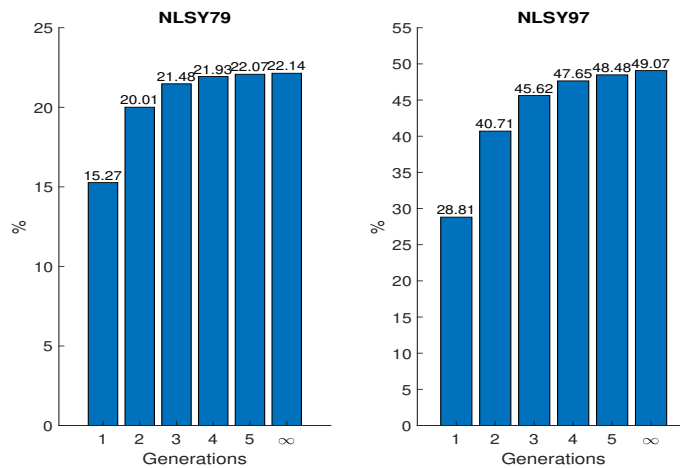


Figure 1.8 – **Educational Mobilities.**

Note: Educational Mobilities: $\Pr(\text{Child with college degree} \mid \text{Parent with no college degree})$.
 Source: NLSY79 & NLSY97.

1.8 Conclusions

We use data from the NLSY to analyse intergenerational mobility in the US using alternative methodologies. First we find that educational mobility has increased since the end of the 1980s, when American universities were opened up to all students. However, increased educational mobility has not translated into greater income mobility.

Second, our analysis suggests that parents' income has a greater impact on children's income when parents are highly educated. Low parental education is not relevant in explaining children's education.

Finally, using mobility matrices, we show that the probability of moving from the bottom to the top of the income distribution has increased from 0.91 per cent in the NLSY79 to 3.16 per cent in the NLSY97. Our analysis further confirms that upward mobility has risen over time, while downward mobility has decreased.

We find that the American system has had two effects. The first effect is giving more opportunities to youths from low-income families whose parents have not graduated from college, and pushing them out of the immobility trap. This reduces the correlation between parents' and children's income. The second effect is insuring the children of highly educated and wealthy parents against intergenerational income fall. This perpetuates privileges and reinforces the social reproduction of elites. Our analysis shows that the first effect is stronger than the second effect.

From a policy perspective, our results suggest that, in the US, making universities open to all is a successful strategy for improving educational opportunities for youths whose parents do not have higher education. Naturally, the success of this type of educational reform depends on country-specific socioeconomic conditions, such as how meritocratic the labour market is.

We also acknowledge that policies to foster social mobility should be applied as a bundle. Some studies highlight how other policy tools (such as public childcare programmes, tax credit schemes and education subsidies) may especially benefit children from low-income families. One example from the US that illustrates this is the Moving to Opportunity programme, which gives poor families vouchers to help them move to better neighbourhoods. Neighbourhood characteristics (such as income segregation, concentrated poverty, inequality, racial segregation, quality of schools and crime rate) are important determinants of social mobility. Therefore, reducing the concentration of poverty and socioeconomic segregation of neighbourhoods can benefit mobility. Moving to

Opportunity has highlighted that having a better neighbourhood and local environment has a beneficial effect on a child's long-term outcomes, including their adult incomes. Chetty and Hendren (2018) show that, on average, boys and girls from low-income families, and who grew up in a disadvantaged neighbourhood, earn about 35 per cent and 25 per cent less, respectively, than children who are otherwise similar but benefited from the Moving to Opportunity programme and moved to a better areas when they were 10 years old.

Other policies can negatively affect upward mobility: Blundell, Costa Dias, Meghir, and Shaw (2016) and Albertini, Poirier, and Terriau (2020) show that in-work benefits and the Earned Income Tax credit (EITC) may affect people's educational choices and labour-market trajectories over their lifetime. In particular, by making low-skilled jobs more attractive, the EITC reduces the return on education, thereby discouraging some youths from pursuing further studies after high school (Albertini et al., 2020). Some studies warn that universal subsidy schemes have only limited redistributive effects. To promote mobility, public spending on education needs to be properly targeted and generate better quality of, and access to, education for disadvantaged groups (Narayan et al., 2018). Chetty et al. (2020) point out that Ivy League colleges predominantly enroll students from high-income families and, therefore, limit intergenerational mobility. To increase intergenerational mobility, Chetty et al. (2020) suggest that these colleges' application and admission processes should give a sliding-scale preference to low- and middle-income students, similar to the preference implicitly given to legacy students at elite private colleges. Fostering employment opportunities and fighting discrimination may also have a beneficial effect on intergenerational mobility. To equalize labour-market opportunities, governments should make it easier for disadvantaged people to access the labour market and do more to protect workers against race discrimination.

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APPENDIX

1.A Age distribution of youth and parents

Figures 1.9 and 1.10 report the distribution of ages for youths and their parents. These figures point that the age of youths is equally distributed through the two versions of the survey.

Year of birth	1957	1958	1959	1960	1961	1962	1963	1964	1965
NLSY79	21.425	24.963	22.600	21.340	22.105	24.950	22.761	23.924	27.170
Year of birth	1980	1981	1982	1983	1984				
NLSY97	34.983	40.436	42.791	39.239	41.176				

Table 1.16 – **Share of Skilled Individuals in the Populations of Parents (%)**

Year of birth	1957	1958	1959	1960	1961	1962	1963	1964	1965
NLSY79	21.425	24.963	22.600	21.340	22.105	24.950	22.761	23.924	27.170
Year of birth	1980	1981	1982	1983	1984				
NLSY97	34.983	40.436	42.791	39.239	41.176				

Table 1.17 – **Share of Skilled Individuals in the Populations of Parents (%)**

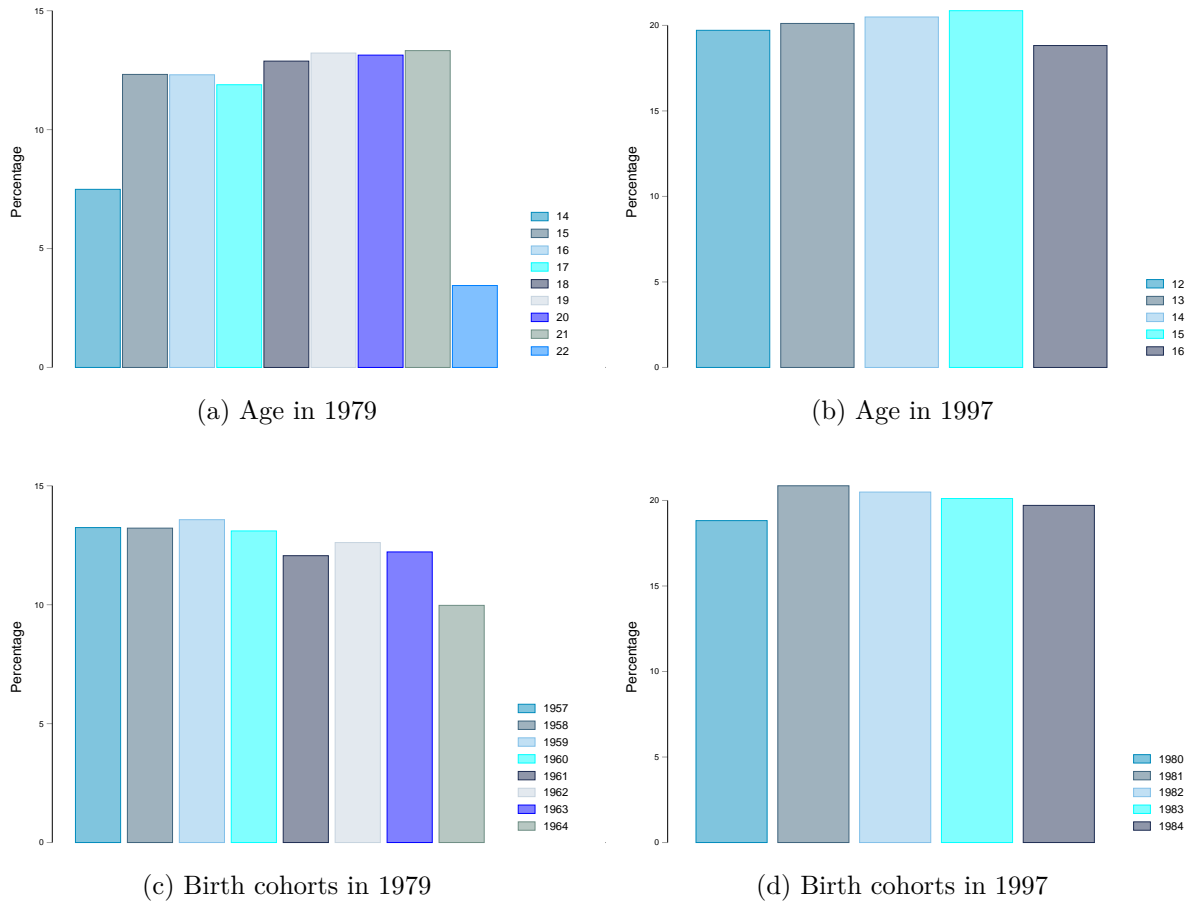


Figure 1.9 – **Age and Birth Cohort Distribution - Youths.** This figure presents the distribution ages (panels (a) and (b)) and birth cohorts (panel (c) and (d)) of youths in the two versions of the NLSY79 and NLSY97. The bins in the graphs are slightly different. We use this information to compute educational mobility.

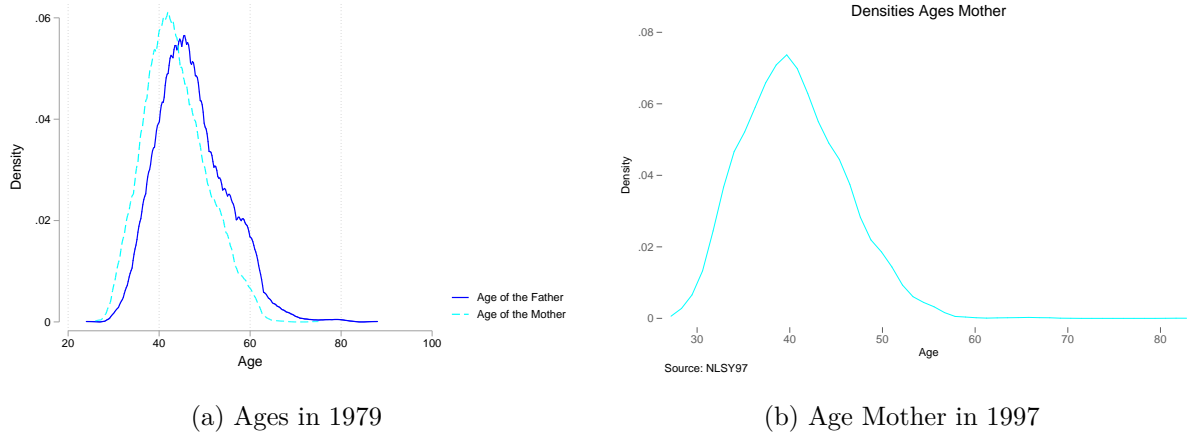


Figure 1.10 – **Age Distribution - Parents of the Youth Respondents.** This figure presents the Kernel densities of ages of parents of the youth respondents for the NLSY79 (panel a) and for the NLSY97 (panel b). The information presented in panel (a) is computed from the ages reported in 1987. Panel (b) presents information only for the mothers of the youths because of data availability. This variable is computed using information reported in 1997 on the age of the mother in the year of birth of the youth respondent.

1.B Educational Mobility - NLSY79

We use the same sample for both educational and income mobility.

Table 1.18 – **Education Transition for Different Birth Cohorts.**

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\beta_{j,k}$	0.250** (0.0800)	0.291*** (0.0836)	0.165* (0.0718)	0.391*** (0.0725)	0.339*** (0.0738)	0.315*** (0.0766)	0.443*** (0.0800)	0.257*** (0.0755)
$\alpha_{j,k}$	0.136*** (0.0241)	0.172*** (0.0261)	0.0918*** (0.0200)	0.118*** (0.0210)	0.141*** (0.0253)	0.103*** (0.0221)	0.133*** (0.0233)	0.163*** (0.0274)
Observations	363	377	403	460	377	341	406	342
Adjusted R^2	0.064	0.069	0.034	0.149	0.116	0.115	0.170	0.062

Notes: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.19 – Education Transition (Youth-Mothers) for Different Birth Cohorts.

Year of birth (j)	1957	1958	1959	1960	1961	1962	1963	1964
$\beta_{j,k}$	0.352** (0.123)	0.229 (0.130)	0.190 (0.122)	0.326** (0.115)	0.184 (0.0991)	0.461*** (0.105)	0.479*** (0.128)	0.437*** (0.115)
$\alpha_{j,k}$	0.156*** (0.0245)	0.207*** (0.0265)	0.109*** (0.0206)	0.167*** (0.0229)	0.193*** (0.0272)	0.123*** (0.0225)	0.172*** (0.0246)	0.186*** (0.0267)
Observations	362	377	402	460	376	340	404	339
Adjusted R^2	0.063	0.019	0.016	0.044	0.018	0.135	0.095	0.078

Note: $k = NLSY79$. Robust standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

1.C Probit models of intergenerational educational mobility

We estimate complementary models to support our results on intergenerational educational mobility. Linear probability models can yield probabilities outside the range between 0 and 1, which may be corrected using a probit or logit configuration. We perform the probit estimation defined in Equation 1.7.

$$P(Y_{i,j,k}|X_{i,j,k}) = \Phi(\psi_{j,k} + \tau_{j,k}X_{i,j,k}) \quad (1.7)$$

where $Y_{i,j,k}$ is a binary variable that is equal to 1 if the youth respondent i is high skilled (i.e. has a bachelor degree) 30 years after his birth cohort j for each NLSY versions $k \in \{NLSY79, NLSY97\}$, $X_{i,k}$ is a binary variable that is equal to 1 if either the mother or the father of the respondent i has a bachelor degree in the NLSY versions k , and Φ is the normal distribution. The predicted probability that a youth will attain a bachelor's degree if their parents have at least a bachelor's degree is calculated using Equation 1.8.

$$P(Y_{i,j,k}|X_{i,j,k} = 1) = \Phi(\hat{\psi}_{j,k} + \hat{\tau}_{j,k})$$

The results reported in Table 1.20 and Table 1.21 confirm our previous results, which point to an increasing trend of educational mobility. The estimates are significant but, when the parents of a youth respondent do not have a bachelor's degree, we observe it has a negative effect on the probability that the youth respondent will attain a bachelor's degree, as the constants through the different specifications have negative signs. Figure 1.11 panel (a) shows the educational mobility trend, which is positive and statistically

significant. Figure 1.11 panel (b) shows the increasing probability that youth will attain a bachelor's degree if their parents have a bachelor's degree.

Table 1.20 – **Probit Education Transition Different Birth Cohorts - NLSY79**

	1957-1987	1958-1988	1959-1989	1960-1990	1961-1991	1962-1992	1963-1993	1964-1994
Parents High Skilled	1.123*** (0.106)	1.041*** (0.0983)	1.051*** (0.107)	1.326*** (0.107)	1.017*** (0.105)	1.231*** (0.104)	1.192*** (0.112)	1.465*** (0.119)
Constant	-0.872*** (0.0511)	-0.919*** (0.0517)	-1.153*** (0.0544)	-1.197*** (0.0530)	-1.011*** (0.0520)	-1.117*** (0.0532)	-1.076*** (0.0538)	-1.142*** (0.0615)
Observations	986	1030	1061	1144	1041	1084	1000	837
Pseudo R^2	0.1006	0.0965	0.0951	0.1436	0.0862	0.1290	0.1122	0.1803

Standard errors in parentheses

Note: Robust standard errors. No sample weights have been used. Source: NLSY79

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.21 – **Education Transition Different Birth Cohorts (Probit Estimates)**

	1980-2010	1981-2011	1982-2012(13)	1983-2013	1984-2014
Parents High Skilled	1.077*** (0.0867)	1.235*** (0.0819)	1.152*** (0.0843)	1.137*** (0.0813)	1.059*** (0.0841)
Constant	-0.864*** (0.0460)	-0.831*** (0.0427)	-0.736*** (0.0431)	-0.813*** (0.0446)	-0.700*** (0.0428)
Observations	1276	1454	1354	1363	1343
Pseudo R^2	0.1038	0.1319	0.1132	0.1191	0.0956

Standard errors in parentheses

Note: We do not observe 2012 nor 2014 youth level of education, we observe instead, 2013 and 2015.

No sample weights have been used. Robust standard errors. Source: NLSY97

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

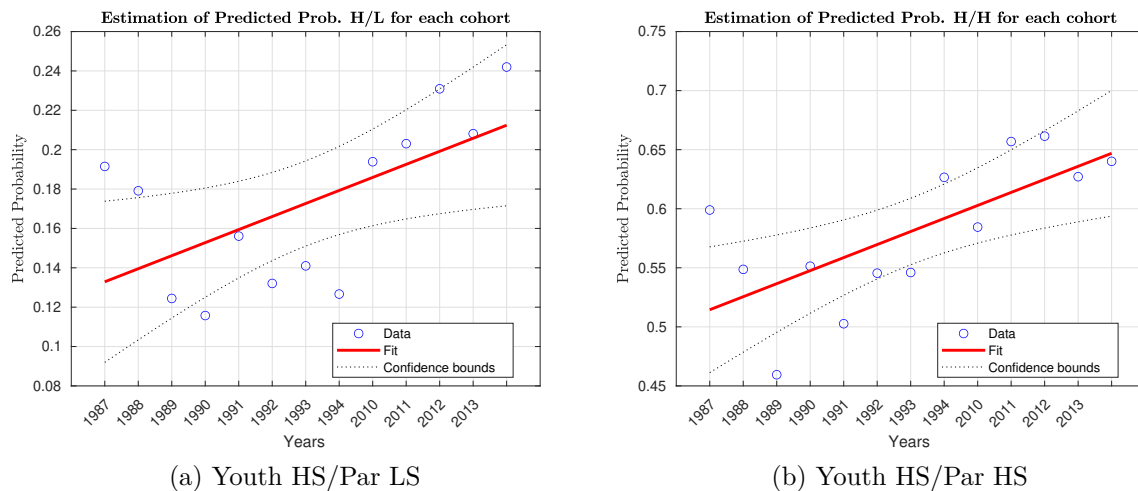


Figure 1.11 – **Predicted Probabilities** Graphs present predicted probabilities issued from the probit estimation. In the panels (a) and (b), the estimated equations are $\theta_t = a + bt + \varepsilon_t$ for $\theta \in \{\psi, \tau\}$. In the panels (a) and (b) the estimated coefficients are $\{0.12627^{***}; 0.0066269^{**}\}$ and $\{0.50345^{***}; 0.011037^{**}\}$ respectively. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

1.D Income distribution of youths

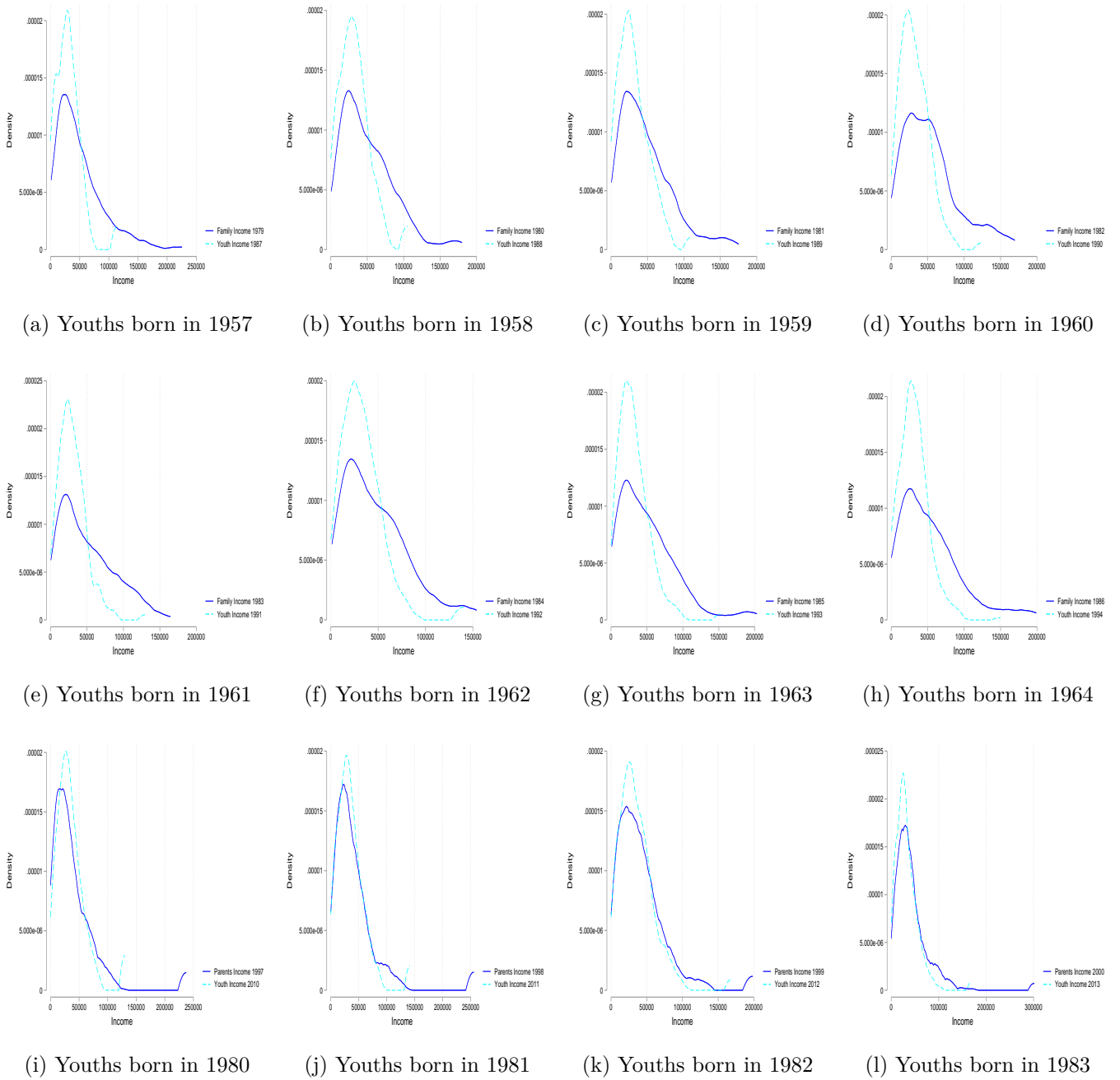


Figure 1.12 – Income distributions

ENSURING THE SUSTAINABILITY OF THE US PAY-AS-YOU-GO SYSTEM

Joint with X. Fairise, F. Langot and A. Popier

2.1 Introduction

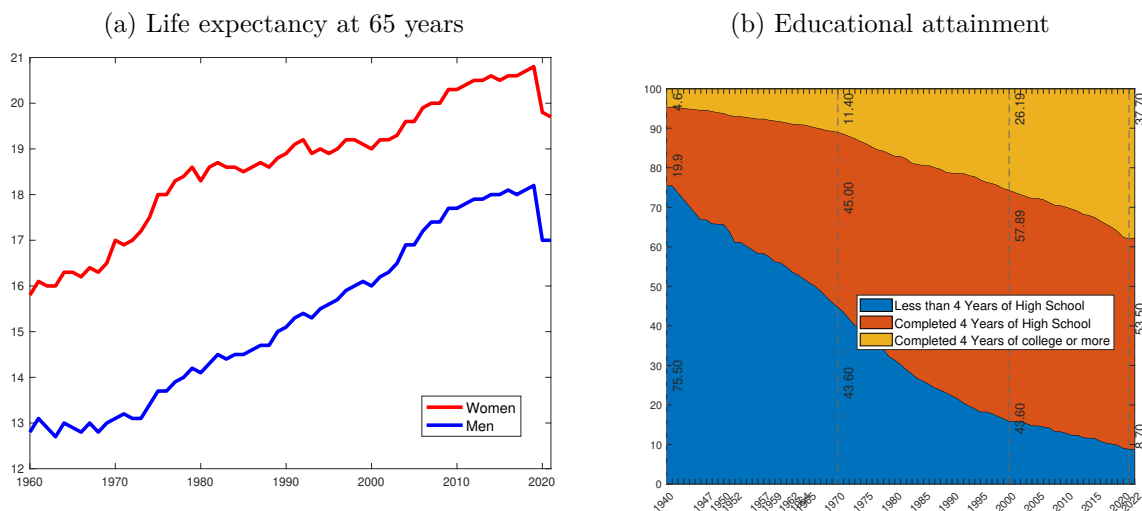
The United States has undergone profound demographic transformations and will continue to experience new ones. The first significant change is the substantial increase in life expectancy. At age 65, life expectancy has risen from 14.5 years in 1960 to 16.5 years in 2010 (see Panel (a) of Figure 2.1), and it is projected to reach 21.5 years by 2100. Consequently, the proportion of individuals aged 65 and older is expected to increase from 17% in 2020 to 22%.¹ This demographic trend challenges the sustainability of the Pay-As-You-Go (PAYG) system (see Poterba (2014)), with the dependency ratio projected to rise from 21.6% in 2010 to 38.6% by 2060. In addition to these demographic changes affecting the age structure of the population, there are changes enhancing the quality of the workforce through increased educational attainment (see Panel (b) of Figure 2.1).² While 24.5% of people had completed 4 years of high school or more in the past, today 91.2% have done so, including 37.7% who have completed 4 years of college or more.

Both of these phenomena increase the "resources" of the US economy as individuals live longer and become more productive. However, while lifespan is extending, the same might not apply to the working span: if the latter does not lengthen, aging could become a "cost" for the economy that would be only partially compensated by the rise in workforce quality.

1. See Administration on Aging, Administration for Community Living, U.S. Department of Health and Human Services (2022). Moreover, Bell and Miller (2005) shows that 35% of US men born in 2010 will reach their 90th birthday.

2. Source: US Census Bureau, 1947, and 1952 to 2002 March Current Population Survey, 2003 to 2022 Annual Social and Economic Supplement to the Current Population Survey (non-institutionalized population, excluding members of the Armed Forces living in barracks). See Census data.

Figure 2.1 – Demographic changes in the US



To reveal the adjustments necessary to balance the US PAYG system, it is essential to consider these two structural changes.

The objective of this chapter is to quantify the adjustments needed for the PAYG system to balance its budget in future periods, given the growth in the fraction of educated people in the labor force. As these structural changes will continue, it is necessary to evaluate the non-stationary nature of this public finance problem. We focus on the three fundamental parameters the PAYG system can modify to balance its budget: it can (i) increase its revenues by raising the contribution rate, (ii) reduce its expenses by lowering pensions, or (iii) raise the retirement age to simultaneously increase revenues and reduce expenses. The first two measures increase distortions and thus reduce work-related remuneration (the wage when individuals are employed, or "deferred" wage when they are retired). These adjustments also tend to increase the probability of being financially constrained: higher taxes magnify this risk for young workers, while reduced pensions increase it for retirees. While these two measures can resolve budgetary problems, the disincentive effect on labor supply reduces their effectiveness. This increase in distortions due to the need for PAYG system financing does not occur when raising the retirement age, but this approach raises the issue of optimally balancing time allocation between work and leisure over the lifecycle.

We propose to evaluate the changes in the PAYG system rules necessary to allow each

of these options to balance its budget.³ We also aim to quantify the impact of rising educational attainment on the PAYG budget. To achieve these objectives, we develop a model with heterogeneous agents à la Aiyagari (1994), where aging is stochastic as in Castañeda, Diaz-Gimenez, and Rios-Rull (2003), and time is continuous as in Achdou, Han, Lasry, Lions, and Moll (2022). As in any OLG model, we account for average career development linked to employment experience (the Mincerian component of workers' wages). To consider both differences in initial wage levels and career progressions, we distinguish between the labor markets of graduates and non-graduates. Agents bear the following risks: *(i)* lifespan is uncertain, *(ii)* around the Mincerian wage, the effective wage fluctuates randomly, and *(iii)* the level of human capital of offspring is imperfectly correlated with that of parents. In our model, where parents are altruistic (rational altruism),⁴ agents save to *(i)* smooth their consumption over their lifetime, knowing that their income drops when they retire, *(ii)* insure their children against possible losses in human capital if knowledge transmission is imperfect and against low income at the start of their career, and *(iii)* smooth their consumption during their working life, which can be impacted by career setbacks. At the individual level, demographic changes modify these savings choices: the extension of lifespan leads to more saving to finance old age, while the popularization of higher education reduces the risk of having a child who does not graduate from college. At the aggregate level, these changes also increase the quality of the workforce by shifting its composition toward more productive workers, thereby improving production efficiency.

Beyond enriching the analysis of the aggregate adjustments occurring when necessary PAYG system reforms are implemented to support structural changes, it is crucial to account for the rich heterogeneity underlying the dynamics of wealth distribution. Empirical evidence reported by Bartscher, Kuhn, and Schularick (2019) and Ekkehard, Langot, Merola, and Tripier (2023) shows that the distribution of skills is essential in explaining rising wealth inequality. Bartscher et al. (2019) refer to a "college wealth divide" to describe the emergence of a substantial college wealth premium (considerably larger than the college income premium) since the 1980s in the US. Considering inequality both between and within skill groups has a long tradition in the literature, starting with the early observation by Gottschalk (1997) that "inequality increased not only among those with different observable traits, such as gender, race, education, and experience,

3. We take each option independently of the other.

4. We model altruism as in Castañeda et al. (2003), Hairault and Langot (2007), and Hairault, Langot, and Sopraseduth (2008).

but also within groups of workers." Building on this evidence, Heathcote, Storesletten, and Violante (2010), Heathcote, Storesletten, and Violante (2017), and Ahn, Kaplan, Moll, Winberry, and Wolf (2018), among others, dissect the rise of wage, earning, and income inequality between and within groups."

We first estimate the adjustments to PAYG system parameters – namely the tax rate, the pension replacement rate, and the retirement age – necessary to accommodate changes in lifespan and workforce composition. Our results show that extending lifespan by 5 years, without changing the retirement age or educational attainment, requires either a 7 percentage points (pp) increase in the tax rate or a 19pp reduction in the pension replacement rate. While increasing the level of education significantly boosts GDP (by around 18%, depending on PAYG system adjustments), it does not generate substantial budgetary margins because pension benefits are indexed to labor income.⁵

Secondly, we show that these PAYG system adjustments, which account for increased lifespan and educational attainment, lead to significant differences in GDP dynamics from 2020 to 2100. If the sustainability of the PAYG system is ensured by increasing taxes, households initially work more. However, after 2030, they reduce their work effort, which falls below its initial level by 2040. This labor supply overshooting allows households to accumulate excess savings to finance their extended lifespan and that of their children. The wealth increase induced by higher educational attainment compensates for the distortions caused by the tax increase only after 2080, resulting in GDP gains. By 2100, the US GDP will increase by 15% solely due to higher educational attainment. Without an increase in education levels, the US GDP would stagnate at its 2020 level, leading to lower consumption, in a context where tax increases are induced by an increasing labor force due to extended lifespan.

If the PAYG system's sustainability is ensured by adjusting pensions, the transitional dynamics are similar, but the need for savings is greater due to reduced pensions, and the labor supply distortion is lower due to constant taxes. Consequently, work effort remains higher than initially, and GDP gains, also supported by higher educational attainment, are greater due to increased savings accumulation. By 2100, US GDP will increase by 17%, with 88% of this growth (15pp) due to higher educational attainment and 12% (2pp) due to increased employment and capital.

5. It reduces the tax rate by 0.2pp, increases the replacement rate by 0.7pp, or lowers the retirement age by one quarter. These findings contrast with Conesa, Kehoe, Nygaard, and Raveendranathan (2020)'s results, which aggregate the accounts of the PAYG system-financing pensions indexed to earnings-and other Social Security benefits, such as health insurance (non-indexed benefits).

In contrast to these two scenarios, where extended lifespan does not provide additional labor market resources, the scenario that adjusts the PAYG system based on extended working life, increasing the retirement age, results in a greater GDP increase of 27% by 2100. This includes 55% (15pp) from higher educational attainment and 45% (12pp) from increased employment and capital. By allocating extended lifespan to the labor market, the benefits of educational investments are maximized. It is also important to note that the increase in efficient employment is achieved more through higher quality and longer duration of use over the lifecycle than by an increase in hours worked per employee.

When adjustments are made via tax increases or pension reductions, wealth inequalities increase. In the first case, this occurs because some young individuals, who are more frequently financially constrained, may be less insured due to low wealth among their parents, resulting in smaller bequests. In the second case, inequalities are pronounced because retirees who may have retired without sufficient savings after poor employment histories cannot rely on generous pensions. However, the increase in inequality is greatest when adjustments to the PAYG system are based on raising the retirement age. By promoting economic activity primarily carried out by increasingly educated individuals, significant gaps emerge between those with high wage income and high savings rates and those who remain at the bottom of the social ladder.

Even though an increase in education levels contributes to enhancing individual welfare, whether for young people at the start of their careers or for the elderly retiring, the increase in lifespan more than offsets this positive effect, leading to a reduction in overall welfare, especially for retirees, regardless of the instrument used to balance the PAYG system's budget.

In the scenario where taxes increase, the welfare of young people declines, and their greater difficulty in saving leads to a sharp reduction in retirees' welfare. In the scenario where pensions are reduced, retirees' welfare drops sharply, which negatively impacts the welfare of young people due to the reduction in inheritances they receive from pensioners upon their death. Finally, in the scenario where the retirement age is increased, retirees experience the smallest reduction in welfare, but young people face a reduced need for insurance, resulting in smaller inheritances and subsequent welfare losses.

After the adjustment period induced by the structural changes, only scenarios where pensions are reduced or the duration of work is prolonged result in an increase in the welfare of working individuals. In all cases, however, the welfare of retirees decreases.

The remainder of the chapter is organized as follows. Section 2.2 discusses the related

literature. Section 2.3 presents the model. Section 2.4 describes the calibration and quantitative methodology. Section 2.5 analyzes the steady states' differences before and after structural changes. Section 2.6 explains the adjustment dynamics between these steady states. Section 2.7 presents the welfare analysis and finally section 2.8 concludes.

2.2 Related Literature

On demographic changes in the US. The demographics of the United States are undergoing a profound transformation. Driven by a significant increase in life expectancy, projected to grow from 16.5 years at age 65 in 2010 to 21.5 years by 2100, the aging population is increasing substantially. In 2020, individuals aged 65 years and older constituted 17% of the total population, with projections indicating that this proportion will rise to 22%, equivalent to 80.8 million individuals, by 2040 (see Administration on Aging, Administration for Community Living, U.S. Department of Health and Human Services (2022)). This demographic trend poses a notable economic challenge to the sustainability of the Pay-As-You-Go (PAYG) system. The dependency ratio, which compares the number of retirees to the working-age population, is anticipated to rise from 21.6% in 2010 to 38.6% by 2060, according to projections by the Social Security Administration (SSA), thus raising concerns about the current sustainability of the US PAYG system.⁶ In an international context, Auclert, Malmberg, Martenet, and Rognlie (2021) show that the direct impact of aging on the wealth-to-GDP ratio of many countries is both positive and large. Even if the age profiles of assets and labor income are fixed, population aging leads to increased saving rates, implying a decline in rates of return, an increase in the wealth-to-GDP ratio, lower asset values, and potentially deepened global imbalances. These facts suggest the need to study the impact of population aging using a dynamic general equilibrium model.

6. See Poterba (2014) for a survey. The sustainability risk of the United States PAYG system also exists in many European countries, as highlighted by Heer, Polito, and Wickens (2023). These authors show that these countries would need to implement a 5% increase in consumption taxes, a 10% reduction in the pension replacement rate, and a two-year increase in the retirement age to significantly reduce their sustainability risk. See also Kotschy and Bloom (2022) for an international comparison of aging population projections. Adjustments to the PAYG system are among the most challenging policy issues to resolve in economics, as evidenced by the protests in France following changes to the system parameters. See French protests in 1995, 2003, 2006, 2010, 2019-2020, 2023.

On PAYG system adjustments. Previous research has emphasized the importance of implementing various policy reforms to restore the equilibrium of the PAYG system in the United States. In line with the studies by Auerbach and Kotlikoff (1987), Hubbard and Judd (1987), Huggett and Ventura (1999), Imrohoroglu, Imrohoroglu, and Joines (2001), and Kitao (2014), E. R. McGrattan and Prescott (2017) examines the aggregate, distributional, and welfare consequences of the PAYG system in response to demographic changes in the US. They analyze the transition from the existing PAYG system to a saving-for-retirement program, entailing the gradual phasing out of payroll taxes and the elimination of PAYG and Medicaid transfers. Their findings show that most households experience welfare improvements (by +16% in consumption equivalent). When pensions are lowered, along with payroll taxes and Medicare transfers, current retirees are indifferent between continuing in the current Social Security system or switching to a saving-for-retirement program, while all workers see welfare improvements across all productivity levels and birth cohorts. These outcomes are driven by the large increase in equilibrium capital resulting from the decline in pensions.

This chapter extends the pioneering work of De Nardi, Imrohoroglu, and Sargent (1999), who calibrated an OLG model on US data to evaluate the effects of eight distinct adjustment packages designed to address the challenges posed by an aging population. Faced with an increasing dependency ratio, they compared the following scenarios: *(i)* maintaining Social Security benefits at initial steady-state levels and adjusting the labor income tax rate to cover the fiscal burden; *(ii)* maintaining Social Security benefits at initial levels and adjusting only the consumption tax rate to cover the fiscal burden; *(iii)* raising the retirement age by two years to reduce retirement benefits, with the remaining fiscal burden covered through adjustments in either the labor income tax rate or the consumption tax rate; *(iv)* reducing Social Security benefits and adjusting the labor income tax rate; *(v)* linking benefits to past earnings while modifying tax rates on labor income or consumption; and *(vi)* gradually phasing out benefits for retirees until they reach zero.

De Nardi et al. (1999) firstly show that labor income tax rates must increase from 29.7% to 59.5% to cover the fiscal burden of the Social Security system, leading to a lower labor supply and output (−17.4%), while the capital stock increases. Secondly, linking retirement benefits to past earnings, which eliminates the distortion in work/leisure allocation, involves a smaller increase in labor income tax rates and results in a milder decline in labor input and GDP (−4.6%) compared to experiment *(i)*. Thirdly, using consumption tax rates to cover the fiscal burden results in these taxes rising from 5.5% in

the initial steady state to 36.9% in the final steady state, leading to declines in aggregate labor input and GDP (−10.7%). Fourthly, linking benefits to contributions (scenario (v)) reduces labor supply distortion (consumption tax rises to only 30.5% compared to 36.9% in scenario (ii)), with gains in GDP (+3.7%), even if labor input declines. Fifthly, increasing the retirement age by two years significantly reduces the fiscal burden, requiring less variation in either consumption or labor income tax rates. Labor income tax rates increase to 52.9%, causing aggregate labor input and GDP to decline (−10.7%). Alternatively, using consumption taxes (31.2%) leads to decreased labor supply and GDP (−2.25%).

In terms of welfare analysis, De Nardi et al. (1999) show that all reforms from (ii) to (vi) lead to higher welfare for future generations than scenario (i). However, in the short run, i.e., for the current generations, the only system that simultaneously raises the welfare of both current and future generations is the one where benefits are more closely linked to past earnings and financed by increasing tax rates on labor income (scenario (v))

On Inter and Intra generational mobilities. The PAYG system is the main public policy for intra-generational insurance and inter-generational redistribution. Therefore, precise modeling of inter-generational and intra-generational mobility is essential.

As emphasized by Fuster (1999), considering altruism (and not just a "warm glow" motive as in De Nardi et al. (1999)) can change the evaluations of the impact of aging on savings, wealth distribution, and aggregate outcomes. In an altruistic model, rich individuals save for bequests, and intergenerational transfers organized by the PAYG system have different impacts on wealth distribution. Fuster, Imrohoroglu, and Imrohoroglu (2003) show that the PAYG system can increase steady-state welfare by insuring to families where children and parents are close to borrowing constraints.⁷

Conesa et al. (2020) have shown that Social Security adjustments also depend on the evolution of the intra-generational labor supply composition. Using a calibrated OLG model for the US that accounts for aging and the increasing share of college degrees among successive generations, they show that the average labor tax rate must increase

7. Horioka, Gahramanov, Hayat, and Tang (2021) shows that Japanese individuals with any form of bequest motive—altruistic or strategic—tend to work more hours per week compared to those without bequest motives. Based on the French experience with pension system reforms, Hairault and Langot (2007) and Hairault et al. (2008) also show that the PAYG system (i) redistributes income toward highly educated families that use these transfers to insure their children against downward social mobility, and (ii) more frequently drives poor families toward financial constraints due to high labor income taxes associated with aging.

from 33.5% to 35.1% (+1.6) pp by 2100. Counterfactual simulations indicate that without an increase in the share of college degrees, the average labor tax rate would need to rise from 33.5% to 47.1% (+13.6) pp, indicating that increased college attainment reduces the required rise in the labor tax rate by 12.0 pp.⁸

Since Conesa et al. (2020)'s model does not incorporate altruism, this significant increase in educational attainment has no direct impact on individuals' behaviors, which only change in response to price changes induced by this demographic shift. Our modeling differs by accounting for altruistic behaviors that directly integrate educational changes, modifying individuals' evaluations of the risk associated with offspring (the intergenerational income risk) based on changes in transitions in educational attainment between parents and children, as measured by different NLSY waves.⁹

2.3 Model

We consider a heterogeneous agents model à la Aiyagari (1994) with stochastic aging à la Yaari (1965) as in Castañeda et al. (2003) (age is the state g) and where time is continuous as in Achdou et al. (2022). The population is constant over time and is normalized to 1. The economy is populated by skilled and unskilled workers (state q). The earning risks are age-specific and skill-specific, modeled by an age-skill-specific earning process (state z). At time t , an agent with wealth a is characterized by the state vector (a, g, q, z, t) . Agents choose the number of hours worked (endogenous labor supply). Finally, there exists a stochastic social mobility between generations that affects saving choices because an agent's altruism is based on child preferences.

8. In Conesa et al. (2020), the share of individuals with a college degree is projected linearly until 2100, optimistically predicting that 70% of the population will be skilled by then.

9. By introducing changes in intra-generational mobility, we also contribute to the literature on wealth inequality and education (see e.g. Heathcote et al. (2010) and 2017). Evidence reported by Bartscher et al. (2019) and Ekkehard et al. (2023) shows that the distribution of skills is crucial for understanding wealth inequality issues. A body of literature on wealth inequality addresses the role of education or skill heterogeneity in changes in the distribution of wealth inequality using general equilibrium models (see e.g. Cooper and Zhu (2016), Kaymak and Poschke (2016), Ahn et al. (2018), Hong, Hoon Seok, and Hye MI (2019), Hubmer, Krusell, and Jr. (2019), or Ekkehard et al. (2023)).

2.3.1 Aging, earnings and social mobility

Each period, some individuals are born and some individuals die.¹⁰ More precisely, when an individual dies, he gives birth to a single child. We consider a homogeneous Markov process $g = \{g(t), t \geq 0\}$ with values in $\mathcal{G} = \{1, 2, 3, 4\}$ and with an infinitesimal generator.

$$\mathcal{A}^g = \begin{pmatrix} -\pi_1 & \pi_1 & 0 & 0 \\ 0 & -\pi_2 & \pi_2 & 0 \\ 0 & 0 & -\pi_3 & \pi_3 \\ \pi_4 & 0 & 0 & -\pi_4 \end{pmatrix}.$$

$g(t)$ is the age-class at time t of the agent. The quantity π_4 is related to the expected retirement age R_A . Over her life cycle, the agent's skill ($q \in \mathcal{Q} = \{u, s\}$) does not change. For the agents in age groups $g \in \{1, 2, 3\}$ with a skill q , the earnings change according to a deterministic growing sequence $\{\omega_{g,q}\}_{g=1}^3, \forall q \in \{s, u\}$: $\omega_{g,q}$ is the human capital of the q -skilled agent at age g and is such that $\omega_{g,s} > \omega_{g,u}, \forall g, q$.

The other changes in earnings come from an idiosyncratic productivity z . This individual risk is age-specific and skill-specific. The idiosyncratic productivity z follows an Ornstein-Uhlenbeck process (corresponding to a discrete time $AR(1)$ process), that is:

$$dz(t) = \theta_{g,q}(\bar{z}_{g,q} - z(t))dt + \sigma_{g,q}dW(t), \quad \forall g \in \{1, 2, 3\}, \quad \forall q \in \{s, u\} \quad (2.1)$$

where $W(t)$ is a Wiener process and $\theta_{g,q}, \sigma_{g,q}$ and $\bar{z}_{g,q}$ are positive parameters. $\bar{z}_{g,q}$ is the unconditional mean, $\sigma_{g,q}$ is the standard deviation of the innovation and $e^{-\theta_{g,q}}$ represents the persistence of the process. For the agents in age group $g \in \{4\}$, the idiosyncratic productivity z does not change, so that $\theta_{4,q} = \sigma_{4,q} = 0$ and $dz(t) = 0$. Furthermore, the process followed by z is continuous over the life-cycle of the agent (from the birth to the death), the parameters of the process change when the agent reaches the next age-class, but there is no jump in the path followed by z , except when the agent dies. Concerning the social mobility, we assume that when the agent with skill-productivity $\{q, z\}$ dies, she expects that her off-spring begins his career with the skill $q' \in \mathcal{Q}$ at a productivity level z' . This off-spring's state (q', z') depends on the skill-productivity of her father. $d\Phi(\check{q}, \check{z}|z, q)$ gives the probability for a (q, z) -parent to have of (\check{q}, \check{z}) -children.

10. For empirical reasons, we assume that there is no demographic growth.

2.3.2 Households' decisions

The utility of the household, compatible with a balanced growth path,¹¹ writes:

$$u(c, h) = \begin{cases} \log(c) - \Theta \frac{h^{1+\psi}}{1+\psi} & \text{if } g \in \{1, 2, 3\} \\ \log(c) & \text{if } g \in \{4\} \end{cases} \quad \text{with } \Theta > 0 \text{ and } \psi \geq 0.$$

$\frac{1}{\psi}$ is the *Frischian* elasticity of labor supply. The budget constraint is

$$\begin{aligned} \dot{a}(t) &= (r - \gamma)a(t) + wz(t)d(h(t), z(t), q(t), g(t)) - c(t) \quad \text{for } a(t) \geq 0 \quad (2.2) \\ d(h, z, q, g) &= \begin{cases} (1 - \tau)\omega_{g,q}h & \text{if } g \in \{1, 2, 3\} \\ p(z)\omega_{4,q}\bar{h}_3 & \text{if } g \in \{4\} \end{cases} \end{aligned}$$

where a is the wealth, γ the exogenous growth rate of (labor augmenting) technological progress,¹² r the interest rate, w the wage rate per hour and per unit of human capital, τ the contribution rate, and $p(z)$ the replacement rate. Indeed, we approximate the US pension system, so that the retired workers earn $p(z)w\omega_{4,q}z\bar{h}_3$ where the replacement rate $p(z)$ decrease with respect to the individual productivity as in the data. This replacement rate applies to a reference earnings levels $w\omega_{4,q}z\bar{h}_3$, which approximates the worker's labor earnings at the end of her career: it depends on (i) the previous productivity z (reached just before retirement), (ii) the previous human capital level, so that $\omega_{4,q} = \omega_{3,q}$ and (iii) the average hours worked \bar{h}_3 before retirement. Thereby the value function solves: for all

11. These restrictions on preferences are crucial because the growth rate of the economy is the return of an unfunded retirement system.

12. With the model's preferences and technology, there is a balanced growth path where consumption, production, capital and wage are growing at rate γ . For the sake of simplicity, the variables c , K , w , Y and a correspond to their counterpart in level divided by the trend $e^{\gamma t}$.

$g = 1, 2, 3$

$$\begin{aligned} \rho_{g,q}v(a, g, q, z) = \max_{c,h} & \left[u(c, h) + \frac{\partial v}{\partial a}(a, g, q, z)((r - \gamma)a + wz(1 - \tau)\omega_{g,q}h - c) \right. \\ & + \pi_g [v(a, g + 1, q, z) - v(a, g, q, z)] \\ & \left. + \frac{\partial v}{\partial z}(a, g, q, z)\theta_{g,q}(\bar{z}_{g,q} - z) + \frac{1}{2} \frac{\partial^2 v}{\partial z^2}(a, g, q, z)\sigma_{g,q}^2 \right] \end{aligned} \quad (2.3)$$

$$\begin{aligned} \rho_{4,q}v(a, 4, q, z) = \max_c & \left[u(c) + \frac{\partial v}{\partial a}(a, 4, q, z)((r - \gamma)a + wzp(z)\bar{h}_3\omega_{4,q} - c) \right. \\ & \left. + \pi_4 \left(\int \eta v(a, 1, \check{q}, \check{z})d\Phi(\check{q}, \check{z}|z, q) - v(a, 4, q, z) \right) \right] \end{aligned} \quad (2.4)$$

where the discount rate $\rho_{g,q}$ is age and skill specific. Individuals belonging to the same dynasty do not overlap. There is uncertainty about the ability of the children, modeled by the distribution function $d\Phi(\check{q}, \check{z}|z, q)$. The bequest motive is driven by the distribution of the ability shocks, and not by their realization.¹³ $\eta \in [0, 1]$ measures the father's concern for his offspring's well being. With $\eta = 1$, the father cares about the utility of his descendant as much as he cares about his own utility. The only choice faced by a retiree is his consumption profile and the optimal amount of financial assets he wants to give to his child, according to the stochastic intergenerational expected changes in ability. The workers choice their optimal sharing between consumption and saving, but also choice their labor supply (extensive margin). The decision rules of the agent solve the above value function and write:

$$\begin{aligned} c(t) &= c(a(t), g(t), q(t), z(t)) \\ h(t) &= h(a(t), g(t), q(t), z(t)) \\ \dot{a}(t) &= \vartheta(a(t), g(t), q(t), z(t)) \end{aligned}$$

13. This might overstate the bequest motive for some parents and understate it for others. It is then not clear how different the retirement distribution would have been if we had allowed parents to know the child ability.

2.3.3 Wealth distribution

Let us denote by $f(a, g, q, z)$ the joint distribution of (a, g, q, z) .¹⁴ Let us denote the saving functions (solutions of equations (2.3) and (2.4)) as follows: $\dot{a}(t) = \vartheta(a, g, q, z)$. Hence, the Kolmogorov forward equation is:

$$0 = -\partial_a[\vartheta(a, g, q, z)f(a, g, q, z)] + \frac{1}{2}\partial_{zz}[\sigma_{g,q}^2 f(a, g, q, z)] - \partial_z[\theta_{g,q}(\bar{z}_{g,q} - z)f(a, g, q, z)] - \pi_g f(a, g, q, z) + \pi_{g-1} f(a, g-1, q, z) \quad \text{for } g \in \{2, 3, 4\} \quad (2.5)$$

$$0 = -\partial_a[\vartheta(a, 1, q, z)f(a, 1, q, z)] + \frac{1}{2}\partial_{zz}[\sigma_{1,q}^2 f(a, 1, q, z)] - \partial_z[\theta_{1,q}(\bar{z}_{1,q} - z)f(a, 1, q, z)] - \pi_1 f(a, 1, q, z) + \pi_4 \eta \int f(a, 4, \check{q}, \check{z}) d\Phi(\check{q}, \check{z}|z, q) \quad \text{for } g = 1 \quad (2.6)$$

2.3.4 Equilibrium

The aggregate capital K and the total hours in efficiency units N are given by

$$K = \sum_{g \in \mathcal{G}} \sum_{q \in \mathcal{Q}} \left[\int_a \int_z a f(a, g, q, z) da dz \right] \quad N = \sum_{g \in \{1,2,3\}} \sum_{q \in \mathcal{Q}} \left[\int_a \int_z \omega_{g,q} h(a, g, q, z) dz da \right]$$

These factors inputs are used to produce Y units of goods thanks to a CRS function:

$$Y = AK^\alpha N^{1-\alpha}$$

where A captures the level of technological knowledge (TFP). If we denote the depreciation rate of capital δ , the input prices $\{r, w\}$ are determined on competitive markets:

$$r - \delta = \frac{\partial Y}{\partial K} \quad \text{and} \quad w = \frac{\partial Y}{\partial N} \quad (2.7)$$

The budget of the pension system is given by:

$$\tau N = \sum_{q \in \mathcal{Q}} \int_a \int_z p(z) \omega_{4,q} z \bar{h}_3 f(a, 4, q, z) dz da \quad (2.8)$$

Equation (2.8) determines τ , if p and the expected retirement age (R_A) keep constant, or p , if τ and R_A keep constant, or R_A if τ and p keep constant. Hence a stationary equilibrium are scalars r, w, τ (or $p(z)$, or R_A) and functions v and f satisfying the PDEs

¹⁴ The population being normalized to 1, $f(a, g, q, z)$ represents the number of agents at state (a, g, q, z) .

(2.3)-(2.4) and the Kolmogorov equations (2.5)-(2.6).

2.4 Calibration

The model operates on an annual basis. The reference period spans from 1990 to 2000, and the model is calibrated using US data.

2.4.1 Calibration based on external information and assumptions

Age groups. Aging is stochastic where $\pi_g dt$ represents the probability of moving to the next age group ($g + 1$) between t and $t + dt$. As it is usual, new agents are considered to be 20 years old, and the life expectancy is $T = 81.5$ years. The working life period is divided into three sub-periods: 20-30 years, 30-50 years and 50- R_A years. An agent of age $g = 4$ is succeeded by a new agent of age $g = 1$. The probabilities π_g deduced from this calibration are reported in Table 2.1. In the benchmark case, we set $R_A = 65$ and thus $\pi_3 = 1/15$ and $\pi_4 = 1/16.5$.

Table 2.1 – Age groups and probability π_g

Age groups	1	2	3	4
Age partition	20 – 30	30 – 50	50 – R_A	$R_A - T$
π_g	1/10	1/20	1/($R_A - 50$)	1/($T - R_A$)

Human capital per age groups. The earnings during working life ($g = 1, 2, 3$) depend on the human capital level $\omega_{g,q}$, $\forall q = u, s$. A skilled worker ($q = s$) possesses at least a bachelor’s degree, while an unskilled worker ($q = u$) does not. The average earnings by age, along with the weight of each age class, are used to derive the average values presented in Table 2.2. In this table, the human capital at age $g = 1$ is normalized to unity. Additionally, the human capital at the time of retirement is assumed to be the same as at the end of the working life. It’s important to disaggregate the results in Table 2.2 between skilled and unskilled workers for a comprehensive analysis.

Using CPS data on average earnings by educational attainment (below bachelor’s degree, bachelor’s degree, master’s degree, and beyond master’s degree), we compute human capital by skill-level over the life-cycle. This computation is conducted under the

Table 2.2 – **Human capital** $\omega_{g,q}$

Age partition	20 – 30	30 – 50	50 – R_A	$R_A - T$
Average earnings	41.7	82.9	80.8	
Average human capital	1	1.99	1.94	1.94

Source: Kuhn and Rios-Rull (2016) data for the years 1989, 1992, 1995, 1998 and 2001 in 2013 US dollar (Survey of Consumer Finance, SCF)

constraint to maintain consistency with the average human capital by age and the ratios of skilled to unskilled earnings (see Appendix 2.A for detailed methodology). The resulting human capital levels for each skill-level and age group are presented in Table 2.3.¹⁵

Table 2.3 – **Human capital by age groups and skill-level**

Age partition	20 – 30	30 – 50	50 – R_A	$R_A - T$
Human capital for unskilled ($\omega_{g,u}$)	0.87	1.64	1.57	1.57
Human capital for skilled ($\omega_{g,s}$)	1.48	3.23	3.24	3.24
Average human capital ($\bar{\omega}_g$)	1.00	1.99	1.94	1.94

Earnings risks. The productivity $z(t)$ of a worker follows the process described in (2.1). Recall that the parameters of the process depend on the skill-level q and on the age g , and these parameters undergo changes as the agent transitions into the next age-class. The unconditional mean $\bar{z}_{g,q}$ is normalized to unity ($\bar{z}_{g,q} = 1$). The discrete time equivalent of the process given by (2.1) writes:

$$z(t+1) = (1 - e^{-\theta_{g,q}}) + e^{-\theta_{g,q}}z(t) + \sigma_{g,q}\varepsilon_{t+1}$$

where $e^{-\theta_{g,q}} = \nu_{g,q}$ is the persistence and $\sigma_{g,q}$ is the standard deviation of the innovation. Note that ε_{t+1} is Gaussian with zero mean and variance $\int_t^{t+1} e^{-2\theta_{g,q}(t+1-s)} ds$.

To calibrate these parameters, Karahan and Ozkan (2013) offer estimates of the age-dependent income process, with their age partition roughly corresponding to ours. Particularly important its persistent component (see Table 2.4).

Additionally, Hong et al. (2019) provide estimates for a skill-dependent income process. For skilled and unskilled workers, the mean variances of the innovation from 1990 to 2000 are $\sigma_s^2 = 0.0221$ and $\sigma_u^2 = 0.0196$, respectively. This information is used to determine the

15. With ξ_s the share of skilled workers, assumed to be stable over time, the average human capital is $\bar{\omega}_g = \xi_s \omega_{g,s} + (1 - \xi_s) \omega_{g,u}$. Using $\kappa_g = \frac{\omega_{g,s}}{\omega_{g,u}}$, we deduce $\omega_{g,u} = \frac{\bar{\omega}_g}{\xi_s \kappa_g + (1 - \xi_s)}$ and $\omega_{g,s} = \kappa_g \omega_{g,u}$.

Table 2.4 – Age dependent income process parameters

Age partition	24 – 33	34 – 52	53 – 60
ν_g	0.8783	0.9712	0.9608
σ_g^2	0.0273	0.0130	0.0258

Source: Karahan and Ozkan (2013)

age-skill dependent variances ($\sigma_{g,q}$ with $g = 1, 2, 3$ and $q = u, s$) of the earnings process. This determination assumes that the following ratios are preserved:

$$\frac{\sigma_s^2}{\sigma_u^2} = \frac{\sigma_{g,s}^2}{\sigma_{g,u}^2}, \quad g = 1, 2, 3 \quad ; \quad \frac{\sigma_3^2}{\sigma_2^2} = \frac{\sigma_{3,s}^2}{\sigma_{2,s}^2} = \frac{\sigma_{3,u}^2}{\sigma_{2,u}^2} \quad ; \quad \frac{\sigma_2^2}{\sigma_1^2} = \frac{\sigma_{2,s}^2}{\sigma_{1,s}^2} = \frac{\sigma_{2,u}^2}{\sigma_{1,u}^2}$$

and assuming that the variance σ_g^2 satisfies¹⁶

$$(1 - \xi_s)^2 \sigma_{g,u}^2 + \xi_s^2 \sigma_{g,s}^2 = \sigma_g^2, \quad g = 1, 2, 3,$$

with the share of skilled $\xi_s = 0.22$, the implied parameters of (2.1) are in Table 2.5.

Table 2.5 – Human capital by age groups and skill-level

Age partition	20 – 30	30 – 50	50 – R_A	$R_A - T$
$e^{-\theta_{g,q}} = \nu_{g,q} \quad \forall q$	0.8783	0.9712	0.9608	0
$\sigma_{g,u}^2$	0.0419	0.0200	0.0356	0
$\sigma_{g,s}^2$	0.0372	0.0177	0.0351	0
$\frac{\sigma_{g,u}^2}{1 - \nu_{g,u}^2}$	0.1833	0.3523	0.4632	0
$\frac{\sigma_{g,s}^2}{1 - \nu_{g,s}^2}$	0.1627	0.3118	0.4567	0

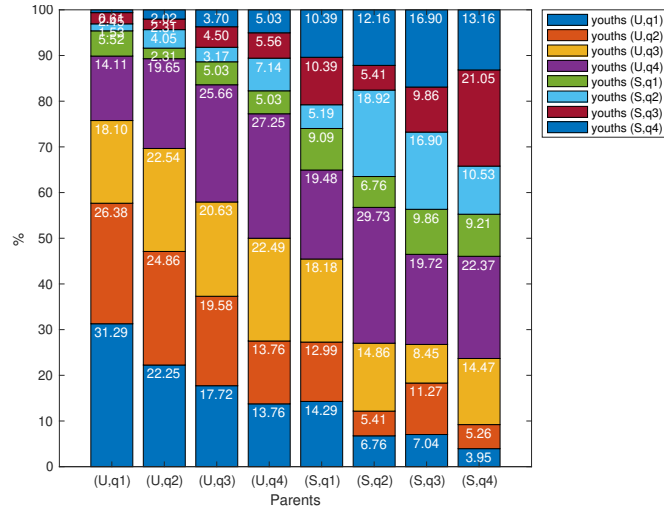
These parameters reveal that the income risk ($\frac{\sigma_{g,q}^2}{1 - \nu_{g,q}^2}$) increases notably with age, multiplying by approximately 2.5 between age 1 and age 3. Meanwhile, the disparities in risk between educated and non-educated individuals remain modest, with the gap not exceeding 10%.

Social mobility across generations. The 1979 National Longitudinal Survey of Youth (NLSY79) data provides insights into the transition between two consecutive generations

16. We also assume the independence of the processes.

within quartile-skill states.¹⁷ Each youth can be identified by a state vector denoting their "skill-quartile," i.e. by their educational attainment (below or above a bachelor's degree) and income quartile. Details of earnings for each skill-quartile state are outlined in Table 2.25 of Appendix 2.C. Additionally, the educational attainment and income quartile of each youth's parents can be determined. Social mobility is assessed through transition probabilities from the parents' skill-quartile state to that of their offspring, as detailed in Table 2.24 in Appendix 2.C. The findings of this statistical analysis are summarized in Figure 2.2.

Figure 2.2 – Social Mobility — NLSY79



Among unskilled parents (83%), those with low wages (bottom quartile of unskilled) have an 89.88% chance of having unskilled children ($31.29 + 26.38 + 18.10 + 14.11$), while those with high wages (top quartile of unskilled) have a 77.26% chance ($13.76 + 13.76 + 22.49 + 27.25$). Among skilled parents (17%), those with low wages (bottom quartile of skilled) have a 35.06% chance of having skilled children ($9.09 + 5.19 + 10.39 + 10.39$), whereas those with high wages (top quartile of skilled) see this chance rise to 53.95% ($9.21 + 10.53 + 21.05 + 13.16$). Thus, the educational attainment and wages of parents significantly influence the educational outcomes of their children. Using this social mobility matrix to determine the steady-state distribution of the economy results in a proportion of 22.34% educated workers. As Conesa et al. (2020) argue, this aligns with the number of graduates recorded by the US Census Bureau in the 1990s.

17. This survey encompassed youths aged between 14 and 22 years old in 1979. Quartiles are evaluated within each subgroup, comprising unskilled and skilled workers.

If parents are altruistic and value the welfare of their children by considering their educational attainment, which influences their labor incomes, intergenerational income risk is high. The probability of skilled parents having skilled children is far from 100%, and upward social mobility for families with unskilled parents is low. This intergenerational earnings risk provides an additional motive for precautionary saving: a bequest can insure children against an unsuccessful academic career that prevents them from obtaining a university degree, and thus the resulting income. However, the overall amount of capital may remain low even if the risk of downward intergenerational mobility is significant, because the economy has a large proportion of unskilled workers who are not affected by this risk and have a low propensity to save.

Grids for earnings. In the model, there are two productivity grids of $J = 10$ points, one for unskilled workers and one for skilled workers. These grids are independent of age and centered around 1. When an agent dies, they are replaced by a new agent characterized by a new "skill-productivity" state vector, drawn conditionally based on the "skill-productivity" state vector of their parents. This transition between generations is described by a Markov matrix. The data in Tables 2.24 and 2.25 must be transformed to describe social mobilities consistent with the model's assumptions.¹⁸

Preferences and technology parameters. The *Frischian* elasticity of labor supply ($1/\psi$) is set to 0.5, consistent with estimates based on microdata ($\psi = 2$). The parameter α of the production function, representing the share of capital income, is set to its standard value of 0.35. We assume that capital depreciates at an annual rate of $\delta = 0.08$. Labor-augmenting technical progress grows at an annual rate of $\gamma = 1.5\%$, which allows for a balanced growth path compatible with historical data. These values are summarized in Table 2.6.

Table 2.6 – Preferences and technology parameters

Preferences	Technology		
ψ	α	δ	γ
2	0.35	0.08	1.5%

18. Appendix 2.D describes how to project the original data, which represents social mobilities in two 4-point grids (the quartiles) governed by an 8×8 transition matrix, onto social mobilities in two J -point grids (the productivity levels in the model) governed by a $2J \times 2J$ transition matrix, using simulation methods.

2.4.2 Calibrations based on model's restrictions

Let's denote \bar{h}_g as the average number of hours worked by individuals of age g , and \bar{h} as the average number of hours worked over the entire population. Let P_i represent the replacement rate of retirees in quartile Qi , and s_j denote the share of wealth owned by agents in wealth quintile j , for $j = Qn1, Qn5$. Additionally, let A_ℓ represent the wealth by age or by skill. By minimizing the distance between the simulated and observed moments

$$\mathcal{M} = \left\{ K/Y, \{\bar{h}_g/\bar{h}\}_{g=1,2,3}, \{P_i\}_{i=Q1,Q2,Q3,Q4}, \text{Gini}, \{A_g/A_1\}_{g=2,3,4}, A_s/A_u, s_{Qn1}, s_{Qn5} \right\}$$

we find the values of the following 13 unknown parameters

$$\mathcal{P} = \{\Theta, \eta, A, \{\rho_{g,u}\}_{g=1,2,3,4}, \{\rho_{g,s}\}_{g=1,2,3,4}, p, \varpi\}$$

where parameters p and ϖ allow to manage how pensions ($e(a, 4, q, z) = p(z)wz\bar{h}\omega_{4,q}$) are indexed to the previous wage ($wz\bar{h}\omega_{4,q}$) through the following function:

$$p(z) = p \exp(-\varpi(z - \underline{z})) \quad \text{where } \varpi > 0$$

The function $p(z)$ determines the reduction of pension as z grows, where $p \in [0, 1]$ represents the highest replacement rate because \underline{z} is the smallest productivity level. Our tractable proxy of the US pension system is designed as follows: (i) The pension is related to past earnings $e(a, 4, q, z) = wzp(z)\bar{h}_3\omega_{4,q}$, where w is the wage rate paying a unit of efficient labor. (ii) The human capital level at retirement is the same as at age $g = 3$ ($\omega_{4,q} = \omega_{3,q}$). (iii) The individual productivity on which pensions are indexed is the last productivity level attained (z is the level at the transition between ages $g = 3$ and $g = 4$). (iv) \bar{h}_3 corresponds to the mean hours worked at age 3. The parameters $\{p, \varpi\}$ are calibrated to reproduce the median replacement rate by lifetime earnings quartile for retired recipients aged 64-66. Table 2.7 contains the calibrated values for the parameter set \mathcal{P} .

The results indicate that agents exhibit strong altruism, with $\eta = 0.95$ being close to perfect altruism ($\eta = 1$). Additionally, the most patient agents tend to have the highest qualifications. However, a very impactful type of educated individual is necessary to accurately reproduce the characteristics of the data. Finally, the pension system is redistributive, as the most productive individuals have a lower replacement ratio compared

Table 2.7 – Preferences and technology parameters \mathcal{P}

Techno.	Preferences										Social Security	
	Common		Skilled				Unskilled				p	ϖ
A	Θ	η	$\rho_{1,s}$	$\rho_{2,s}$	$\rho_{3,s}$	$\rho_{4,s}$	$\rho_{1,u}$	$\rho_{2,u}$	$\rho_{3,u}$	$\rho_{4,u}$		
0.092	0.95	0.95	0.8	0.0299	0.005	$1e^{-12}$	0.45	0.048	0.015	0.001	0.8	0.2

to the least productive ($\varpi > 0$).

Table 2.8 compares observed and simulated moments, showing that our model reproduces the aggregate ratios quite well (K/Y and $\{\bar{h}_g/\bar{h}\}_{g=1,2,3}$).

Table 2.8 – Targeted and simulated moments

	Capital		Hours		Pensions: replacement rates			
	K/Y	\bar{h}_1/\bar{h}	\bar{h}_2/\bar{h}	\bar{h}_3/\bar{h}	P_{Q1}	P_{Q2}	P_{Q3}	P_{Q4}
Data	3	0.9915	1.0089	0.9841	0.82	0.64	0.59	0.40
Model	2.9246	0.9175	1.0252	1.0214	0.8298	0.6475	0.5742	0.3816
	Wealth							
	Gini	A_2/A_1	A_3/A_1	A_4/A_1	A_s/A_u	s_{Qn_1}	s_{Qn_5}	
Data	0.85	4.92	10.81	8.72	3.39	0%	0.805	
Model	0.6481	4.9085	10.2538	6.0255	3.4045	0%	0.6806	

Sources. Capital output ratio: Nardi (2004). Average worked hours by age group: E. McGrattan and Rogerson (2004) (see Appendix 2.B). Gini, wealth ratios (by age, by skill) and wealth shares of first and fifth quintile: Kuhn and Rios-Rull (2016). Replacement rate for pensions: Biggs and Springstead (2008).

Regarding the moments characterizing inequalities, *(i)* the lifecycle profile of wealth generated by the model is close to the data, except for retirees, where it slightly underestimates wealth, and *(ii)* the wealth premium (ratio of the wealth of skilled workers relative to unskilled workers) is well reproduced. However, for the Gini coefficient and the share of wealth owned by the richest households, our model generates lower statistics than those observed in US data.

Furthermore, the initial steady state yields the PAYG system parameters presented in Table 2.9, given a retirement age (R_A) of 65 and a life expectancy (T) of 81.5 years. A wage tax rate of over 20% is of the same order of magnitude as that reported by De Nardi et al. (1999). However, our average replacement ratio is higher (close to 60% compared to 45% in De Nardi et al. (1999)). This is because, in De Nardi et al. (1999)'s model, part of the taxes is used to finance public expenditure, which is not accounted for in our model.

Note that the basic calculation of the replacement rate in a representative agent world

Table 2.9 – PAYG system Parameters

	τ	rep. rate	R_A	T
Benchmark	0.2355	0.6201	65	81.5

would yield $\text{rep. rate} = \frac{R_A - 20}{T - R_A} \tau = 0.6422$, which is slightly higher than the figure deduced from the model. This discrepancy reflects the revenue loss associated with lower starting career wages, impacting the replacement ratio to balance the PAYG system accounts.

2.5 Comparison of Steady State Results

2.5.1 Demographic and Educational Changes in the Long Run

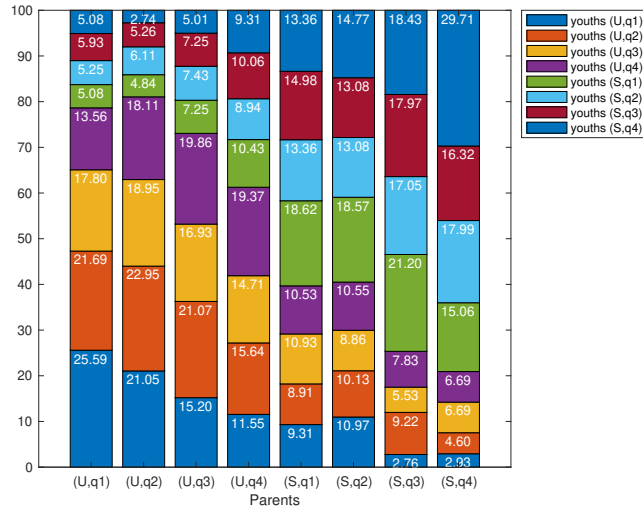
Demographic changes. It is assumed that the life expectancy will be $T' = 86.5$ years in 2100. Consequently, only one probability in the matrix \mathcal{A}^g is modified: π_4 now equals $1/(T' - R_A) = 1/21.5$.

Educational changes. It is assumed that future social mobility will be determined by a transition matrix, estimated using NLSY97 data. This dataset provides information on social mobility among individuals aged 12 to 16 in 1997 and their parents. The NLSY97 panel begins 20 years after the NLSY79 panel, allowing for the integration of data on the rise in educational attainment observed in the US between the 1980s and 1990s (when NLSY79 panel youths graduated) and the 2000s and 2010s (when NLSY97 panel youths graduated). The results of this statistical analysis are presented in Figure 2.3.

Among the parents who are unskilled (70%), those with a low wage (bottom quartile of unskilled) have a 78.64% chance of having unskilled children ($25.59 + 21.69 + 17.80 + 13.56$), whereas those with a high wage (top quartile of unskilled) have a 61.27% chance ($11.55 + 15.64 + 14.71 + 19.37$). For parents who are skilled (30%), those with a low wage (bottom quartile of skilled) have a 60.32% chance of having skilled children ($18.62 + 13.36 + 14.98 + 13.36$), while those with a high wage (top quartile of skilled) have a 79.08% chance ($15.06 + 17.99 + 16.32 + 29.71$). Using this matrix to deduce the steady-state share of skilled workers yields a proportion of 45.53% educated workers, which closely aligns with the US Census Bureau data in 2020 (see also Conesa et al. (2020)).

In the estimates derived from NLSY79, there has been a notable increase in upward social mobility among families with unskilled parents. Similarly, the probability

Figure 2.3 – Social Mobility — NLSY97



of families with skilled parents having skilled children has also risen. These trends can be attributed to the broader accessibility of American universities (see e.g. Ekkehard, Gonzalez-Pulgarin, Langot, and Merola (2024)). As the expectation of low-skilled parents for their descendants to attain skills and achieve higher incomes grows, the incentive to leave assets as bequests diminishes. Conversely, for skilled parents, the risk of their children remaining unskilled is significantly lower than in the 1980s, reducing the incentives for providing bequests. However, this transition toward an economy with a higher proportion of skilled workers fosters saving behavior, given that individuals are wealthier.

We depart from the methodology of Conesa et al. (2020) by not projecting the evolution of social mobility beyond 2100. Instead, starting from 2018, we maintain a constant social mobility matrix determined by NLSY97 data. Consequently, the proportion of educated workers in the economy remains fixed at 45.53%, a significant increase from the benchmark value of 22.34% derived from NLSY79. This decision is motivated by the challenges associated with reliably predicting all elements of the social mobility matrix, which comprises an 8×8 matrix. Assuming a linear increase in the proportion of educated workers in the future may be overly optimistic, particularly given potential diminishing returns from the education system, especially considering that the most substantial increases are likely already realized.

2.5.2 Disentangling the impact of the structural changes

The behavior of economic agents is influenced by shifts in expected life duration, as life expectancy increases from 16.5 years at age 65 to 21.5 years. Concurrently, there is a rise in educational attainment, with the proportion of college-educated workers rising from 22.34% to 45.53%. This uptick in average educational attainment implies adjustments in social mobility, impacting progeny risk. To isolate and analyze the distinct contributions of demographic and educational factors to economic outcomes, we undertake separate examinations of each permanent change: (i) demographic changes only, with the mobility matrix retaining values based on NLSY79, and (ii) educational attainment changes only, with the mobility matrix maintaining NLSY97-based values while life expectancy remains at its initial level of 16.5 years.

For these two structural changes, we undertake a series of policy experiments under various settings. In the initial scenario, the government employs three distinct economic policy instruments to manage the budget of the PAYG system in response to demographic shifts: (i) adjusting the labor income tax rate, (ii) reducing the replacement rate, and (iii) postponing the mandatory retirement age.

Impacts of the Demographic Changes

Macroeconomic Aggregates. Tables 2.10 and 2.11 provide a comparison between the initial (labelled "Benchmark") and final steady states, based on the implemented policy change: $\Delta\tau$ for adjustments involving a tax on labor incomes, Δp for changes concerning pensions, and ΔR_A for modifications related to the retirement age.

Table 2.10 – PAYG System Parameters

Scenario	τ	p	ret. age
Benchmark	0.2355	0.8	65
$\Delta\tau$	0.3063 (30.06%)	0.8 (0%)	65 (0%)
Δp	0.2355 (0%)	0.6167 (-22.91%)	65 (0%)
ΔR_A	0.2355 (0%)	0.8 (0%)	70.32 (8.18%)

τ the tax rate, p scale parameter of pensions and "ret. age" the retirement age

Table 2.10 illustrates that financing an additional 5 years of retired life (from 16.5 to 21.5 years) can be achieved through either raising the tax rate from 23.55% to 30.63%

or reducing the scale parameter of pensions from 0.8 to 0.6167. This reduction in scale parameter corresponds to a decline in the pension replacement ratio from 62.01% to 46.97% (as indicated in Table 2.11). Alternatively, to maintain the current level of system generosity (with unchanged tax rate and replacement ratio), the retirement age would need to be raised to 70 years and 4 months, effectively extending the working life to accommodate the gains in life expectancy.

Table 2.11 – **Macroeconomic Aggregates**

Scenario	Y	K	N	\bar{h}	K/Y	rep rate
Benchmark	0.0577	0.1689	1.2728	0.9896	2.9246	0.6201
$\Delta\tau$	0.0581	0.1716	1.2743	0.9898	2.9528	0.6167
	(0.69%)	(1.59%)	(0.11%)	(0.02%)	(0.96%)	(-0.54%)
Δp	0.0601	0.1846	1.289	1.0013	3.0735	0.4697
	(4.15%)	(9.29%)	(1.27%)	(1.18%)	(5.09%)	(-24.25%)
ΔR_A	0.0646	0.1964	1.3954	0.9929	3.0383	0.6227
	(11.95%)	(16.28%)	(9.63%)	(0.33%)	(3.88%)	(0.41%)

Y is the aggregated output, K the aggregated capital, N the efficiency of employment, \bar{h} the aggregated number of hours, K/Y the capital-output ratio, “rep rate” the replacement rate

In the scenario depicted in Table 2.11, demographic changes are mitigated through adjustments in labor taxes ($\Delta\tau$). With an extended life expectancy, individuals perceive an increased longevity risk, prompting a need for heightened savings. Anticipating a longer retirement period, households are incentivized to save more for retirement. Consequently, in order to finance this precautionary saving, households respond by increasing their work hours to augment income. However, this incentive to work is counteracted by the rise in labor income taxes, adjusted by the government from 23.55% to 30.63% to address fiscal pressure arising from the prolonged retirement period. While this tax increase reduces the incentive to work, it is outweighed by the need to boost savings, resulting in a marginal overall increase in total work hours (+0.02%). As savings accumulate, there is also a corresponding rise in capital (+1.6%), leading to an overall increase in production (+0.7%).

When adjusting the PAYG system budget through a reduction in pensions (Δp), the incentive for saving becomes more pronounced than in the previous scenario. Anticipating a longer retirement with lower pensions, individuals are motivated to save more and consequently increase their work hours to ensure financial security during retirement. The resulting increases in both capital (+9.3%) and hours worked (+1.18%) surpass those observed in the previous scenario. This is partly because distortions in labor supply do

not increase as they did previously. As a result, the overall increase in production is more substantial (+4.16%).

It's noteworthy that in this scenario, the most significant increase occurs in the number of hours worked. With the tax burden remaining constant and pensions decreasing, households are unable to spread the additional work effort over more years of activity. Consequently, they find themselves working more hours each day.

Finally, the economy achieves its highest output growth (+12%) when the adjustment of the PAYG system is accomplished through increases in the retirement age (ΔR_A). The rise in life expectancy has a moderate impact on the production process. In this case, if pension levels remain constant, the incentive to save increases due to the extended retirement duration. However, this extension is less pronounced than in previous scenarios, as only a fraction of the life expectancy increase translates into longer leisure period. Consequently, there is a marginal increase in hours worked (+0.3%), while capital experiences a substantial increase (+16.3%) due to the enhanced resources generated by this adjustment.

Inequalities. Table 2.12 compares the implications of different PAYG system adjustments on inequalities. Increasing life expectancy, which heightens the need for savings, amplifies existing inequalities due to households' differing capacities to save.

Table 2.12 – **Inequalities**

Scenario	Gini	$s_{Q_{n_5}}$	A_2/A_1	A_3/A_1	A_4/A_1	A_s/A_u
Benchmark	0.6481	0.6806	4.9085	10.2538	6.0255	3.4045
$\Delta\tau$	0.6974 (7.60%)	0.7679 (12.82%)	4.3878 (-10.60%)	9.5068 (-7.28%)	5.9194 (-1.76%)	3.4549 (1.48%)
Δp	0.7105 (9.63%)	0.7689 (12.96%)	4.7132 (-3.97%)	11.5367 (12.51%)	6.0824 (0.94%)	3.2765 (-3.75%)
ΔR_A	0.7132 (10.04%)	0.7809 (14.73%)	4.1232 (-15.99%)	11.0286 (7.55%)	6.059 (0.55%)	3.4983 (2.75%)

$s_{Q_{n_5}}$ is the share of the wealth of agents belonging to the fifth quintile

In the scenario where the effort to save is less pronounced ($\Delta\tau$), there is a marginal increase in wealth inequality, as measured by the Gini coefficient and the share of wealth owned by the richest. This is because individuals increasingly rely solely on their pensions for consumption during their elderly years. The higher tax burden on working-age individuals narrows wealth disparities between the young and those in age groups 2 and

3, as the young derive their wealth from inheritances while individuals in age groups 2 and 3 rely on savings, which are more difficult to accumulate due to reduced labor income caused by higher taxes. The ratio A_s/A_u increases since the tax burden is more burdensome for those without a university degree.

If the tax burden remains unchanged, the effort to save is less constrained. Consequently, in the scenario where the PAYG budget is adjusted through a reduction in pensions (Δp), there is an increase in the ratios $A_{g=2,3,4}/A_1$, the Gini coefficient, and the share of wealth owned by the wealthiest households.

This effect is even more pronounced when the PAYG budget adjustment involves raising the retirement age (ΔR_A). With this adjustment, more resources become available, facilitating the accumulation of savings and accentuating differences in career trajectories within the labor market.

Impacts of Changes in Educational Attainments

This scenario explores the impact of increased educational attainment, modeled as a change in social mobility using two waves of the NLSY (NLSY79 and NLSY97). In this setting, demographics remain unchanged while social mobility transitions to the levels estimated using NLSY97. This shift has two opposing effects. On one hand, the incentive for parents to save diminishes as it becomes easier for children to attain education regardless of their parents' education level, reducing the need to safeguard against less likely downward social mobility. On the other hand, with an increasing proportion of educated individuals and a corresponding rise in the fraction of people with a low marginal propensity to consume, aggregate savings increase.

Macroeconomic Aggregates. Table 2.13 shows that despite the rise in the proportion of educated workers from 22.34% to 45.53%, the costs of the PAYG system experience only a slight reduction. This results in a small decrease in the tax rate by 0.2 percentage points, a slight increase in the replacement rate of pensions by 0.76pp (+0.95%), or the option to advance the retirement age by only 2 months. It's essential to note that the decrease in the replacement ratio, as shown in Table 2.14, doesn't imply a reduction in the average pension but rather indicates that pensions have increased less compared to labor incomes.

Table 2.14 shows that, irrespective of the PAYG system adjustment scenario, an economy with a higher proportion of skilled workers exhibits increased production and greater

Table 2.13 – PAYG System Parameters

Scenario	τ	p	ret. age
Benchmark	0.2355	0.8	65
$\Delta\tau$	0.2333	0.8	65
	(-0.93%)	(0)	(0%)
Δp	0.2355	0.8076	65
	(0)	(0.95%)	(0%)
ΔR_A	0.2355	0.8	64.83
	(0)	(0)	(-0.26%)

τ the tax rate, p scale parameter of pensions and “ret. age” the retirement age

wealth. Consequently, the capital-output ratio experiences a considerable increase. The higher fraction of graduates also leads to an increase in the number of hours worked per person, as skilled individuals tend to work more intensively.

Table 2.14 – Macroeconomic Aggregates

Scenario	Y	K	N	\bar{h}	K/Y	rep rate
Benchmark	0.0577	0.1689	1.2728	0.9896	2.9246	0.6201
$\Delta\tau$	0.0681	0.2019	1.4911	0.9925	2.9629	0.6074
	(18.02%)	(19.53%)	(17.15%)	(0.29%)	(1.31%)	(-2.04%)
Δp	0.0681	0.2014	1.4906	0.9921	2.959	0.6135
	(18.02%)	(19.24%)	(17.11%)	(0.25%)	(1.17%)	(-1.06%)
ΔR_A	0.0679	0.2009	1.4864	0.9924	2.9599	0.6073
	(17.67%)	(18.94%)	(16.78%)	(0.28%)	(1.20%)	(-2.06%)

Y is the aggregated output, K the aggregated capital, N the efficiency of employment, \bar{h} the aggregated number of hours, K/Y the capital-output ratio, “rep rate” the replacement rate

These findings contrast with those of Conesa et al. (2020), which suggest that an increase in the proportion of educated individuals in the economy could potentially lead to a 12 percentage point reduction in the required increase in the labor tax rate. In our model, where all pensions are indexed to wages, there is no inherent reason for an increase in education levels to alleviate the tax burden. In contrast, Conesa et al. (2020)’s model includes a broader range of social security expenditures beyond pensions, such as Medicare, Medicaid, and Emergency Relief, whose benefits are not indexed to incomes. Consequently, Conesa et al. (2020) shows that as the proportion of skilled workers rises, the fraction of expenses related to these programs decreases, while tax revenues increase due to higher average wages, thereby alleviating tax pressure. Hence, the substantial dividends highlighted by Conesa et al. (2020) stem from programs other than the PAYG

system, which falls beyond the scope of our study.

Inequalities. As the proportion of skilled individuals increases in the economy, a larger share of the population undergoes significant wage growth throughout their life cycles.¹⁹

Table 2.15 – **Inequalities**

Scenario	Gini	s_{Qn_5}	A_2/A_1	A_3/A_1	A_4/A_1	A_s/A_u
Benchmark	0.6481	0.6806	4.9085	10.2538	6.0255	3.4045
$\Delta\tau$	0.657 (1.35%)	0.6984 (2.54%)	5.9696 (17.77%)	12.0642 (15.00%)	6.6914 (9.95%)	3.2955 (-3.30%)
Δp	0.6569 (1.35%)	0.6972 (2.43%)	5.9649 (21.52%)	12.0053 (17.08%)	6.686 (10.96%)	3.3008 (-3.04%)
ΔR_A	0.6568 (1.34%)	0.6965 (2.33%)	5.9883 (21.99%)	12.0195 (17.21%)	6.6873 (10.98%)	3.2945 (-3.23%)

s_{Qn_5} is the share of the wealth of agents belonging to the fifth quintile

This results in an expansion of wealth inequalities between the young and the elderly, as illustrated in Table 2.15. Moreover, irrespective of the scenario for adjusting the PAYG system, the wealth gap between skilled and unskilled workers narrows with an increase in the proportion of skilled workers. This suggests that highly skilled individuals, who face a reduced risk of downward mobility, require less savings due to the significant decline in this risk over time. Lastly, the Gini coefficient of the wealth distribution increases due to the predominant effect of steeper labor earnings outweighing the reduction in precautionary saving against downward mobility risks.

2.6 Aggregate and distributional impacts of the PAYG system adjustments

In this scenario, the adjustments required for the PAYG system to absorb both shocks – increased life expectancy and a higher share of skilled workers – combine the mechanisms described for each shock separately. Our assessment of the necessary tax increase to accommodate both demographic and educational changes can be compared to the estimates of Attanasio, Kitao, and Violante (2010) and Conesa et al. (2020), which suggest

19. Referring to Table 2.3, we observe that wages for unskilled workers increase by a factor of 1.8851 (1.8046) between ages 1 and 2 (age 3), compared to 2.1824 and 2.1892 for skilled workers.

that the labor tax rate should rise by 12.7 pp and 13.6 pp, respectively, by 2080 to finance the increased expenditures of the PAYG system.

2.6.1 Macroeconomic Aggregates

Our assessment of the effects related to aging is notably more pronounced than those of Attanasio et al. (2010) and Conesa et al. (2020), as indicated in Tables 2.16 and 2.10.

Table 2.16 – PAYG System Parameters

Scenario	τ	p	ret. age
Benchmark	0.2355	0.8	65
$\Delta\tau$	0.3033 (28.78%)	0.8 (0%)	65 (0%)
Δp	0.2355 (0%)	0.6230 (-22.12%)	65 (0%)
ΔR_A	0.2355 (0%)	0.8 (0%)	70.08 (7.82%)

τ the tax rate, p scale parameter of pensions and “ret. age” the retirement age

Figure 2.4 illustrates the adjustments of the PAYG system parameters, including the tax rate (τ , panel (a)), the scale parameter of pensions (p , panel (b)), and the retirement age (panel (c)).²⁰

The transition dynamics indicate that a reform initiated in 2018 would complete its adjustment phase after 60 years.

Panel (d) in Figure 2.4 illustrates a notable increase from 36.5% to 48% (+31%) in the proportion of retirees to the working-age population when the retirement age remains unchanged (scenarios $\Delta\tau$ and Δp). Conversely, if the retirement age is adjusted, this ratio remains constant. Panel (e) of Figure 2.4 shows how the average replacement ratio decreases across all scenarios (see also Table 2.17). This reduction is driven by the increase in the share of skilled workers, which elevates the total amount of labor income more than the total amount of pensions, given the redistributive component inherent in the latter.

Table 2.17 shows that postponing the retirement age leads to the largest increase in production. The benefits from enhanced productivity through education are further

²⁰ When calculating these transition paths, we assume that demographics and social mobility adjust gradually. These adjustments are governed by the function $x_t = (x_0 - x_T) \exp(-0.004 t^2) + x_T$, where x represents the life expectancy at age 65 or the elements of the mobility matrix. x_0 and x_T denote the initial and terminal values, respectively. The value 0.004 is chosen so that the adjustment concludes after 40 years, i.e., by 2060.

Figure 2.4 – PAYG System Parameters and Indicators

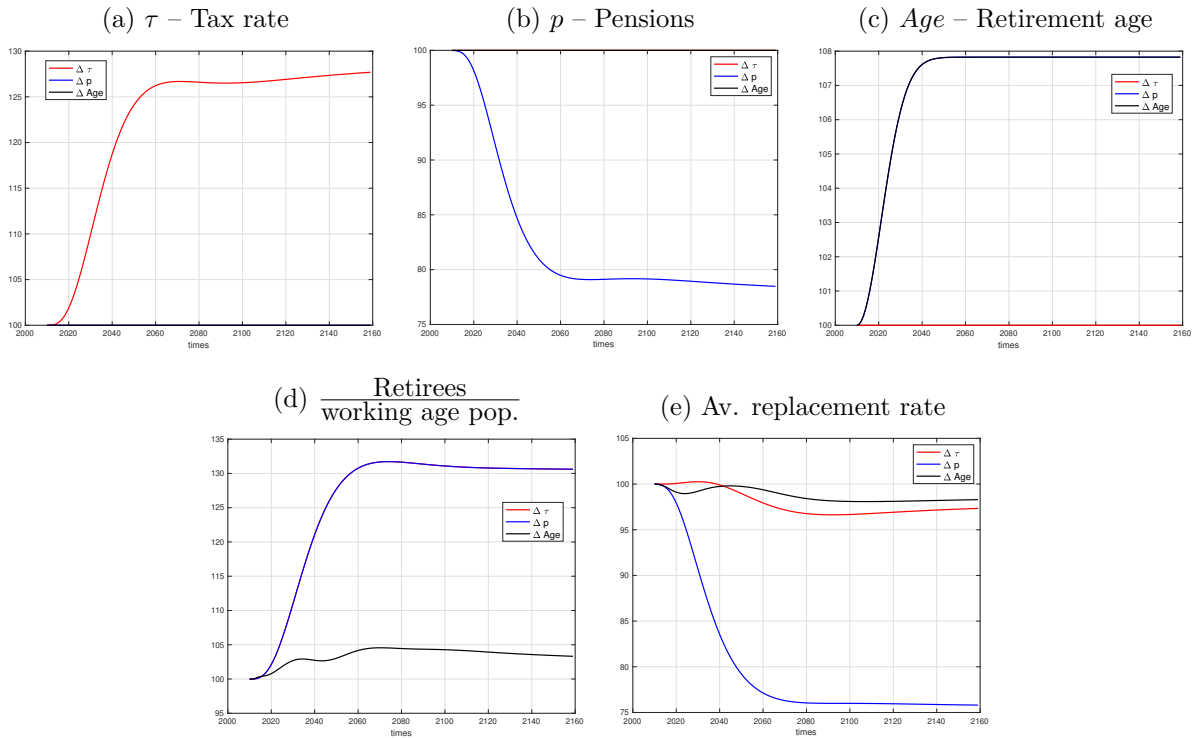
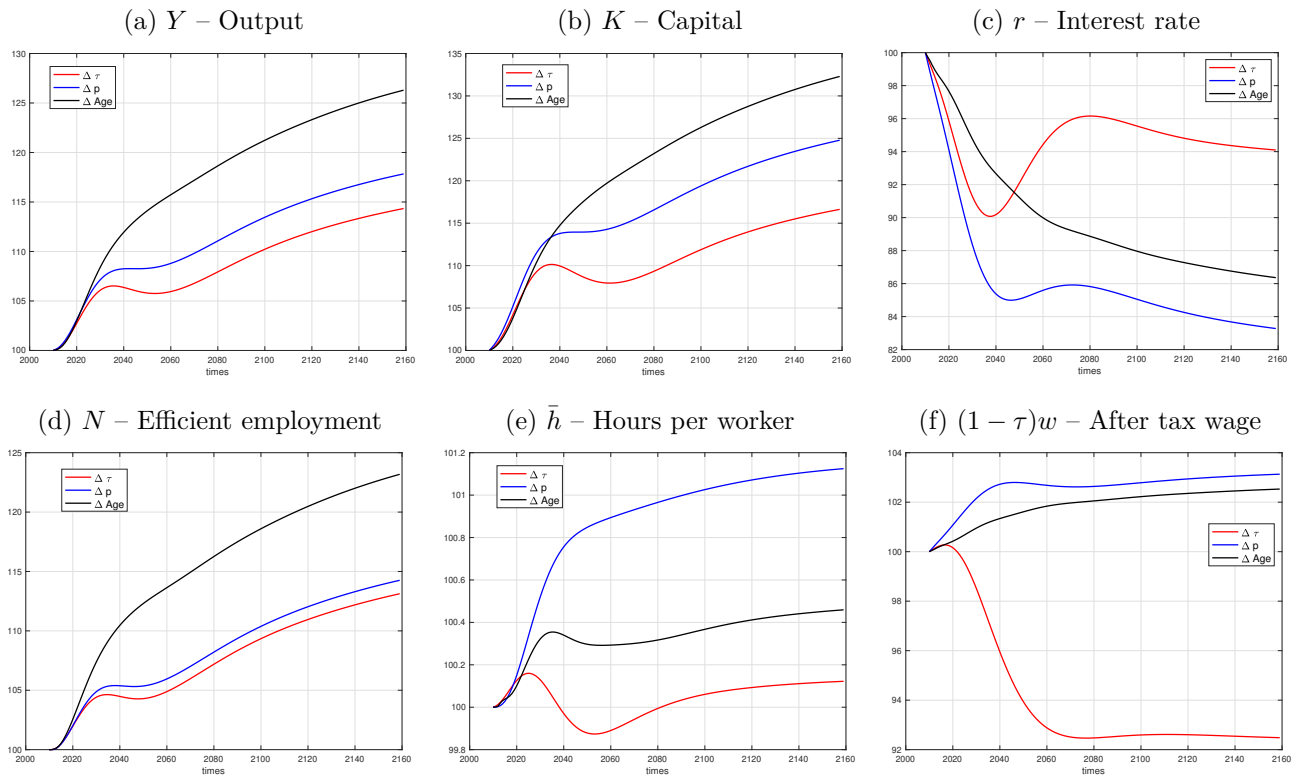


Table 2.17 – Macroeconomic Aggregates

Scenario	Y	K	N	\bar{h}	K/Y	rep rate
Benchmark	0.0577	0.1689	1.2728	0.9896	2.9246	0.6201
$\Delta\tau$	0.0685	0.2048	1.4934	0.9928	2.9878	0.6043
	(15.76%)	(17.52%)	(14.77%)	(0.32%)	(2.11%)	(-2.61%)
Δp	0.0708	0.22	1.5097	1.0037	3.1079	0.4647
	(22.70%)	(30.25%)	(18.61%)	(1.42%)	(6.26%)	(-25.06%)
ΔR_A	0.0762	0.2343	1.6339	0.9958	3.0757	0.6088
	(32.06%)	(38.72%)	(28.37%)	(0.62%)	(5.16%)	(-1.82%)

Y is the aggregated output, K the aggregated capital, N the efficiency of employment, \bar{h} the aggregated number of hours, K/Y the capital-output ratio, “rep rate” the replacement rate

Figure 2.5 – Transitions of Aggregates (base=100 in 2018)



amplified by the extended use of the workforce in production.

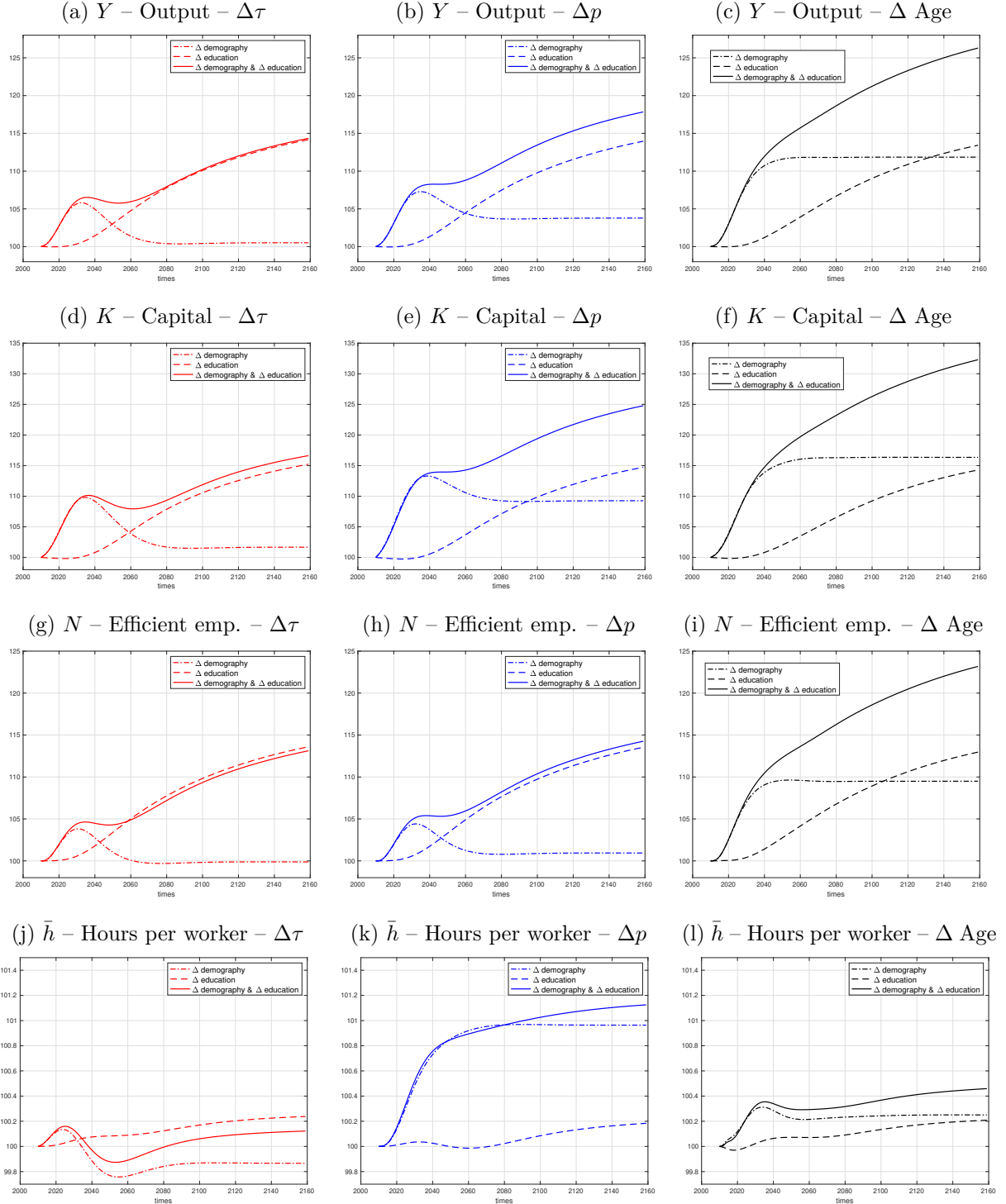
The increase in life expectancy requires additional resources, leading to increases in both employment and capital, regardless of adjustments to the PAYG system. Since longer life expectancy results in a more extended period with low retirement incomes, there is a heightened need for savings to ensure smoother consumption over the life cycle. This increases the capital-to-income ratio (K/Y). However, if the PAYG system adjusts its budget by raising taxes, it dampens the increases in employment (N or \bar{h}) needed to finance the longer life expectancy. This approach partially addresses the additional savings need by maintaining pension levels over an extended horizon. The increase in employment is because, in this scenario, the post-tax wage decreases (see Panel (f) of Figure 2.5), while the pre-tax wage increases, driven by the dynamics of the capital-to-income ratio.

It is crucial to emphasize that adjustments through tax rate increases or pension reductions result in stagnation or even a decrease in GDP 20 years after their implementation (see Panel (a) of Figure 2.5). This can be partially attributed to the increased savings requirement induced by the extension of life expectancy. This saving effort is undertaken by the first generation informed of the demographic change. However, once the expected life extension becomes effective in the long run, savings are decumulated by the large number of retirees, contributing to the decline in GDP. The short-run increase in capital is accompanied by an increase in labor effort when the adjustment is made through pension reductions. In contrast, when the adjustment is made through tax rate variations, the reduction in labor effort counteracts the GDP growth related to savings (see Panels (d) and (e) of Figure 2.5).

Breakdown. We propose a separation of the forces at play in each PAYG system adjustment: tax adjustment ($\Delta\tau$), pension adjustment (Δp), and retirement age adjustment (ΔR_A).

To understand the dynamics, we analyze the impact of demographic changes and educational choices. Figure 2.6 illustrates the paths of aggregated variables under two scenarios: (i) where only demographics change and (ii) where only education changes. We then compare these scenarios with a situation where both changes occur simultaneously. (See Figure 2.10 in Appendix 2.F for a detailed breakdown of PAYG system parameters and demographic variables). The analysis reveals that adjustments to these variables occur gradually, mirroring temporal shifts in life expectancy. Notably, around 90% of

Figure 2.6 – Transitions of Aggregates: a Decomposition (base=100 in 2018)



these adjustments are attributed to demographics, while changes in education levels have minimal impact. This finding is unsurprising, given that taxes and pensions, indexed to wages, are only marginally affected by shifts in workforce composition.

Focusing on GDP, Panels (a), (b), and (c) in Figure 2.6 highlight two significant forces at play. On one hand, the demographic shock notably boosts GDP in the short term (first 20 years post-reform), followed by a decline except in the scenario with a postponed retirement age, where it plateaus at its peak. This adjustment is driven by the rising trajectory of taxes, encouraging increased work before reaching the maximum tax rate. In the case of pension reduction, the need for resources in old age prompts increased work for savings. On the other hand, the continuous growth in the number of educated workers contributes to an increase in GDP. The impact of education outweighs that of aging. Therefore, without the contribution of education, adjusting through increased income tax might result in stagnant economic growth, whereas the increase in education leads to permanent GDP increases.

Panels (g) to (l) in Figure 2.6 illustrate how adjustments via the tax rate affect labor supply differently compared to other adjustments. When adjusting through the tax rate, there is a reduction in labor supply following the demographic shock, attributed to increased tax distortion. Notably, there is no thus increase in the extensive margin of employment, a common outcome for both tax and pension adjustments, as the duration of employment remains unaffected. Conversely, when adjusting by extending the working life, employment grows through the extensive margin, attracting more participants without being deterred by higher taxation. This increase in employment also amplifies the financing needs associated with an aging population. It's noteworthy that when adjusting pensions, the substantial need for resources to finance aging prompts households to significantly increase working hours. These households are not discouraged by taxation, which remains stable in this case (see Panel (k) in Figure 2.6).

2.6.2 Inequalities

Table 2.18 shows a notable rise in wealth inequalities, as indicated by the Gini coefficient of wealth. This increase is particularly pronounced when the PAYG system becomes more solvent through pension reduction, compared to maintaining its generosity by raising taxes.

The Figure 2.8 illustrates that demographic changes are the primary driver of this increase, overshadowing the comparatively lower impact of increased educational levels.

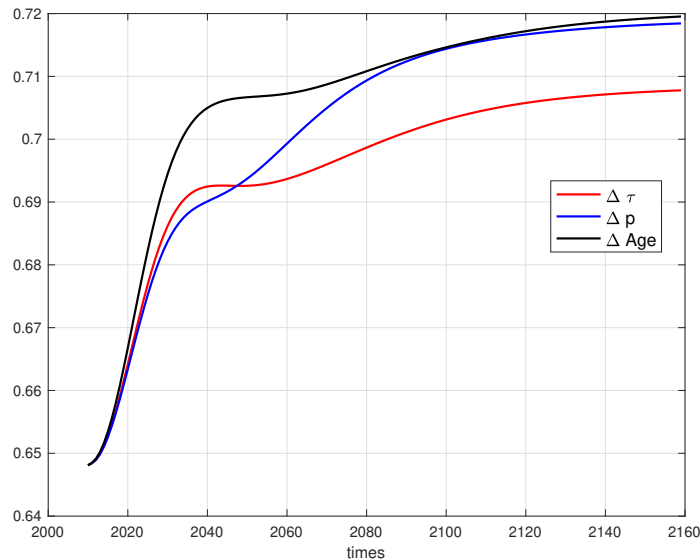
Table 2.18 – Inequalities

Scenario	Gini	$s_{Q_{n_5}}$	A_2/A_1	A_3/A_1	A_4/A_1	A_s/A_u
Benchmark	0.6481	0.6806	4.9085	10.2538	6.0255	3.4045
$\Delta\tau$	0.7082	0.7570	5.4254	11.3571	6.5738	3.3357
	(9.27%)	(11.22%)	(10.53%)	(10.75%)	(9.09%)	(-2.02%)
Δp	0.7193	0.7664	5.6974	13.3978	6.7185	3.1997
	(10.98%)	(12.60%)	(16.07%)	(30.66%)	(11.50%)	(-6.015%)
ΔR_A	0.7204	0.7789	5.0523	12.9237	6.7125	3.3847
	(11.15%)	(14.44%)	(2.92%)	(26.03%)	(11.40%)	(-0.58%)

$s_{Q_{n_5}}$ is the share of the wealth of agents belonging to the fifth quintile

This observation is further supported by Tables 2.12 and 2.15.

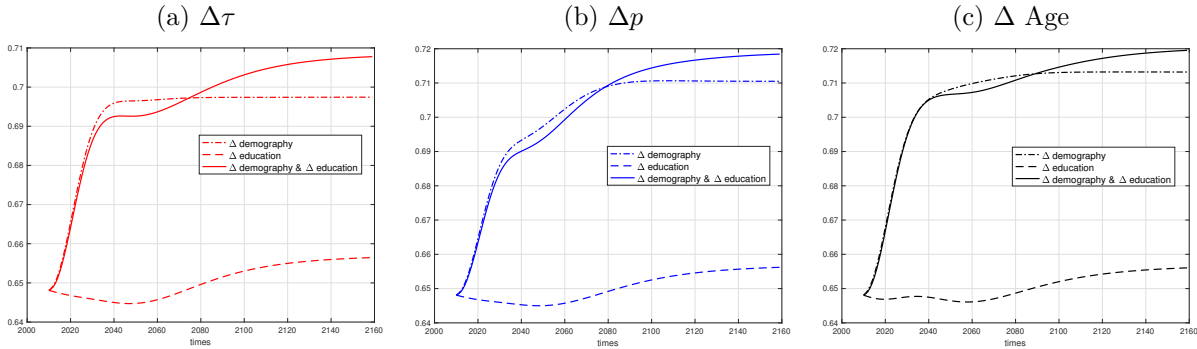
Figure 2.7 – Wealth Inequality: Gini



Furthermore, Figure 2.8 suggests that education initially reduces inequality in the short term, before its full impact on savings takes time to materialize. Interestingly, the adjustment with the potential for the greatest efficiency gains, namely the postponement of the retirement age, also appears to contribute the most to increased wealth inequality, indicating a potential policy trade-off

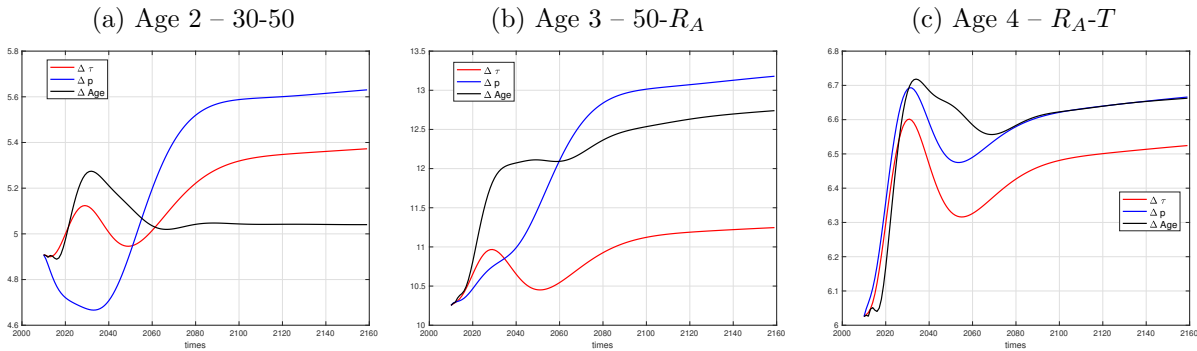
The adjustment through tax increases disproportionately burdens the young, who typically have lower incomes, thereby increasing the likelihood of financial constraints for this group. However, as pension generosity is preserved in this adjustment, the risk of financial constraints is partially mitigated by financial bequests from parents who transfer

Figure 2.8 – Wealth Inequality: Decomposition of the Gini



a portion of their pensions to their children. On the other hand, adjusting through pension reductions heightens the risk of financial constraints among retirees, necessitating a greater savings effort to safeguard against this risk.

Figure 2.9 – Wealth Inequality by Age: A_g/A_1 , for $g = 2, 3, 4$



This explains the significant increases in wealth ratios, A_g/A_1 , for $g = 2, 3, 4$ (see also Figure 2.9). It's worth noting that in the short term (first 20 years), when the adjustment involves pension reductions, the inherited capital was accumulated by cohorts enjoying high pensions. This allowed young individuals to have a high average wealth level (A_1), elucidating the decrease in A_2/A_1 . For individuals aged between 50 and R_A (age group 3), this initial wealth effect is dominated by the need to save for old age. In both adjustments, through tax increases or pension reductions, inequalities increase. In the first case, this is because some young individuals may be more or less insured due to varying levels of wealth among their parents, leading to heterogeneous bequests. In the second case, inequalities arise because retirees may have retired without sufficient savings, reflecting their employment histories.

When adjusting the PAYG system through a postponement of the retirement age, the tax burden remains unchanged, thus posing no increased risk of financial constraints for the young. Notably, the ratio A_2/A_1 is lower compared to cases where the adjustment is made through taxes, as A_1 decreases significantly due to a larger number of financially constrained young individuals. For individuals aged between 50 and R_A (age group 3), the savings effort is less intense compared to scenarios where pensions decrease, as pension generosity is maintained, yet higher than scenarios where taxes increase, due to increased incentives for economic participation. Finally, for retirees, postponing the retirement age results in the highest relative purchasing power, as pensions remain high, and accumulated savings are at their peak.

2.7 Welfare

Prior to the period $t = 0$, the economy is in an initial steady state (indexed by 0), during which information regarding demographic shifts, social mobility, and adjustments to the PAYG system is unavailable. In this steady state, the agents' value functions are denoted as $v^0(a, g, q, z)$, and the distribution of agents is represented by $f^0(a, g, q, z)$. Following the period $t = 0$, information about future adjustments becomes available. With knowledge of demographic and social mobility changes, the PAYG system adapts through tax (scenario A), pension (scenario B), or retirement age (scenario C). Consequently, conditioned upon each policy choice, the agents' value functions evolve as $v_t^Z(a, g, q, z)$ for $t \in [0, \infty)$. Prior to $t = 0$, the value functions are expressed as follows:

$$\mathcal{AV} = \mathbf{U} \quad \text{where} \quad \begin{cases} \dim(\mathbf{V}) &= (I \times J \times A \times Q) \times 1 \\ \dim(\mathbf{U}) &= (I \times J \times A \times Q) \times 1 \\ \dim(\mathbf{A}) &= (I \times J \times A \times Q) \times (I \times J \times A \times Q) \end{cases}$$

Here, \mathbf{V} (\mathbf{U}) represents the stacked vector of value functions $v(a, g, q, z)$ (instantaneous utility functions $u(a, g, q, z)$), with I denoting the size of the capital grid, J denoting individual productivity, A representing the number of age classes, and Q indicating the number of skills. Let \mathbf{V}_0^Z denote the value function at period $t = 0$, after information on future adjustments becomes available. If policy Z is chosen (the first period of the transitional path), we define the variation in consumption Δ^Z as the change that would render the individual indifferent between the pre- and post-reform situations. This can be expressed as follows:

$$\begin{aligned} \mathcal{A}V_0^Z &= \log(1 + \Delta) + U \\ \Rightarrow \Delta^Z &= \exp(\mathcal{A}[V_0^Z - V]) - 1 \end{aligned}$$

If $\Delta^Z < 0 \forall Z \in \{A, B, C\}$, then the changes in the environment reduce the welfare of the agents. In this case, the variation in initial consumption must be negative compensation to ensure that agents remain indifferent between the initial steady state and the new scenario. Therefore, the consumption variation that compensates an agent of type $(g, q) = (\mathbf{g}, \mathbf{q})$ is

$$\Delta_{\mathbf{g}, \mathbf{q}}^Z = \frac{\int_a \int_z c^0(a, \mathbf{g}, \mathbf{q}, z) \Delta(a, \mathbf{g}, \mathbf{q}, z) f^0(a, \mathbf{g}, \mathbf{q}, z) da dz}{\int_a \int_z c^0(a, \mathbf{g}, \mathbf{q}, z) f^0(a, \mathbf{g}, \mathbf{q}, z) da dz}$$

Results. Table 2.19 indicates that (i) demographic changes reduce welfare regardless of whether the agent is young or retired, with or without a diploma. On the other hand, (ii) increasing educational attainment improves agents' welfare, except for unskilled retirees when the PAYG system adjusts through an extension of the duration of activity.²¹

Table 2.19 – **Compensating Variations in Consumption (%) — Short run**

	Young ($g = 1$)		Retiree ($g = 4$)	
	Unskilled ($q = u$)	Skilled ($q = s$)	Unskilled ($q = u$)	Skilled ($q = s$)
	Adjustments via a tax increase ($\Delta\tau$)			
Demography	-1.8961	-1.2652	-39.2823	-33.5653
Education	0.0926	0.1176	2.2450	4.1629
Total	-1.7948	-1.1378	-37.7771	-30.5023
	Adjustments via a pension decrease (Δp)			
Demography	-1.8298	-1.2218	-43.8361	-38.3303
Education	0.1015	0.1237	2.6682	4.5803
Total	-1.7156	-1.0872	-42.0720	-35.0823
	Adjustments via a raising in retirement age (ΔR_A)			
Demography	-2.1999	-1.6907	-22.8937	-26.2194
Education	0.2095	0.0294	-4.2704	12.5737
Total	-2.0033	-1.6649	-26.7649	-16.5708

Each figure gives the consumption loss that the agent is willing to accept in order not to leave the initial stationary state

21. This last result suggests that the productivity increases resulting from higher educational attainment are insufficient to compensate for the reduction in retirement duration for unskilled retirees.

Therefore, households perceive the extension of lifespan as a cost, which isn't fully offset by the productivity gains resulting from increased education.

Understanding the magnitude of compensatory consumption variations requires consideration of agents' impatience, which tends to increase with age (see Table 2.7). While tax increases may seem burdensome for young people due to their lower wages and higher susceptibility to financial constraints, their present-oriented preferences diminish the perceived impact of potential losses. Skilled young individuals, although more impatient than their unskilled counterparts (see Table 2.7), still face lower financial constraints following tax hikes, explaining why these adjustments to the PAYG system are less burdensome for them. However, as the young individuals reach retirement, they observe a reduction in their savings efforts due to increased wage taxes, coupled with longer retirement periods. Given their patience (see Table 2.7), they highly value these declines in retirees' purchasing power. Furthermore, their strong altruism leads them to consider the welfare losses that their children may suffer. In contrast, retirees experience significant reductions in well-being due to tax increases, despite not being directly affected by payroll tax hikes.

The impact of increasing the level of education is more pronounced among skilled workers, whether they are currently employed or retired. This is because higher education leads to increased wages (a direct effect for employees) and reduces the likelihood of their children having a lower level of education than their parents (effect of increasing education on retirees).

Reductions in pensions affect the welfare of young people less than that of retired individuals, regardless of their skill level.

When adjustments to the PAYG system involve postponing the retirement age, retirees experience lower losses because: *(i)* the extension of lifespan does not increase the retirement period, and *(ii)* pension levels remain stable. Conversely, young people experience greater losses compared to other scenarios, even though tax pressure has not increased. This reduction in their well-being can be attributed to a decrease in the inheritances they receive. With a longer duration of activity resulting from postponing the retirement age, young individuals can expect higher lifetime wages, leading retirees to leave them with less precautionary savings.

In Table 2.19, compensating variations in consumption are calculated at the time when agents receive information about changes in the environment. The long-term adjustments discussed in section 2.6.1 are therefore integrated at a large discount. If we consider young people entering the market in 2100 rather than those in 2020, at a time when

Table 2.20 – **Compensating Variations in Consumption (%) — Long run**

	Young ($g = 1$)		Retiree ($g = 4$)	
	Unskilled ($q = u$)	Skilled ($q = s$)	Unskilled ($q = u$)	Skilled ($q = s$)
	Adjustments via a tax increase ($\Delta\tau$)			
Demography	-4.9356	-5.0437	-63.4310	-55.4582
Education	0.5206	0.5446	4.8669	8.6090
Total	-4.2543	-4.3327	-61.5523	-51.4137
	Adjustments via a pension decrease (Δp)			
Demography	0.9732	1.2369	-71.8113	-64.7153
Education	-0.0158	-0.0310	6.8687	10.4143
Total	0.9333	1.1784	-69.5451	-60.5417
	Adjustments via a raising in retirement age (ΔR_A)			
Demography	0.7483	0.9530	-34.8967	-29.3701
Education	0.0297	0.0065	0.5769	3.1097
Total	0.7744	0.9507	-35.0879	-28.2250

Each figure gives the consumption loss that the agent is willing to accept in order not to leave the initial stationary state

economic adjustments will likely have been largely made, it appears that adjustments to the PAYG system by reducing pensions or postponing the retirement age improve their well-being (see Table 2.20).²² However, even on this horizon, these reductions in pensions or the postponement of the retirement age do not improve the well-being of retirees. This is particularly pronounced with a decrease in pensions, as the savings effort fails to compensate for their decline.

2.8 Conclusion

The United States is undergoing significant demographic and educational shifts, prompting an examination of their implications for the sustainability of the Pay-As-You-Go (PAYG) system. We have developed a model featuring heterogeneous agents, where aging is stochastic, and altruistic agents face social mobility risks. Aging and social mobility evolve over time due to increases in lifespan and in educational attainment.

We analyze three alternative scenarios to balance the budget of the PAYG system: (i) an increase in tax rates, (ii) a reduction in pensions, and (iii) a postponement of the retirement age. The first two measures adversely affect work-related remunerations

²². In this case, compensating variations in consumption are given by $\Delta_\infty = \exp(\mathcal{A}^{-1}[\mathbf{V}_\infty^Z - \mathbf{V}]) - 1$, where \mathbf{V}_∞^Z is the value function at the end of the transitional path.

(direct with tax rise and indirect with pension cuts) and increase the likelihood of financial constraints, particularly for young individuals with tax increases and retirees with pension cuts. These distortions are mitigated when adjusting the PAYG system through changes in the retirement age.

Simulations show that a 5-year increase in lifespan requires either a 7 pp increase in tax rates or an 18 pp reduction in the pension replacement ratio without changing the retirement age. The wealth increase induced by increases in educational attainments led as well to GDP gains after 2080 projections. Without the increase in the educational attainment, US GDP would stagnate at 2020 levels, reducing consumption, especially if the PAYG system is sustained through tax increases. Adjusting the system through pension cuts requires greater savings and leads to lower labor supply distortions, resulting in higher GDP gains. Adjusting the PAYG system via changes in the retirement age yields the highest GDP increase among the considered measures.

We observe an increase in wealth inequalities with tax hikes and pension reductions, with the highest rise seen when adjusting the PAYG system based on a higher retirement age.

Regarding welfare, the positive impact of increased education is outweighed by the negative impact of lifespan extension across all age groups and scenarios considered. Tax increases reduce the welfare of young people, and their difficulty in saving exacerbates this effect during retirement. Pension cuts sharply decrease retirees' welfare, impacting young people through reduced inheritances. Postponing the retirement age leads to the smallest reduction in retirees' welfare but also reduces young people's insurance needs. As a result, young people receive smaller inheritances, leading to welfare losses.

Once the adjustment period for structural changes has passed, only scenarios involving pension reduction or retirement age postponement lead to increased welfare for working individuals, while retirees' welfare decreases in all cases.

This project has two main limitations: the lack of integration of individual choice regarding retirement age and the omission of other financing needs of social security linked to aging and education, such as changes in health expenditures. These aspects will be addressed in future studies.

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2.A Human capital by age

To determine the skill premium, we use CPS data that provide earnings by age and educational attainment:²³

- Nine educational attainment are considered (from less than the 9th grade to the doctorate degree;
- Age partitions are 18-24 years, 25-34 years, ..., 55-64 years.

For educational attainment up to the bachelor's degree, earnings are given from the age of 18 years. From master's degree and beyond, earnings are given from the age of 25. Taking into account the data for the period 1990-2000, we compute the average earnings for holders of an education level below the bachelor's degree, for holders of a bachelor's degree and for holders of a master's degree and beyond²⁴ (see Table 2.21). We also compute the average earnings for holders of a bachelor degree and beyond (last line of Table 2.21).

Table 2.21 – **Annual earnings (in dollar 2019) by age partition and educational attainment**

Age partition	18 – 24	25 – 34	35 – 44	45 – 54	55-64
less than bachelor's degree	16487	34762	42316	45643	41292
Bachelor's degree	28699	55189	72049	77453	73638
Master's degree and beyond		69410	105560	108870	102940
Bachelor's degree and beyond		58394	83250	90470	86355

Source: CPS data over the period 1990-2000

We use the data of Table 2.21 to compute the skill premium for our three age groups. As earnings of holders of a master's degree (and beyond) are not given for the age group 18-24, we use the average earnings of bachelor's holder to assess the earnings of 18-24 years

²³. Note that the CPS provides the mean earnings by gender with the respective number of male and female in the sample. We then deduce the average earnings over male and female.

²⁴. From the CPS, we know the number of individuals concerned for each age class and each education level. This allows to deduce the average earnings for the three levels of educational attainment presented in Table 2.21.

old skilled workers. For the following age groups, earnings of educated people are given by those of holder of bachelor's degree and beyond. By mean of a linear interpolation, we estimate the average earnings of educated and non educated people for our three age groups. For each age group, we take the central age of the interval to which the mean earning of the group is assigned. The central ages are stored in vector $T_a = [21.5, 30, 40, 60]$. We store in vectors N_U and N_S the earnings of skilled and unskilled workers, that is:

$$\begin{aligned} N_U &= [16487, 34762, 42316, 45643, 41292] \\ N_S &= [28699, 58394, 83250, 90470, 86355] \end{aligned}$$

Nota that vector N_S is constructed using the first element of the third line of Table 2.21 and the last line of Table 2.21. We assess the earnings of 18-24 years old skilled workers by mean of the earnings of holders of a bachelor's degree. The last line of Table 2.21 is obtained using the data of the third and fourth line (columns 2 to 5).

We want to determine the interpolated earnings at ages of $a \in [25, 35, 57]$, that is the center of interval 20 – 30, 30 – 50 and 50 – 65. The weights used for the interpolation at age a are given by:

$$\begin{aligned} \underline{W}(a) &= \frac{T_a(i_a) - a}{T_a(i_a) - T_a(i_a - 1)} \\ \overline{W}(a) &= \frac{a - T_a(i_a - 1)}{T_a(i_a) - T_a(i_a - 1)} \end{aligned}$$

with $a \in [T_a(i_a - 1), T_a(i_a)]$. We deduce the interpolated levels of earnings of unskilled and skilled workers, that is:

$$\begin{aligned} H_U(a) &= \underline{W}(a)N_U(i_a - 1) + \overline{W}(a)N_U(i_a) \\ H_S(a) &= \underline{W}(a)N_S(i_a - 1) + \overline{W}(a)N_S(i_a) \end{aligned}$$

Applying the above formulas provides the results of table 2.22.

Table 2.22 – **Annual earnings (in dollar 2019) for the three age groups**

Age partition	20 – 30	30 – 50	50 – 65
Unskilled	24012	42316	42597
Skilled	40926	83250	87590
Ratio of Skilled to Unskilled ($\kappa_g = \omega_{g,s}/\omega_{g,u}$)	1.70	1.97	2.06

2.B Data hours worked by age

Table 2.23 – Hours worked by age – E. McGrattan and Rogerson (2004)

	15-24	25-34	35-44	45-54	55-64	65-74	75-99
1980	34.57	40.65	41.01	40.80	39.58	31.15	29.35
1990	33.32	41.45	41.78	41.70	39.37	31.10	28.12
2000	32.83	42.18	42.52	42.56	40.30	30.56	27.29
Average	33.57	41.42	41.77	41.68	39.75	30.93	28.25

From the average over the years 1980-2000 (last line of the Table 2.23), a polynomial is estimated to have an estimate of the number of hours worked for each year between 14 years and 75 years. This then makes it possible to reconstruct the number of hours worked for each of the age groups in the model (20-30, 30-50 and 50-65 years).

2.C Data on social mobility

2.C.1 Social mobility based on NLSY79

Table 2.24 – Transition probabilities NLSY79

		low education				high education			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
low education	Q1	0.3129	0.2638	0.1810	0.1411	0.0552	0.0153	0.0245	0.0061
	Q2	0.2225	0.2486	0.2254	0.1965	0.0231	0.0405	0.0231	0.0202
	Q3	0.1772	0.1958	0.2063	0.2566	0.0503	0.0317	0.0450	0.0370
	Q4	0.1376	0.1376	0.2249	0.2725	0.0503	0.0714	0.0556	0.0503
high education	Q1	0.1429	0.1299	0.1818	0.1948	0.0909	0.0519	0.1039	0.1039
	Q2	0.0676	0.0541	0.1486	0.2973	0.0676	0.1892	0.0541	0.1216
	Q3	0.0704	0.1127	0.0845	0.1972	0.0986	0.1690	0.0986	0.1690
	Q4	0.0395	0.0526	0.1447	0.2237	0.0921	0.1053	0.2105	0.1316

Table 2.25 – Earnings NLSY79

	low education				high education			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mean	8104.53	21887.74	33190.58	56392.46	17665.24	36898.34	49967.89	78975.85
Std	5057.92	3123.77	3842.36	17396.41	8675.33	3622.60	4014.64	23284.97
Minimum	3046.62	18763.98	29348.23	38996.05	8989.90	33275.74	45953.25	55690.88
Maximum	13162.45	25011.51	37032.94	73788.86	26340.57	40520.94	53982.52	102260.81

2.C.2 Social mobility based on NLSY98

Table 2.26 – Transition probabilities NLSY98

		low education				high education			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
low education	Q1	0.2559	0.2169	0.1780	0.1356	0.0508	0.0525	0.0593	0.0508
	Q2	0.2105	0.2295	0.1895	0.1811	0.0484	0.0611	0.0526	0.0274
	Q3	0.1520	0.2107	0.1693	0.1986	0.0725	0.0743	0.0725	0.0501
	Q4	0.1155	0.1564	0.1471	0.1937	0.1043	0.0894	0.1006	0.0931
high education	Q1	0.0931	0.0891	0.1093	0.1053	0.1862	0.1336	0.1498	0.1336
	Q2	0.1097	0.1013	0.0886	0.1055	0.1857	0.1308	0.1308	0.1477
	Q3	0.0276	0.0922	0.0553	0.0783	0.2120	0.1705	0.1797	0.1843
	Q4	0.0293	0.0460	0.0669	0.0669	0.1506	0.1799	0.1632	0.2971

Table 2.27 – Mean earnings NLSY98

		low education				high education			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Mean		7343.62	20284.75	30833.40	52938.72	14140.38	30869.23	43487.28	76082.14
Std		4353.28	3392.43	3000.48	18509.63	6960.96	3680.61	4075.35	25886.72
Minimum		1696.90	23677.18	33833.88	71448.35	21101.33	34549.84	47562.62	101968.86
Maximum		11696.90	23677.18	33833.88	71448.35	21101.33	34549.84	47562.62	101968.86

2.D Social mobility: from data to model

The main difficulty is to extend an initial 4 points grid for each skill to a $J = 10$ points grid for each skill and to compute the consistent transition matrix adapted to this new large grid.

2.D.1 The transformation of the grid

The discrete space of the data. In the NLSY79, we have two skill levels $q \in \{u, s\}$ and four (average) earnings level by skill. Earnings are ranked by ascending order and indexed from 1 to 4. For a skill level q , earnings belong to the set $\mathcal{G}_q = \{o_{q,1}, \dots, o_{q,4}\}$. The complete grid is $\mathcal{G} = \{\mathcal{G}_u, \mathcal{G}_s, \} = \{o_{u,1}, o_{u,2}, o_{u,3}, o_{u,4}, o_{s,1}, o_{s,2}, o_{s,3}, o_{s,4}\}$. The transition between two generations is described by a matrix Λ (tables 2.24 and 2.26) (probability of moving from a point of \mathcal{G} to another).

The grid \mathcal{G} is built using data of table 2.25, earnings being divided by their mean value. Let λ be the unconditional distribution deduced from matrix Λ ($\lambda = \Lambda' \lambda$). Let denote by $O_{q,i}$, $\Sigma_{q,i}$, $\underline{O}_{q,i}$ and $\overline{O}_{q,i}$ the quantities of table 2.25. We deduce:

$$\overline{O} = \sum_q \sum_i \lambda_{q,i} O_{q,i}, \quad o_{q,i} = \frac{O_{q,i}}{\overline{O}}, \quad \sigma_{q,i} = \frac{\Sigma_{q,i}}{\overline{O}}, \quad \underline{o}_{q,i} = \frac{\underline{O}_{q,i}}{\overline{O}}, \quad \overline{o}_{q,i} = \frac{\overline{O}_{q,i}}{\overline{O}}$$

From the short discrete space of the data to the long discrete space of the model. Each skill specific grid \mathcal{G}_q (4 points) is replaced by a new $J = 10$ equidistant points grid denoted by $\mathcal{X}_q = \{\chi_{q,1}, \dots, \chi_{q,J}\}$. The productivity (assimilated to earnings) of a worker, during her life, takes its values on the grid \mathcal{X}_q , the skill level being fixed once and for all at the beginning of the worker's life²⁵.

Consider now the whole grid $\mathcal{X} = \{\mathcal{X}_u, \mathcal{X}_s\}$. This grid includes $2J$ points. In order to build the grid $\mathcal{X} = \{\mathcal{X}_u, \mathcal{X}_s\}$, we impose that the extremities of the grid \mathcal{X}_q satisfy $\chi_{q,1} = \underline{o}_{q,1}$ and, $\chi_{q,J} = \overline{o}_{q,4}$. Each grid \mathcal{X}_q is composed of J equidistant points, the distance between two points being given by $\epsilon_q = \frac{\chi_{q,J} - \chi_{q,1}}{J-1}$. The following numerical values are obtained:

$$\begin{aligned} \mathcal{X}_u &= \{0.0882, 0.3158, 0.5433, 0.7709, 0.9984, 1.2260, 1.4536, 1.6811, 1.9087, 2.1362\} \\ \mathcal{X}_s &= \{0.2603, 0.5603, 0.8603, 1.1604, 1.4604, 1.7604, 2.0604, 2.3605, 2.6605, 2.9605\} \end{aligned}$$

25. Recall that this grid is associated to the discretization of equation (2.1)

2.D.2 Estimation of the new transition matrix

Having fixed the new grid \mathcal{X} , we have now to determine the new transition matrix Υ . The $2J \times 2J$ matrix Υ is estimated by mean of numerical simulations.

- Using the Markov matrix Λ , simulate a series $\{o_t\}_{t=0}^T$,
- Perform an OLS estimate of the process:

$$o_t = \rho o_{t-1} + (1 - \rho)\bar{o} + \sigma_v v_t, \quad v_t \sim \mathcal{N}(0, 1)$$

with λ the autoregressive coefficient, \bar{o} the mean value and σ_v the standard error of the innovation. The centered process writes:

$$\hat{o}_t = \rho \hat{o}_{t-1} + \sigma_v v_t \tag{2.9}$$

- Using equation (2.9), simulate a series $\{\hat{o}_t\}_{t=0}^T$.
- Do the following logistic transformation:

$$\tilde{o}_t = \frac{1}{1 + \exp(-\hat{o}_t)}$$

which ensures $\tilde{o}_t \in [0, 1]$.

- For each date t , consider o_t which satisfies $o_t = o_{q,i}$ and compute:

$$y_t = o_{q,i} + [\bar{o}_{q,i} - o_{q,i}] \times \tilde{o}_t$$

Each y_t is finally replaced by its closest value which provides a series $\{\chi_t\}_{t=0}^T$ with $\chi_t \in \mathcal{X}$.

Between t and $t + 1$, there is a change of generation. The sequences $\{\chi_t\}_{t=1}^{T-1}$ and $\{\chi_{t+1}\}_{t=1}^{T-1}$ represent the parents and children earnings respectively. We have $T - 1$ transitions between successive generations. For each $t = 1, \dots, T - 1$, we observe the transition from a generation to the following, that is the transition from $\chi_t \in \mathcal{X}$ to $\chi_{t+1} \in \mathcal{X}$. Concerning the transition between one point of the grid \mathcal{X} to another, there is $N \times N$ possibilities and the possible transitions are given by the $\mathcal{X} \times \mathcal{X}$ (the Cartesian product of \mathcal{X} by \mathcal{X}). For each pair (χ_t, χ_{t+1}) , with $t = 1, \dots, T - 1$ we locate the element of $\mathcal{X} \times \mathcal{X}$ to which it corresponds and we count each type of transition. Having counted each type of transition, we can deduce the transition matrix Υ . Let $N_{(q,j),(q',j')}$ be the number of transitions from $\chi_{q,j}$ to $\chi_{q',j'}$ which have been counted. The transition probability is given

by:

$$\lambda_{(q,j),(q',j')} = \frac{N_{(q,j),(q',j')}}{\sum_{\mathbf{q} \in \{u,s\}} \sum_{j=1}^J N_{(q,j),(\mathbf{q},j)}}.$$

2.E Numerical method of the approximated solution

2.E.1 Approximation of the HLB equations for numerical solutions.

The solution of the HJB is efficient only with an *implicit* method. The derivative in the a dimension is again approximated using an upwind method, ie. using either a forward or a backward difference approximation depending on the sign of the drift:

$$\partial_{a,B}v_{i,j,g} = \frac{v_{i,j,g} - v_{i-1,j,g}}{\Delta a} \quad ; \quad \partial_{a,F}v_{i,j,g} = \frac{v_{i+1,j,g} - v_{i,j,g}}{\Delta a}$$

An upwind method is not necessary for the derivatives in the z . This is because the z -process features a diffusion term which is strictly positive everywhere and well-defined boundary conditions. Therefore the derivative in the z -dimension can be approximated using a simple forward difference approximation (a backward difference approximation would have worked equally well):

$$\partial_z v_{i,j,g} = \frac{v_{i,j+1,g} - v_{i,j,g}}{\Delta z} \quad ; \quad \partial_{zz} v_{i,j,g} = \frac{v_{i,j+1,g} - 2v_{i,j,g} + v_{i,j-1,g}}{(\Delta z)^2}$$

$v_{i,j,g}^{n+1}$ is implicitly defined by the equation

$$\begin{aligned} \frac{v_{i,j,g}^{n+1} - v_{i,j,g}^n}{\Delta} + \rho v_{i,j,g}^{n+1} &= u(c_{i,j,g}^n) + \partial_a v_{i,j,g}^{n+1} (wz_{j,g} + ra_{i,g} - c_{i,j,g}^{n+1}) \\ &+ \mu_{j,g} \partial_z v_{i,j,g}^{n+1} + \frac{\sigma_{j,g}^2}{2} \partial_{zz} v_{i,j,g}^{n+1} + \pi_g (v_{i,j,g+1}^{n+1} - v_{i,j,g}^{n+1}) \end{aligned}$$

Note the $n + 1$ superscripts on the right-hand side of the equation. The main advantage of the implicit scheme is that the step size Δ can be arbitrarily large.

We use an "upwind scheme". The idea is still to use the forward difference approximation whenever the drift of the state variable is positive and the backward difference approximation whenever it is negative. We use the following finite difference approxima-

tion:

$$\begin{aligned}
 \frac{v_{i,j,g}^{n+1} - v_{i,j,g}^n}{\Delta} + \rho v_{i,j,g}^{n+1} &= u(c_{i,j,g}^n) + \partial_{a,B} v_{i,j,g}^{n+1} \underbrace{[wz_{j,g} + ra_{i,g} - c_{i,j,g}^{n+1}]^-}_{=s_{i,j,g,B}} \\
 &\quad + \partial_{a,F} v_{i,j,g}^{n+1} \underbrace{[wz_{j,g} + ra_{i,g} - c_{i,j,g}^{n+1}]^+}_{=s_{i,j,g,F}} \\
 &\quad + \mu_{j,g} \partial_z v_{i,j,g}^{n+1} + \frac{\sigma_{j,g}^2}{2} \partial_{zz} v_{i,j,g}^{n+1} + \pi_g (v_{i,j,g+1}^{n+1} - v_{i,j,g}^{n+1}) \\
 \frac{v_{i,j,g}^{n+1} - v_{i,j,g}^n}{\Delta} + \rho v_{i,j,g}^{n+1} &= u(c_{i,j,g}^n) + \frac{v_{i,j,g} - v_{i-1,j,g}}{\Delta a} s_{i,j,g,B} + \frac{v_{i+1,j,g} - v_{i,j,g}}{\Delta a} s_{i,j,g,F} \\
 &\quad + \mu_{j,g} \frac{v_{i,j+1,g} - v_{i,j,g}}{\Delta z} + \frac{\sigma_{j,g}^2}{2} \frac{v_{i,j+1,g} - 2v_{i,j,g} + v_{i,j-1,g}}{(\Delta z)^2} \\
 &\quad + \pi_g (v_{i,j,g+1}^{n+1} - v_{i,j,g}^{n+1})
 \end{aligned}$$

where $c_{i,j,g}^n = (u')^{-1}[(v_{i,j,g}^n)']$ and $(v_{i,j,g}^n)'$ is obtained using the saving decision. Indeed, savings is given by

$$s_{i,j,g,F} = z_j w + ra_i - (u')^{-1}(v'_{i,j,g,F}) \quad s_{i,j,g,B} = z_j w + ra_i - (u')^{-1}(v'_{i,j,g,B})$$

where we suppress n superscripts for notational simplicity. Then use the following approximation for $v'_{i,j,g}$:

$$v'_{i,j,g} = v'_{i,j,g,F} \mathbb{I}_{s_{i,j,g,F} > 0} + v'_{i,j,g,B} \mathbb{I}_{s_{i,j,g,B} < 0} + \bar{v}'_{i,j,g} \mathbb{I}_{s_{i,j,g,F} \leq 0 \leq s_{i,j,g,B}}$$

where \mathbb{I} denotes the indicator function.²⁶ Collecting terms, we have for the exogenous states:

$$\vartheta_{j,g} = \frac{\mu_{j,g}}{\Delta z} + \frac{\sigma_{j,g}^2}{2(\Delta z)^2} \quad ; \quad \theta_{j,g} = -\frac{\mu_{j,g}}{\Delta z} - \frac{\sigma_{j,g}^2}{(\Delta z)^2} - \pi_g \quad ; \quad \zeta_{j,g} = \frac{\sigma_{j,g}^2}{2(\Delta z)^2}$$

26. The meaning of the last term is as follows. First note that since v is concave in b , we have $v'_{i,j,g,F} < v'_{i,j,g,B}$ and so $s_{i,j,g,F} < s_{i,j,g,B}$. Therefore, for some grid points i , $s_{i,j,g,F} \leq 0 \leq s_{i,j,g,B}$. At these grid points, we set savings equal to zero and hence set the derivative of the value function equal to $\bar{v}'_{i,j,g} = u'(z_{j,g} + ra_i)$.

leading to

$$\begin{aligned} \frac{v_{i,j,g}^{n+1} - v_{i,j,g}^n}{\Delta} + \rho v_{i,j,g}^{n+1} &= u(c_{i,j,g}^n) + \frac{v_{i,j,g} - v_{i-1,j,g}}{\Delta a} s_{i,j,g,B} + \frac{v_{i+1,j,g} - v_{i,j,g}}{\Delta a} s_{i,j,g,F} \\ &\quad + \vartheta_{j,g} v_{i,j+1,g} + \theta_{j,g} v_{i,j,g} + \zeta_{j,g} v_{i,j-1,g} + \pi_g v_{i,j,g+1}^{n+1} \end{aligned}$$

At the boundaries in the j dimension, the equations become

$$\begin{aligned} \frac{v_{i,1,g}^{n+1} - v_{i,1,g}^n}{\Delta} + \rho v_{i,1,g}^{n+1} &= u(c_{i,1,g}^n) + \frac{v_{i,1,g} - v_{i-1,1,g}}{\Delta a} s_{i,1,g,B} + \frac{v_{i+1,1,g} - v_{i,1,g}}{\Delta a} s_{i,1,g,F} \\ &\quad + \vartheta_{1,g} v_{i,2,g} + (\theta_{1,g} + \zeta_{1,g}) v_{i,1,g} + \pi_g v_{i,1,g+1}^{n+1} \\ \frac{v_{i,J,g}^{n+1} - v_{i,J,g}^n}{\Delta} + \rho v_{i,J,g}^{n+1} &= u(c_{i,J,g}^n) + \frac{v_{i,J,g} - v_{i-1,J,g}}{\Delta a} s_{i,J,g,B} + \frac{v_{i+1,J,g} - v_{i,J,g}}{\Delta a} s_{i,J,g,F} \\ &\quad + (\vartheta_{J,g} + \theta_{J,g}) v_{i,J,g} + \zeta_{J,g} v_{i,J-1,g} + \pi_g v_{i,J,g+1}^{n+1} \end{aligned}$$

When the agent is retired, the HJB equation is different. Its approximation is simply given by

$$\begin{aligned} \frac{v_{i,j,g}^{n+1} - v_{i,j,g}^n}{\Delta} + \rho v_{i,j,g}^{n+1} &= u(c_{i,j,g}^n) + \frac{v_{i,j,g} - v_{i-1,j,g}}{\Delta a} s_{i,j,g,B} + \frac{v_{i+1,j,g} - v_{i,j,g}}{\Delta a} s_{i,j,g,F} \\ &\quad + \eta \pi_g \left(\sum_{\iota} \omega_j(\iota) v_{i,\iota,g+1}^{n+1} - v_{i,j,g}^{n+1} \right) \end{aligned}$$

Thus, for $g = 4$, we have

$$\vartheta_{j,4} = 0 \quad ; \quad \theta_{j,4} = -\pi_g \quad ; \quad \zeta_{j,4} = 0$$

2.E.2 Matrices of the linear system.

Lets us denote \mathbf{V} the $(I \times J \times G)$ vector of the value functions:

$$\mathbf{V} = [\mathbf{V}^1, \dots, \mathbf{V}^G]$$

where each $(I \times J)$ vector \mathbf{V}^g is given by

$$\mathbf{V}^g = [v_{1,1,g}, \dots, v_{I,1,g}, v_{1,2,g}, \dots, v_{I,2,g}, \dots, v_{1,J,g}, \dots, v_{I,J,g}]$$

The solution of the linear system formed by the HJB equation is given by

$$\frac{1}{\Delta} (\mathbf{V}^{n+1} - \mathbf{V}^n) + \rho \mathbf{V}^{n+1} = \mathbf{U}^n + \mathbf{A}^n \mathbf{V}^{n+1}$$

where the matrix $\mathbf{A}^n = \mathbf{B}^n + \mathbf{C}$. The transition matrix \mathbf{C} that governs the dynamics of the exogenous variables is given by:

$$\mathbf{C} = \begin{bmatrix} \mathbf{C}^1 & \mathbf{\Pi}^1 & 0 & 0 \\ 0 & \mathbf{C}^2 & \mathbf{\Pi}^2 & 0 \\ 0 & 0 & \mathbf{C}^3 & \mathbf{\Pi}^3 \\ \mathbf{\Pi}^4 & 0 & 0 & \mathbf{C}^4 \end{bmatrix}$$

where each $(I \times J) \times (I \times J)$ matrix \mathbf{C}^g is given by

$$\mathbf{C}^g = \begin{bmatrix} \mathbf{C}_{1,1}^g & \mathbf{C}_{1,2}^g & 0 & \cdots & \cdots & \cdots & \cdots \\ \mathbf{C}_{2,1}^g & \mathbf{C}_{2,2}^g & \mathbf{C}_{2,3}^g & 0 & \cdots & \ddots & \ddots \\ 0 & \mathbf{C}_{3,2}^g & \mathbf{C}_{3,3}^g & \mathbf{C}_{3,4}^g & 0 & \ddots & \ddots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots \\ 0 & \cdots & \cdots & \cdots & \cdots & \mathbf{C}_{I,J-1}^g & \mathbf{C}_{I,J}^g \end{bmatrix}$$

with the $(I \times J)$ matrices $\mathbf{C}_{i,j}^g$ defined s.t.

$$\mathbf{C}_{i,i-1}^g = \begin{bmatrix} \zeta_{i,g} & 0 & \cdots & \cdots \\ 0 & \zeta_{i,g} & 0 & \ddots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \zeta_{i,g} \end{bmatrix} \quad \mathbf{C}_{i,i}^g = \begin{bmatrix} \theta_{i,g} & 0 & \cdots & \cdots \\ 0 & \theta_{i,g} & 0 & \ddots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \theta_{i,g} \end{bmatrix} \quad \mathbf{C}_{i,i+1}^g = \begin{bmatrix} \vartheta_{i,g} & 0 & \cdots & \cdots \\ 0 & \vartheta_{i,g} & 0 & \cdots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \vartheta_{i,g} \end{bmatrix}$$

except for the boundary conditions, where they are defined by

$$\mathbf{C}_{1,1}^g = \begin{bmatrix} \theta_{1,g} + \zeta_{1,g} & 0 & \cdots & \cdots \\ 0 & \theta_{1,g} + \zeta_{1,g} & 0 & \ddots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \theta_{1,g} + \zeta_{1,g} \end{bmatrix} \quad \mathbf{C}_{1,2}^g = \begin{bmatrix} \vartheta_{1,g} & 0 & \cdots & \cdots \\ 0 & \vartheta_{1,g} & 0 & \cdots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \vartheta_{1,g} \end{bmatrix}$$

$$\mathbf{C}_{I,J}^g = \begin{bmatrix} \theta_{1,g} + \vartheta_{1,g} & 0 & \cdots & \cdots \\ 0 & \theta_{1,g} + \vartheta_{1,g} & 0 & \ddots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \theta_{1,g} + \vartheta_{1,g} \end{bmatrix} \quad \mathbf{C}_{I,J-1}^g = \begin{bmatrix} \zeta_{1,g} & 0 & \cdots & \cdots \\ 0 & \zeta_{1,g} & 0 & \cdots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \zeta_{1,g} \end{bmatrix}$$

For $g \in \{1, 2, 3\}$, the $(I \times J) \times (I \times J)$ matrices $\mathbf{\Pi}^g$ are given by

$$\mathbf{\Pi}^g = \begin{bmatrix} \pi_g & 0 & \cdots & \cdots \\ 0 & \pi_g & 0 & \cdots \\ \vdots & \ddots & \ddots & \ddots \\ 0 & \cdots & 0 & \pi_g \end{bmatrix}$$

whereas for $g = 4$, the $(I \times J) \times (I \times J)$ matrix $\mathbf{\Pi}^4$ is

$$\mathbf{\Pi}^4 = \begin{bmatrix} \mathbf{\Pi}_1(1)^4 & \mathbf{\Pi}_1(2)^4 & \cdots & \cdots & \mathbf{\Pi}_1(J)^4 \\ \mathbf{\Pi}_2(1)^4 & \mathbf{\Pi}_2(2)^4 & \cdots & \cdots & \mathbf{\Pi}_2(J)^4 \\ \vdots & \vdots & \ddots & \ddots & \vdots \\ \mathbf{\Pi}_J(1)^4 & \mathbf{\Pi}_J(2)^4 & \cdots & \cdots & \mathbf{\Pi}_J(J)^4 \end{bmatrix} \quad \text{with } \mathbf{\Pi}_j(\iota)^4 = \pi_4 \omega_j(\iota) Id_I$$

The matrix B^n that governs the dynamics of the endogenous variables is given by

$$\mathbf{B}^n = \begin{bmatrix} (\mathbf{B}^1)^n & 0 & 0 & 0 \\ 0 & (\mathbf{B}^2)^n & 0 & 0 \\ 0 & 0 & (\mathbf{B}^3)^n & 0 \\ 0 & 0 & 0 & (\mathbf{B}^4)^n \end{bmatrix}$$

where each $(I \times J) \times (I \times J)$ matrix \mathbf{B}^g is given by

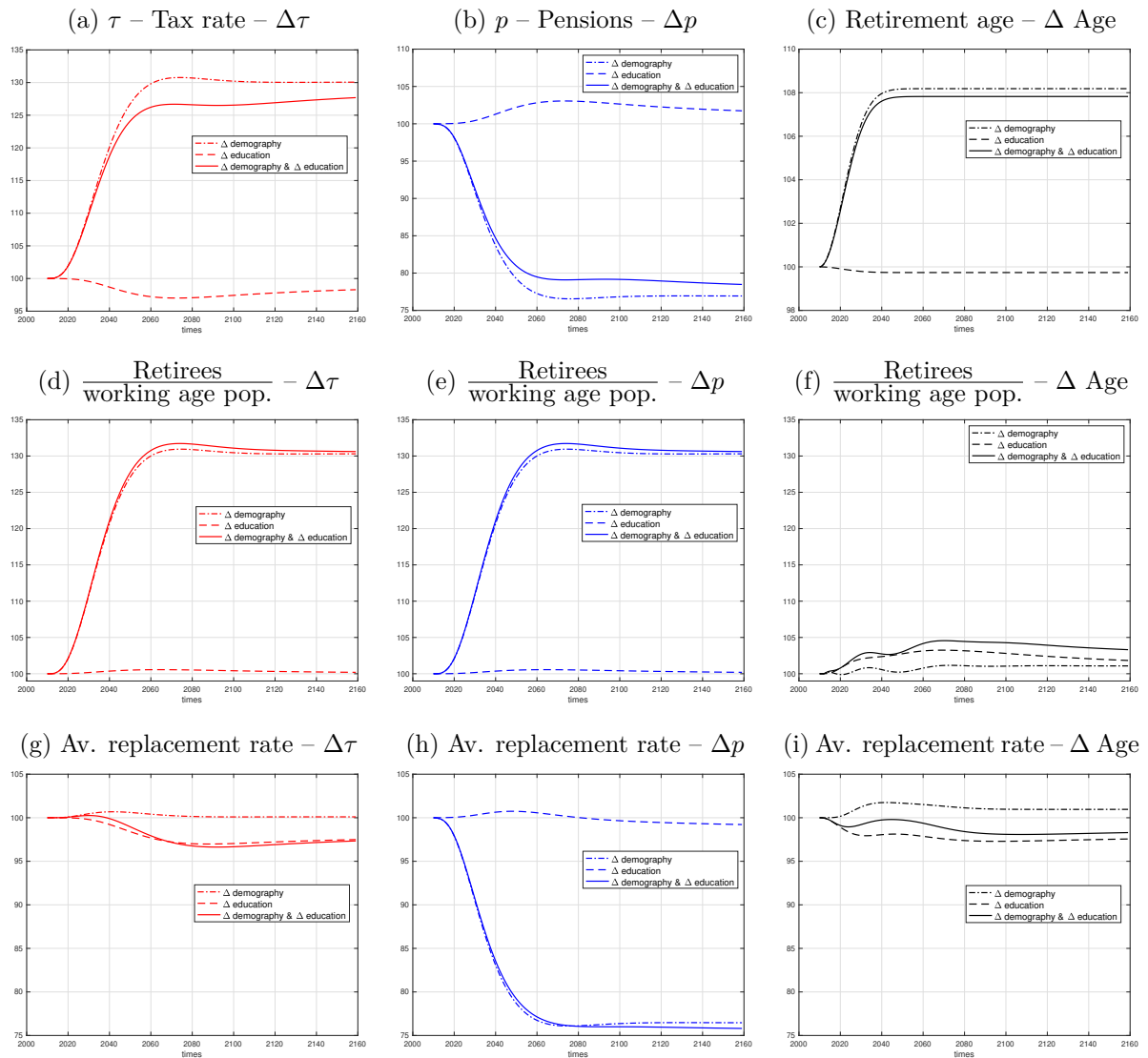
$$\mathbf{B}^g = \begin{bmatrix} y_{1,1}^g & z_{1,1}^g & 0 & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & 0 \\ x_{1,2}^g & y_{1,2}^g & z_{1,2}^g & 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & x_{1,I}^g & y_{1,I}^g & 0 & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & 0 & 0 & y_{2,1}^g & z_{2,1}^g & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 & x_{2,2}^g & y_{2,2}^g & z_{2,2}^g & 0 & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & 0 & x_{2,I}^g & y_{2,I}^g & 0 & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & y_{1,J}^g & z_{1,J}^g & 0 & \vdots \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & x_{1,J}^g & y_{1,J}^g & z_{1,J}^g & 0 \\ \vdots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & \ddots & 0 & \ddots & \ddots & \ddots \\ \vdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \vdots & \ddots & x_{I,J}^g & y_{I,J}^g \end{bmatrix}$$

where

$$\begin{aligned} x_{i,j}^g &= -\frac{s_{i,j,g,B}}{\Delta a} \\ y_{i,j}^g &= -\frac{s_{i,j,g,F}}{\Delta a} + \frac{s_{i,j,g,B}}{\Delta a} \\ z_{i,j}^g &= \frac{s_{i,j,g,F}}{\Delta a} \end{aligned}$$

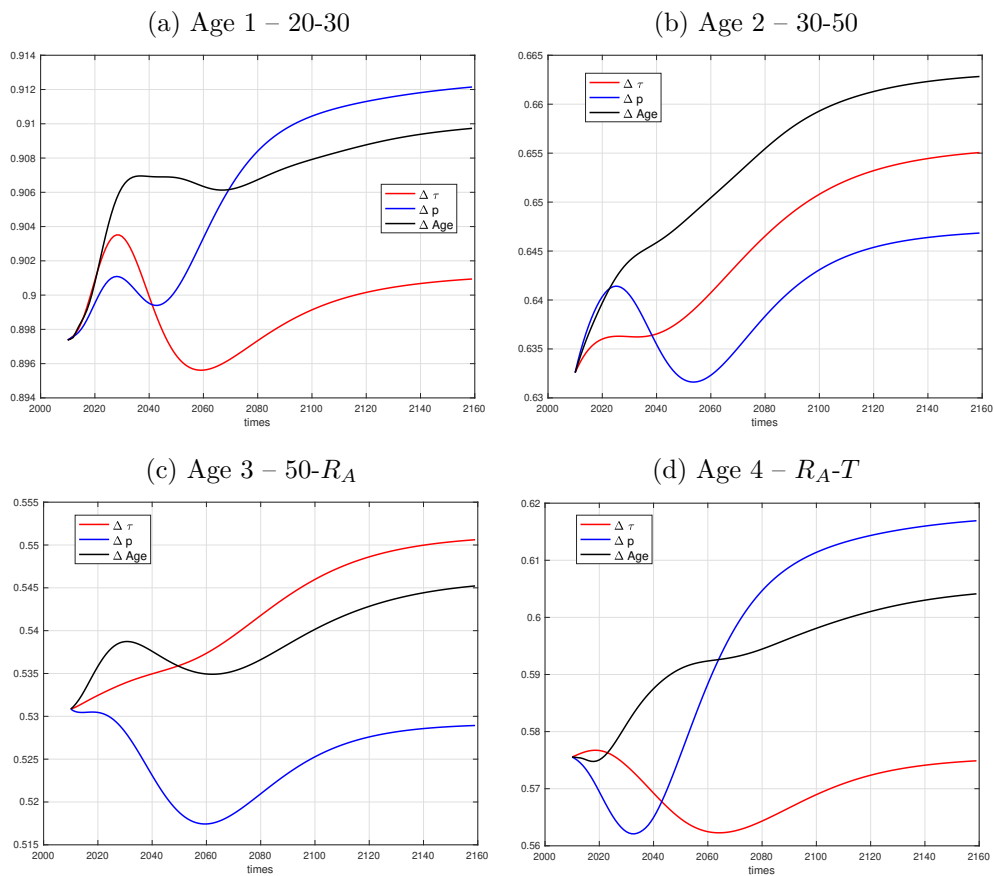
2.F Decomposition of the PAYG system adjustments

Figure 2.10 – Transitions of Aggregates: a Decomposition



2.G Inequalities within Age

Figure 2.11 – Wealth Inequality by Age: Gini



THE IMPACT OF FIRING COSTS ON WAGES ACROSS VARIOUS EDUCATIONAL CATEGORIES

3.1 Introduction

A large body of research has examined the effects of employment protection on unemployment flows, but there is still much to be explored regarding its impact on wages. This chapter analyzes the relationship between increased firing costs and wage trends across different educational categories in the United States from 1977 to 1997. In particular, according to a simple labor market framework of supply and demand, increased employment costs would shift the labor demand curve downward, resulting in reduced employment and wages (Autor, Donohue, & Schwab, 2006). However, can we observe this result in the data and in a flow model of the labor market? Empirically, two major phenomena were observed in the United States during the period 1977-1997; firstly, the increase in firing costs across states as exceptions to the employment-at-will doctrine were adopted (see e.g. Autor (2003) and Autor et al. (2006)). Secondly, there was well-documented wage inequality across different educational categories during the same period (see e.g. Katz and Autor (1999), Acemoglu and Autor (2011)). Therefore, this chapter aims to understand whether these two empirical facts are related.

To address the aforementioned question, I employ recent econometric methodologies, specifically using a difference-in-difference approach with staggered treatment based on the findings of Roth, Sant'Anna, Bilinski, and Poe (2023), Callaway and Sant'Anna (2021), and Sun and Abraham (2021). Additionally, I use a search and matching model of the labor market, segmented by different educational levels and characterized by endogenous job finding probabilities and endogenous job destruction, in line with the works of Mortensen and Pissarides (1994), Pissarides (2000), and Kugler and Saint-Paul (2004).

The econometric analysis relies on state-level panel data, which includes aggregated information on wages across different educational categories, employment characteristics, and exceptions to the employment-at-will doctrine. This data is obtained from the Current Population Survey, surveys by the Bureau of Economic Analysis, the Employment Survey of the Bureau of Labor Statistics, and Autor (2003). Furthermore, the theoretical framework is calibrated using data from Cairo and Cajner (2018).

This paper establishes both theoretically and empirically a negative impact of increasing firing costs on wages, particularly for individuals who are high school dropouts or have education levels greater than college attainment, indicating a polarized effect. Empirically, the Average Treatment Effect of rising firing costs shows a negative effect on wages within selected states. It is important to note that due to data limitations, the econometric regressions could not be executed using information covering the entire United States territory. Furthermore, the magnitude of these effects varies depending on the level of education. Notably, the estimations reveal a strong negative effect for individuals with greater than college education and for high school dropouts. The theoretical model indicates that firing costs have a detrimental impact on equilibrium wages for incumbent workers. When the model is calibrated, the results suggest a negative effect of increasing employment protection at both ends of the spectrum across various educational levels. Consistent with the empirical findings, this effect is more pronounced for individuals who are high school dropouts or have education levels greater than college attainment. The extent of these results might potentially be explained by simultaneous declines in dismissal thresholds and varying arrival probabilities of idiosyncratic shocks.

Variations in firing costs impact the productivity threshold at which firms decide to lay off workers, as they are now obligated to retain employees they would otherwise let go. This introduces distortions in firms' aggregate productivity, resulting in lower wages. Additionally, firms operating in different sub-markets, composed of workers with varying levels of education, might face different risks of being affected by idiosyncratic shocks. In particular, firms recruiting workers with very low or very high educational levels face higher uncertainty, increasing the likelihood of being affected by an idiosyncratic shock. Therefore, the combination of decreasing dismissal thresholds and variations in the arrival probabilities of idiosyncratic shocks across different educational groups explains the empirical and theoretical results of this chapter.

The primary contribution of this chapter is the understanding of the negative effect of adopting at least one exception to the employment-at-will doctrine on the wages of high

school dropouts and individuals with education levels greater than a college degree. Previous research has empirically analyzed this relationship for the United States; however, the results differ from those presented in this chapter. For instance, Autor et al. (2006) found no significant effect of adopting one of the exceptions to the employment-at-will on wages. The results in this chapter diverge from Autor et al. (2006) because I use recent econometric developments that better capture the heterogeneity over time. Additionally, I employ a more granular division of educational categories, distinguishing between five levels: high school dropout, high school graduate, some college, college graduate, and greater than college. In contrast, Autor et al. (2006) examined only two aggregated categories: lower and higher educated. Furthermore, this chapter provides not only empirical insights but also delves into theoretical analysis to understand the underlying drivers of the relationship between wages and firing costs.

Related Literature Since the seminal paper by Lazear (1990), numerous researchers have tried to elucidate the effects of employment protection. However, both empirical and theoretical findings remain inconclusive regarding these effects on employment (Autor, Kerr, & Kugler, 2007). Furthermore, theory fails to provide clear predictions on the effects on wages. On one hand, firing costs protect incumbent workers but make the firms to be more reluctant to hire new workers, potentially resulting in lower employment and wages (Autor et al., 2006). Lazear (1990) argues that any optimal contract can undo the effects of severance payments because any mandatory governmental transfer from agent A to agent B can be compensated by a voluntary transfer of the same amount from B to A.¹

Generally, theoretical findings can be divided into two main categories. On one hand, standard competitive models of the labor market suggest that employment protection can be compared to mandated employment benefits, which increase the costs of hiring new workers, thereby causing a leftward shift in the labor demand curve. However, this initial effect can potentially be mitigated through Coasean negotiations, leading to a rightward shift in labor supply that compensates for the initial demand curve shift. In such cases, overall employment levels remain unchanged, but wages decrease to offset the costs associated with the mandated transfers (Autor et al., 2007). These increased costs also raise the adjustment costs for firms, potentially causing them to retain unproductive

1. See the research by Summers (1989) for further details on how negotiation between a worker and employer might lead to an efficiency contract in the presence of an employee mandatory benefit.

workers whose wages exceed their productivity. On the other hand, within the tradition of flow models of the labor market, Pissarides (2000) finds that the outside wage increases by a fraction of the hiring subsidy. Conversely, the outside wage decreases by a fraction of the firing tax, as the firm becomes liable to the tax if the worker accepts the job. The inside wage is unaffected by the hiring subsidy but increased with firing taxes since the firm should pay the tax if the worker doesn't agree to continue the job match. Additionally, Blanchard and Tirole (2008) suggest that higher firing taxes can lead to increased wages, as worker bargaining power strengthens.

From an empirical perspective, Lazear (1990) offers some insights into the effects of severance payments on employment. He finds that such payments lower the number of jobs in the economy, reduce the size of the labor force, and increase the unemployment rate. Additionally, Bentolila and Bertola (1990) highlights the crucial role of economic uncertainty and dynamics in shaping a firm's firing and hiring policies. They note that the impact of firing costs depends on the economic context. For instance, during the 1980s, firing costs were notably significant in countries like Germany, the UK, and France. This significance was particularly pronounced after the first oil shock, which witnessed a simultaneous drop in demand and productivity growth rates, alongside heightened volatility. Acemoglu and Angrist (2001) find a decrease in relative employment among disabled individuals aged 21 to 39, with no discernible effects on wages. Furthermore, firings were observed to be higher in states with more discrimination charges related to the American with Disabilities Act. Kugler and Saint-Paul (2004) find that unemployed job seekers faced reduced probabilities of finding employment compared to their employed counterparts, due to a combination of increased employment protection and adverse selection. Autor et al. (2006) find modest effects of adopting the implied contract exception on the employment-to-population ratio in state labor markets, ranging between -0.8% and -1.6%. This impact was more pronounced for women, young individuals, and those with lower education levels in the short term, but for older and more educated workers in the long term. Finally, Autor et al. (2007) found a decline in total factor productivity in states adopting Covenant of Good Faith and Fair Dealing exceptions.

Evidence regarding the impact of employment protection on wages is limited. Autor et al. (2006) find no significant effects of exceptions to the employment-at-will doctrine on workers' wages. Cervini-Plá, Ramos, and Silva (2014) focused on the effects of reducing payroll taxes and firing costs in Spain, using a matching model to assess the impact on entry wages for both new entrants and incumbents. They observed ambiguous effects of

payroll taxes on wages and, consistent with the results discussed in this chapter, negative effects of firing costs on entry-level wages. Their evaluation of the Spanish reform relied on standard difference-in-difference estimations, comparing individuals affected by the reform (young and old workers) with those in their prime working age. Their econometric estimations suggest that reduced firing costs and payroll taxes led to increased wages for new entrants and incumbents. More recently, Doepke and Gaetani (2020) highlight the significant role of employment protection in explaining the college wage premium. It influences the incentives for both firms and workers to invest in productive relationships. German firms, unlike those in the United States, tend to create job positions that enable low-skilled workers to learn on the job, accumulate skills, enhance productivity, and consequently, increase their wages.

3.2 Data for Measuring the Effect of the Firing Costs on Wages

I constructed a panel dataset using individual-level information aggregated at the US state level. The primary data source is the IPUMS version of the Current Population Survey (CPS) of the United States, encompassing data on Gross Domestic Product (GDP) and employment from the Bureau of Economic Analysis, as well as unemployment statistics and various demographic characteristics obtained from surveys conducted by the Bureau of Labor Statistics. US states were classified based on their adoption of exceptions to the employment-at-will doctrine, following the categorization used by Autor (2003). The final dataset spans the period from 1977 to 1997, with the exclusion of the District of Columbia due to data availability issues. Notably, specific states were omitted from the preferred estimation; refer to Appendix 3.B for further details.

Wages. The central variable in this analysis is "wages," which is based on the `INCWAGE` data from the CPS. It provides information about the nominal total pre-tax wage and salary income received as an employee for the previous calendar year. The survey question related to this variable has undergone slight changes over different samples (for more details, refer to appendix 3.B).

Education. This chapter constructs and analyzes five educational variables using the `educ` and `higrade` variables from the CPS. Workers are categorized into five distinct

groups. *(i)* High school dropouts: Individuals with 0 to 12 years of education, unfinished. *(ii)* High school diploma holders: Individuals with 12 years of education or possessing a high school diploma. *(iii)* Some college education: Individuals who completed one, two, or three years of college or did not finish four years of college. *(iv)* College-educated workers: Individuals with a college degree or four years of college education. *(v)* Those with greater than college educational levels: Individuals with a master's, PhD degree, or more than four years of college education.

Exceptions to the Employment-at-will. Autor (2003), Autor et al. (2006), and Autor et al. (2007) have extensively documented the implementation of exceptions to the employment-at-will policy across US states from 1950 to 1997.² The employment-at-will policy allows employers to discharge or retain employees at will, with or without cause, without being inherently unlawful. It states that employers can "discharge or retain employees at will for good cause or for no cause, or even for bad cause without thereby being guilty of an unlawful act per se."³

According to Kugler and Saint-Paul (2004), exceptions to the employment-at-will policy in the United States can be classified into three categories: the implied contract, the public policy, and the good faith exception. The implied contract exception suggests that there are implied contractual provisions that limit the ability of employers to fire workers. The public policy exceptions restrict employers' ability to terminate contracts of workers who are reluctant to commit actions against or protected by public policy. Finally, the good faith exception limits employers from terminating contractual relationships to avoid the payment of pensions and bonuses.

Autor et al. (2006) and Autor et al. (2007) argue that exceptions to the employment-at-will policy have distorted employers' ability to easily terminate workers, resulting in media attention, costly litigations, and heightened economic uncertainty regarding termination practices. The public policy exception, however, holds lower legal and economic significance, as courts tend to focus on clear violations of the law rather than general or vague transgressions (Autor et al., 2007). The good faith doctrine, similarly, has seen limited application, but as Kugler and Saint-Paul (2004) mention, it is the most far-reaching regulation, requiring dismissals to be grounded in valid causes.

2. For further details on the evolution of the implementation of exceptions to the employment-at-will across US states, see Figure 3.6 in Appendix 3.A.

3. (*Payne v. Western & Atlantic Railroad*, 1884, Tennessee Supreme Court, 82 Tenn. 507 (1884), 519-20, 1884 WL 469 at *6 (Sep. term 1884)), as cited in Kugler and Saint-Paul (2004).

3.3 Econometric Strategy

3.3.1 Average Treatment Effect in Staggered Settings

The adoption of exceptions to the employment-at-will policy across US states has occurred gradually. California was the pioneering state in this regard, as the public policy exception was first recognized by the California Supreme Court in 1959. Subsequently, this exception became widely adopted; by the end of the 1980s, 34 states had implemented it, and this number increased to 43 states by the end of the 1990s. By 2006, 11 states had adopted the good faith exception, and 41 states had adopted the implied contract exception (Autor et al., 2007). The varying timing of adoption among states creates heterogeneity, posing challenges in assessing the impact of these policies at the state level.

Several years ago, conventional econometric methods might have led me to classify US states into two groups: treated and untreated states, with treated states being those that implemented reforms to the employment-at-will policy. Subsequently, I would have regressed the state aggregated wages on the dummy variable for treated vs. untreated states, while controlling for state and time effects. However, recent econometric advancements in difference-in-difference analysis suggest that the Two-Way Fixed Effects (TWFE) model could be controversial in this context, due to the heterogeneity in the timing of the policy adoption. Moreover, this econometric approach is valid only under certain assumptions, including the parallel trends and the no anticipation. In cases where these assumptions hold, it is possible to show that the population coefficient of the TWFE coincides with the average treatment effect of the difference-in-difference estimation (see, for example, (Roth et al., 2023)).

As previously discussed, the implementation of exceptions to the employment-at-will policy varies over time, rendering TWFE models inadequate for estimating the average treatment effect.⁴ Anticipating issues with the implementation of TWFE, Autor et al. (2007) propose conducting different experiments across multiple years. Specifically, they compare states that have implemented a specific exception to the employment-at-will policy with states that have not implemented any exception during the same time period. Consequently, some states serve as treated units in certain periods and control units

4. Roth et al. (2023) provide a detailed explanation of this issue, highlighting that the estimated parameter of a TWFE model does not correspond to a causal parameter. Specifically, the estimation of β_{TWFE} corresponds to a potentially non-convex weighted average of the difference-in-difference estimator, which may produce negative estimates and reverse the sign of the causal effect.

in others. However, no discussion is made on the main assumptions surrounding this econometric approach.

This chapter adopts a different methodology, specifically I use the research findings of Callaway and Sant’Anna (2021), who have developed alternative estimators to address potential heterogeneity in treatment across units or time, as well as cases where the nature of treatment is staggered. I opt for the algorithm proposed by Callaway and Sant’Anna (2021) as it provides the most suitable solution to address the empirical challenges in this study. Additionally, it ensures the validity of modified versions of the parallel trends and no anticipation assumptions. The unconditional parallel trends assumption also appears to be weaker in comparison to alternative specifications.

Following the works and particularly the notations of Roth et al. (2023) and Callaway and Sant’Anna (2021), and considering extended versions of the parallel trends and no anticipation assumptions,⁵ the estimation of the group-time average treatment effect (ATT) for units belonging to a particular group (g) at a specific time period (t) is conducted by estimating:

$$ATT(g, t) = \mathbb{E}[W_{it} - W_{i,g-1} | G_i = g] - \mathbb{E}[W_{it} - W_{i,g-1} | G_i \in \mathcal{G}]$$

The above expression can be estimated as:

$$\hat{ATT}(g, t) = \frac{1}{N_g} \sum_{i:G_i=g} [W_{it} - W_{i,g-1}] - \frac{1}{N_{\mathcal{G}}} \sum_{i:G_i \in \mathcal{G}} [W_{it} - W_{i,g-1}] \quad (3.1)$$

Where W_{it} represents the logarithm of the average aggregated wages of workers with a particular level of education for state i in year t . Let $G_i = \min\{t : D_{it} = 1\}$ denote the earliest period at which unit i received treatment. D_{it} is a dummy variable equal to 1 if the state unit received treatment in year t , indicating the adoption of at least one of the exceptions to the employment-at-will policy previously discussed. If the unit never received treatment during the sample period, $G_i = \infty$.

Treatment is considered an absorbing state, meaning that once a unit is treated ($D_{it} =$

5. Two important remarks: 1. The parallel trends assumption, in its strongest form, assumes that the dependent variable would have evolved *parallelly* in the absence of treatment. 2. The no anticipation assumption establishes that the treatment of an untreated unit today does not depend on its future timing.

1), it remains treated for all subsequent years ($t \geq G_i$). Consequently, $R_{it} = t - G_i + 1$ represents the time relative to treatment, with $R_{it} = 1$ indicating the first treated period for state i . The expression (3.1) provides a generalization of the standard difference-in-difference estimator, as discussed by Roth et al. (2023).

According to Roth et al. (2023), the equation (3.1) can be interpreted as a comparison between the expected change in wages for cohort g between periods $g - 1$ and t compared to the expected outcome of a control group of states not-yet/never treated at year t . Callaway and Sant’Anna (2021) consider two options for \mathcal{G} . The first is to use the never treated units ($\mathcal{G} = \{\infty\}$) and the second uses the not yet treated units ($\mathcal{G} = \{g' : g' > t\}$). In this chapter, the not-yet-treated approach is privileged as the number of never treated states is very low.

3.3.2 Implementation

This section presents the primary results of the previously discussed econometric strategy. States are classified into three categories: ‘treated,’ ‘never treated,’ and ‘not yet treated.’ ‘Treated’ states implemented at least one of the most common exceptions to the employment-at-will policy within a specific year between 1977 and 1997. ‘Never treated’ states, including Florida, Georgia, Louisiana, and Rhode Island, did not enact any employment-at-will regulations during that period. It’s important to note that states transition from ‘not yet treated’ to ‘treated’ upon implementing these regulations.

The estimation of expression (3.1) initially compares ‘not-yet treated’ states with treated states; subsequently, estimates are computed using ‘never treated’ units. The average treatment effect is initially estimated without covariates because including them would not be methodologically valid.⁶ The chapter presents estimates of the effects of increased employment protection on wages across five educational categories, followed by a discussion of the assumptions required for the estimates to be valid. The main results are presented in Table 3.1 (see Appendix 3.E for a detailed presentation of the estimations).

Table 3.1 presents estimates for the average treatment effect, weighted only by group size, on wages across various educational categories, including high school dropouts, high school graduates, individuals with some college education, college graduates, and those with education levels higher than college. In column 2, the estimates are based on ‘not-yet-treated’ states as the comparison group, assuming unconditional parallel trends without

⁶. Callaway and Sant’Anna, 2021 argue that covariates should be measured before treatment implementation

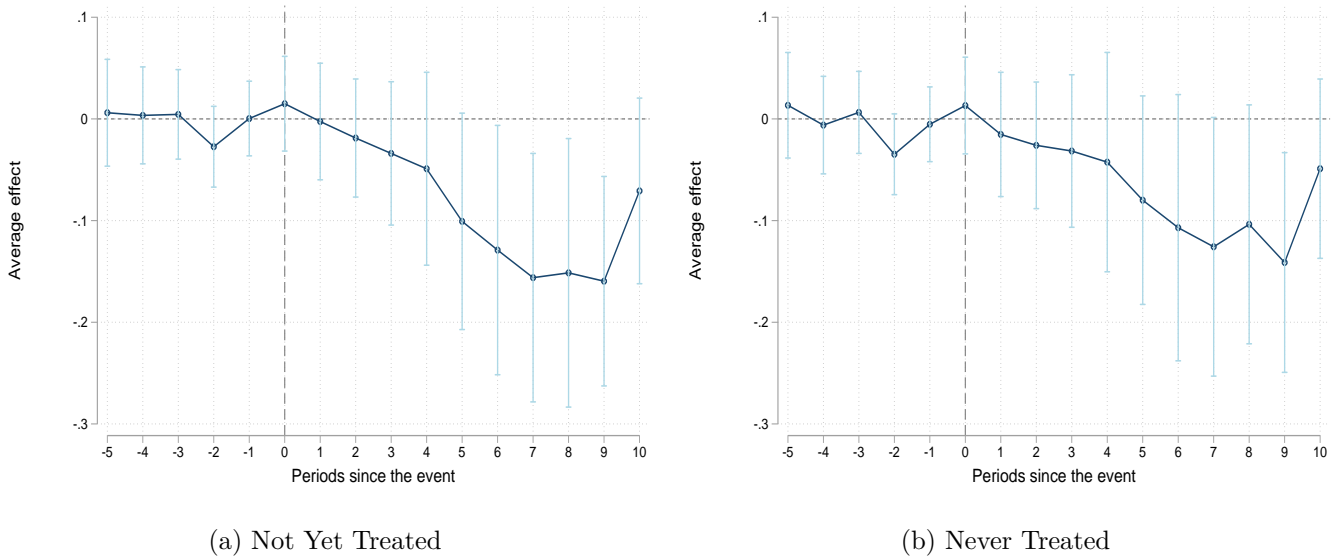


Figure 3.1 – **Average Treatment Effect, Wages High School Dropout**

Panels (a) and (b) present the effects of the employment protection prior and posterior to the implementation of the reform. The comparison group used in the panel (a) is the not yet treated units, while in panel (b) the comparison is made with never treated units. The estimation uses the method of Callaway and Sant’Anna (2021).

covariates. Conversely, column 3 uses ‘never-treated’ states as the comparison group, under the unconditional parallel trends hypothesis. These estimates correspond to the expression (3.1). The results reveal a statistically significant negative average treatment effect on wages for high school dropouts and individuals with education levels higher than college, indicating that increases in employment protection, specifically the tightening of employment-at-will regulations, negatively impact wages. For instance, adopting one of the exceptions to employment-at-will implies a reduction of 8.82% in average wages at the state level (column 2). To illustrate, if real wages for high school dropouts averaged \$6,906.096 in 1990 at the state level, the adoption of one of the exceptions led to an average loss of \$608 compared with states that have not implemented the reform but will do so later. Regarding individuals with education levels higher than college, their average real wages were \$45,231.24 in 1990; hence, the reduction would be 5.46% (column 2) or \$2,470 after increased employment protection compared to states that have not yet implemented the reform.

Estimates in column 3 presented in Table 3.1 are similar, but the comparison group is the ‘never-treated’ states. Interestingly, the effects are more pronounced for high school

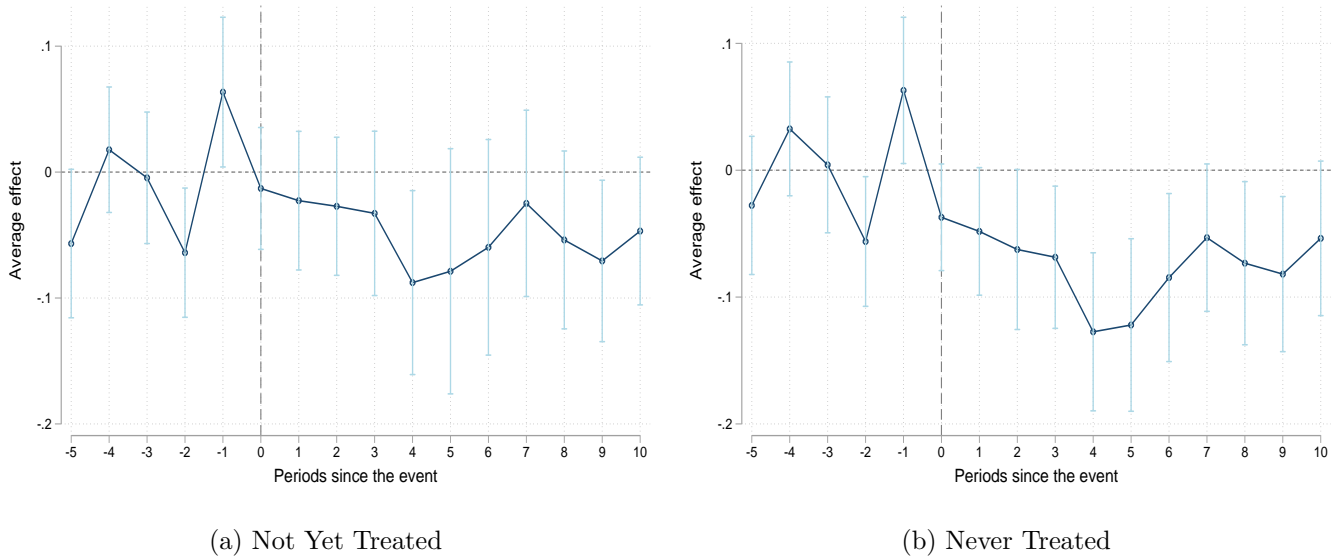


Figure 3.2 – **Average Treatment Effect, Wages Greater than College**

Panels (a) and (b) present the effects of the employment protection prior and posterior to the implementation of the reform. The comparison group used in the panel (a) is the not yet treated units, while in panel (b) the comparison is made with never treated units. The estimation uses the method of Callaway and Sant’Anna (2021).

dropouts than for individuals with education levels higher than college. This suggests that the rise in firing costs in the United States from 1977 to 1997 resulted in polarized and negative effects on the wage-educational distribution, potentially exacerbating wage inequalities across high school dropouts and individuals with higher than college education.

The event study graphs for high school dropouts and individuals with education beyond college are presented in Figures 3.1 and 3.2, respectively. These graphs indicate no significant effects before the reform, but they do reveal some negative effects following the implementation of exceptions to the employment-at-will. In particular, after nine periods of implementing the reforms, states will expect to see average wages of high school dropouts to reduce more than 10% (see panel (a) of figure 3.1). For individuals with educational levels beyond college, wages are expected to fall around 9% after four periods of implementing the reform (see panel (a) of figure 3.2).

Autor et al. (2007) find no significant effect of adopting any of the exceptions to the employment-at-will doctrine on wages among different socio-economic groups classified by gender, age, or educational level (high school or less, and at least some college). In

Table 3.1 – Effect of the Firing Costs on Wages of Different Educational Categories

Average Treatment Effect (Sample Weighted Average)		
	Unconditional Parallel Trends (without covariates. Not yet as comparison)	Unconditional Parallel Trends (without covariates. Never treated as comparison)
High School Dropout Wages	-0.0882238* (0.014)	-0.0770335* (0.038)
High School Wages	-0.0159317 (0.496)	-0.0138913 (0.593)
Some College Wages	-0.0321528 (0.341)	-0.0257788 (0.478)
College Wages	-0.0246264 (0.501)	-0.0407847 (0.268)
Greater than College Wages	-0.054616* (0.029)	-0.0742299* (0.002)
P-values in parenthesis. * Significance at 5%.		

a parallel econometric exercise, the effect of the employment-at-will doctrine on wages remains insignificant when using only two categories for the level of education: high and low, similar to the categorization used by Autor et al. (2007).⁷ The differences between the results presented in this chapter and those in Autor et al. (2007) likely stem from this issue. Specifically, the composition of wages may incorporate divergent trends that offset each other, resulting in nonsignificant effects when using a global division of wages by educational category, rather than a more granular one.

Few studies have empirically examined the effects of increasing employment protection on wages. For instance, Leonardi and Pica (2013) evaluates the 1990 Italian reform to employment protection legislation and find a small but significant negative effect on wages for firms with 15 or fewer employees relative to larger firms. Similarly, Cervini-Plá et al. (2014) find that reduced firing costs and payroll taxes had a positive effect on wages in Spain after the 1997 reform. The results presented in this chapter are in line with these previous studies but differ because I evaluate the effects on wages across different educational categories.

7. In this case, the worker population is divided between high and low educated individuals. High-educated individuals have at least 4 years of college education, while low-educated individuals have lower levels of education. The econometric exercise, similar to the equations presented previously, yields no significant results using either the 'not-yet-treated' or 'never-treated' units. This exercise is not presented in the chapter, but results are available on request.

3.3.3 Discussion on the Assumptions

This section discusses the main assumptions of the econometric method outlined in Callaway and Sant'Anna (2021) and the corresponding results. The first assumption concerns the absorbing state of treated units, with the additional requirement that no unit is treated in the first period. This assumption is mostly met by the subset of the sample used in this paper, as all states remained treated after the implementation of the treatment. However, due to data limitations, it was not possible to consider states with regulatory changes before 1960, as time series data on wages starts after 1960.

The second assumption outlined in Callaway and Sant'Anna (2021) pertains to random sampling, which is largely met by the subsample. The third assumption, "limited treatment anticipation," means that units might anticipate but not perfectly predict the treatment. In the context of exceptions to employment-at-will, states may anticipate the policy's adoption, but the precise timing of such adoption is uncertain due to, e.g., political considerations.

Callaway and Sant'Anna (2021) discuss two versions for the parallel trends assumption depending on the choice of the comparison group: 'not yet treated' or 'never treated' units. This assumption is more flexible than the standard parallel trends requirement as it should only hold conditionally on covariates that influence the trends of outcomes over time when their distribution differs across groups. If the number of 'never treated' units is very low, it's advisable to use the 'not yet treated' as comparison group, although this comes with some limitations. In the absence of treatment anticipation, using 'never treated' units does not impose restrictions on observed pre-treatment trends, unlike the 'not yet treated' group. Not restricting pre-trends implies that outcomes might not have evolved in parallel prior to treatment implementation, but trends could align in later periods. In this paper, the 'not yet treated' units is privileged and the unconditional parallel trends assumption should therefore hold, which is partially met since at least one pre-trend is significant. Finally, Callaway and Sant'Anna (2021) note that the generalized propensity score should be uniformly bounded away from 1.

It is also important to remark the potential issue of endogeneity given that the reform has known effects on employment as discussed in Autor (2003), Autor et al. (2007) and Kugler and Saint-Paul (2004). Therefore, economic agents might anticipate these effects and relocate to states with less strict labor regulations.

3.4 The Model

3.4.1 Description of the Model

The continuous-time model presented in this chapter is an extension of the framework proposed by Mortensen and Pissarides (1994), Pissarides (2000), and Kugler and Saint-Paul (2004), adapted to accommodate various types of workers. Each firm offers one job, which may be filled or remain vacant. Jobs are destroyed if they are not producing or searching. Job creation occurs when a firm with a job meets a worker, and starts producing. Endogenous job destruction occurs when there is a separation, and the job leaves the market. Workers are differentiated by their level of education, including high school dropouts (*HSD*), high school graduates (*HS*), some college graduates (*SC*), college graduates (*COL*), and those with education levels higher than college (*GCOL*). Additionally, workers vary in terms of their productivity, denoted by η , which is influenced by their level of education. High school dropouts exhibit the lowest productivity level.

Firms can freely enter the market by creating vacancies, incurring a cost C for keeping positions unfilled. During the hiring process, workers arrive at vacant jobs at an initially exogenous rate f . Before the match, firms lack information about the workers' type or past work history; they only observe the applicant's level of education and can direct their search to specific markets. After hiring, firms observe the worker's productivity. When a match is formed, production begins, and the firm's output per unit of time becomes $m + \eta$, where m represents the match-specific component and η is worker-specific. Firms prefer to hire workers with high η to insure against low m , thereby retaining workers and avoiding firing costs.

The firing costs, included in this model, refer to the administrative costs incurred by a firm when terminating an employee and facing potential litigation. These costs, denoted by F , are entirely exogenous to the model. Similar to Pissarides (2000), firing costs are considered a cost to the firm rather than a compensation received by the worker. If these costs were purely transfers, they would not affect overall employment levels, as discussed by Mortensen (1978) and Lazear (1990) cited by Acemoglu and Angrist (2001). Additionally, Pissarides (2000) argues that any transfers made by the firm would already be factored into the negotiated wage and would not directly impact the model's dynamics. In this chapter, firing costs remain constant and do not vary based on workers' skill levels.

Initially, firms create jobs with a match-specific component equal to the upper support of the job productivity distribution, denoted by \bar{m} . However, firms may experience an

idiosyncratic shock that changes the job's productivity. Upon the arrival of the shock, the new productivity of the match is drawn from a distribution $G(m)$ with support $[\underline{m}, \bar{m}]$. These shocks arrive at jobs at a Poisson rate γ . Following Mortensen and Pissarides (1994), once these shocks occur, the new productivity drawn is independent of the initial productivity and irreversible. Using the Poisson rate to model these shocks implies persistence in job-specific shocks ($\gamma < \infty$).

The Nash Sharing Rule: Initial or Outside Wages

Wage determination follows a surplus-sharing rule, where wages are set to divide the surplus of the match at all times in fixed proportions. β represents the share of the worker, defined in the interval $(0, 1)$. Wages are renegotiated every time a productivity shock occurs. According to Diamond (1982), wages are set so that the worker is indifferent between accepting the job and continuing to search, while the firm is indifferent between hiring the worker and waiting for a new worker to fill the job.

In the presence of firing costs, incumbent (inside) and new workers (outside) face different wages. For new workers, the outside wage is set to maximize the standard Nash product derived from the surplus of the match at the maximum productivity level \bar{m} :

$$(E(\bar{m}, \eta) - U(\eta))^\beta (J(\bar{m}, \eta) - V)^{1-\beta}$$

In this case, the worker evaluates the value of being employed at the maximum productivity level compared to being unemployed. Similarly, the firm assesses the value of having the vacancy filled at the maximum productivity level versus having it remain vacant.

Once the worker is hired, the firm's benefit from maintaining the employment contract is $J(m, \eta)$. However, if the firm decides to terminate the working relationship, it will incur a loss of $J(m, \eta) + F$, with F , the firing costs, being operational. Consequently, if incumbent workers have the opportunity to renegotiate the contract after being hired, the new wage, referred to as the 'inside' wage, is determined to maximize the following Nash rule:

$$(E(m, \eta) - U(\eta))^\beta (J(m, \eta) - V + F)^{1-\beta}$$

Over the next subsections the expressions for $E(m, \eta)$, $J(m, \eta)$, V , and $U(\eta)$ are defined.

The Value Function of Being Employed

$$rE(m, \eta) = w(m, \eta) + \gamma \left[\int_{m_c}^{\bar{m}} E(x, \eta) g(x) dx + G(m_c(\eta))U(\eta) - E(m, \eta) \right]$$

Workers employed in a job receive a wage denoted as $w(m, \eta)$, determined through Nash bargaining. Here, m_c represents the threshold productivity level below which a worker is fired. The expression within square brackets quantifies the capital gain or loss incurred when the firm experiences a shock; essentially, it represents the expected return $E(m, \eta)$ that the worker, with productivity η and match specific component m , foregoes upon experiencing the shock. If the resulting productivity level, falls outside the range $[m_c, \bar{m}]$, the worker is terminated and transitions into the pool of unemployment, where they receive an expected return $U(\eta)$.

The Value Functions of Being Unemployed

The equation below represents the present-discounted value of the income flow of the unemployed worker.

$$rU(\eta) = b + f \left[E(\bar{m}, \eta) - U(\eta) \right]$$

Here, b denotes the real return of being unemployed, which can represent unemployment benefits. The expression within brackets quantifies the expected capital gain from transitioning between states of employment and unemployment. The parameter f represents the probability of moving into employment, initially considered exogenous but subsequently becoming endogenous in this chapter.

The Value Function of a Filled Job

The present discounted value of expected profit from a filled job is denoted as $J(m, \eta)$, which depends on the firm's idiosyncratic output per unit of time, represented as $m +$

η , where m denotes the match-specific component and η represents the worker-specific component. If a job is destroyed, the firm foregoes the value $J(m, \eta)$ and incurs the firing cost F . Consequently, the firm terminates the worker if $J(m, \eta) < -F$. The threshold for dismissal, or the reservation productivity, is defined by $J(m_c(\eta), \eta) + F = 0$. The value function of an occupied job is expressed as follows:

$$rJ(m, \eta) = m + \eta - w(m, \eta) + \gamma \left[\int_{m_c}^{\bar{m}} J(x, \eta)g(x) dx - G(m_c(\eta))F - J(m, \eta) \right]$$

Idiosyncratic productivity shocks might arrive at rate $\gamma > 0$ and are drawn from the distribution $G(m)$.

The Value of a Vacancy

The equation below presents the expected-discounted value from a vacancy. According to Pissarides (2000), the firm is the owner of the job, which is treated as an asset. In a perfect capital market, the capital cost rV is equal to the rate of return of the job. The costs per unit of time of having the job vacant are denoted as C . The parameter a , initially exogenous but becomes endogenous afterwards, represents the rate of worker arrivals to vacant jobs. The net return, $J(\bar{m}, \eta) - V$, represents the yield of the change of state.

$$rV = -C + a(J(\bar{m}, \eta) - V)$$

All jobs are created at maximum idiosyncratic productivity $m = \bar{m}$. The firms will continue opening vacancies until the profits from vacancies equals zero $V = 0$.

Optimal Wages

The inside and outside equilibrium wages are defined below. The complete solution of the model is presented in the appendix 3.F.

The **Inside wage**

$$w(m, \eta) = \beta(m + \eta + rF) + (1 - \beta)b + \beta f(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

The Outside wage

$$w_0(\bar{m}, \eta) = \beta(\bar{m} + \eta - \gamma F) + (1 - \beta)b + f\beta(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

In a general equilibrium context, wages depend on several factors including the match-specific component (m), the individual component (η), and firing costs, (F). The wage equations resemble those presented in Pissarides (2000), with the notable addition of the worker-specific component (η). However, there are some nuances in the presentation. Here, I explicitly highlight the dependence of both inside and outside wages on the dismissal threshold ($m_c(\eta)$), as this will be crucial in determining the effect of firing costs on these wages. It's also important to note that the wages presented here do not incorporate market tightness (θ), which will come into play once job-finding probabilities become endogenous.

3.4.2 Effects of the Firing Costs

This section discusses the main findings regarding the effect of the firing costs on wages. While both the inside and the outside wages depend on the firing costs parameter (F) as in Pissarides (2000), this chapter focuses on inside wages because the firing costs are operative for incumbent workers.

Exogenous Meeting Rates

Initially assuming that the job finding rate, f , is exogenous, the impact of firing costs on wages can be determined by differentiating the inside wage equation:

$$\frac{dw(m, \eta)}{dF} = -\beta f \frac{1 - \beta}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta(r - (1 - \beta)f) \quad (3.2)$$

The above expression explicitly highlights the need of calculating the effect of firing

costs on the dismissal threshold $m_c(\eta)$. This result is the first significant finding of this paper, as summarized in Proposition 3.4.1.

Proposition 3.4.1. *Considering exogenous job finding probabilities, f , the effect of the firing costs on the dismissal threshold is negative $\frac{dm_c(\eta)}{dF} < 0$.*

Proposition 3.4.1 shows that an increase in employment protection prompts firms to lower the dismissal threshold. Consequently, firms retain workers who would otherwise be fired, thus reducing overall productivity. The firm encounters a trade-off between retaining workers with lower productivity levels and incurring the cost of termination, F , (for further details, refer to Appendix 3.F.2). This phenomenon mirrors the findings in Pissarides (2000), where job destruction decreases as firing costs increase, implicitly indicating a decrease in the dismissal threshold. The reservation productivity lowers as it is now more costly to destroy jobs. This impact on the dismissal threshold facilitates the computation of expression (3.2), leading to the second proposition of this paper.

Proposition 3.4.2. *Considering exogenous job finding probabilities, f , the effect of the firing costs on wages is determined by a single expression: $1 - (\gamma + r)$. For $(\gamma + r)$ sufficiently low, the effect of increasing firing costs on wages is positive.*

Proposition 3.4.2 is deemed reasonable given the model's continuous-time nature and the monthly calibration, ensuring that γ and r remain sufficiently low. The proportion of firms affected by idiosyncratic shocks will be crucial in understanding the impact of firing costs on wage dynamics, especially when considering endogenous job finding probabilities and various educational backgrounds. With γ and r at sufficiently low levels, the 'discounted' effect of firing costs on the dismissal threshold outweighs the negative influence induced by job finding probabilities. Additional details on Proposition 3.4.2 can be found in Appendix 3.F.2.

However, in the context of exogenous job finding probabilities, the analysis may not fully capture all labor market dynamics. The next section introduces endogenous job finding probabilities.

Endogenous Meeting Rates

Now, let's consider endogenous job finding probability. In this context, a matching technology, denoted as $H(u, v)$, governs the meetings between unemployed workers and job vacancies. This function exhibits constant returns to scale. Additionally, we introduce

an indicator of labor market tightness, defined as the ratio of unemployed individuals to job vacancies, denoted as θ . The job finding rate, f , is now determined by $\theta q(\theta)$.

$$\begin{aligned} q(\theta) &= \frac{H(u, v)}{v} = H\left(\frac{1}{\theta}, 1\right) \\ f &= \theta q(\theta) \end{aligned}$$

With the new labor market conditions defined, it is possible now to assess the impact of firing costs on wages as follows

$$\frac{dw(m, \eta)}{dF} = \underbrace{-\beta (1 - \beta)\theta q(\theta) \frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta(r - (1 - \beta)\theta q(\theta))}_{\text{Expression (3.2)}} + \underbrace{\beta(\theta q'(\theta) + q(\theta)) \frac{c}{q(\theta)} \frac{d\theta}{dF}}_{\text{New term}} \quad (3.3)$$

Expression (3.3) can be divided into two components. The first term resembles the effect of firing costs on wages when job finding probabilities are exogenous, as shown in expression (3.2). The new term, highlighted in red, represents the additional effect resulting from the influence of firing costs on market tightness (see appendix 3.F.2 for further details). With endogenous meeting rates, the overall impact of firing costs on wages hinges on their effect on labor market tightness (θ) and the dismissal threshold ($m_c(\eta)$).

The system of two equations obtained from differentiating the job creation and job destruction conditions with respect to the firing costs parameter, F , allows for the determination of the effects of firing costs on the dismissal threshold ($m_c(\eta)$) and market tightness (θ). Based on these results, Proposition 3.4.3 is presented:

Proposition 3.4.3. *Consider endogenous job finding probabilities. The effect of the firing costs on the dismissal threshold is negative, $\frac{dm_c(\eta)}{dF} < 0$. And the effect of the firing costs on the labor market tightness is negative, $\frac{d\theta}{dF} < 0$.*

Proposition 3.4.3 expands upon Proposition 3.4.1 by considering endogenous meeting rates (see Appendix 3.F.2 for the proof). In this context, an increase in firing costs can lead to a decrease in labor market tightness (θ) because it may reduce the number of unemployed. Simultaneously, the productivity threshold ($m_c(\eta)$) decreases with increased firing costs, causing firms to retain workers they previously intended to let go.

While the effect of firing costs on the dismissal threshold continues to be negative, the effect is now different in the context of endogenous job finding probabilities. In this case, $\frac{dm_c(\eta)}{dF}$ is as follows:

$$\frac{dm_c(\eta)}{dF} = -\frac{\left(r + \beta f \frac{1}{\varepsilon_{q|\theta}}\right)(r + \gamma)}{r + \beta f \frac{1}{\varepsilon_{q|\theta}} + \gamma G(m_c(\eta))} \quad (3.4)$$

Where $\varepsilon = |q'(\theta) \frac{\theta}{q(\theta)}|$. The expression (3.4) is similar to the effect of firing costs on the dismissal threshold ($m_c(\eta)$) in the case of exogenous job finding probabilities, presented below.

$$\frac{dm_c(\eta)}{dF} = -\frac{(r + \beta f)(r + \gamma)}{r + \beta f + \gamma G(m_c(\eta))} \quad (3.5)$$

Expressions (3.4) and (3.5) become equivalent as $\varepsilon_{q|\theta} \rightarrow 1$. However, in this scenario, the matching function is undetermined. The derivation of (3.4) can be found in Appendix 3.H.

In the calibration of the general equilibrium model, job-finding probabilities ($\theta q(\theta)$) and job separation rates ($\gamma G(m_c(\eta))$) are determined based on the findings of Cairo and Cajner (2018). Given the prevailing near-zero interest rates, the influence of firing costs on $m_c(\eta)$ will largely depend on the arrival rate of idiosyncratic shocks (γ).

These results enable the computation of the expression (3.3), which can be presented as follows:

$$\frac{dw}{dF} = \beta \left(\frac{r \varepsilon_{q|\theta} (r + \gamma G(m_c(\eta))) - q(\theta) \theta ((1 - \beta) \gamma G(m_c(\eta)) - r \beta)}{\varepsilon_{q|\theta} (r + \gamma G(m_c(\eta))) + \beta q(\theta) \theta} \right) >? \quad (3.6)$$

Appendix 3.G details the derivation of expression (3.6). In a general equilibrium framework, the impact of firing costs (F) on wages is undetermined. However, this impact hinges on how firing costs influence labor market tightness (θ) and the dismissal threshold ($m_c(\eta)$).

Firing costs exert a negative effect on market tightness, thereby diminishing job finding probabilities – a trend observed in studies such as Kugler and Saint-Paul (2004). Consequently, if employment protection regulations lead to reduced job-finding probabilities, workers may find themselves with fewer outside options and may consequently accept lower wages. This relationship is captured by the derivative $q(\theta) + \theta q'(\theta)$, where

$q'(\theta) < 0$. Therefore, as firing costs increase, the ultimate effect on job finding probability depends on the gap between $q(\theta)$ and $\theta q'(\theta)$.

Moreover, if employment protection lowers the dismissal threshold ($m_c(\eta)$), average productivity might decline, potentially exerting downward pressure on wages.

The theoretical model sheds light on the factors influencing the relationship between wages and firing costs. It suggests that variations in job-finding probability and dismissal thresholds, largely determined by γ , play crucial roles.

The arrival of idiosyncratic shocks, denoted as γ , appears particularly significant. If a substantial portion of firms experience such shocks, overall worker productivity may tend to decline, resulting in lower wages. Additionally, a high γ may induce greater reluctance among firms to hire new workers within a specific market segment. Consequently, in a scenario with heightened employment protection, the impacts on θ and $m_c(\eta)$ could be magnified due to fluctuations in γ .

Due to the challenge in determining the direction of the effects of firing costs on wages, identification involves calibrating the general equilibrium model and subsequently introducing variations in firing costs.

3.5 Calibration of the General Equilibrium Model

The equations below define the equilibrium of the labor market and are necessary for carrying out the calibration exercise.

$$0 = m_c(\eta) + \eta + rF - b + \frac{\gamma}{r + \gamma} \frac{(\bar{m} - m_c(\eta))^2}{2(\bar{m} - \underline{m})} - f\beta \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \quad (3.7)$$

$$\frac{C}{q} = (1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \quad (3.8)$$

$$fu = \gamma \frac{m_c(\eta) - \underline{m}}{\bar{m} - \underline{m}} (1 - u) \quad (3.9)$$

$$f = A\theta^\alpha \quad (3.10)$$

$$q = A\theta^{\alpha-1} \quad (3.11)$$

Equation (3.7) depicts the job destruction condition, while Equation (3.8) represents the job creation condition. Expression (3.9) describes labor market flows, and (3.10) denotes the job finding probability. Furthermore, the matching function, expressed in

terms of the market tightness (θ), is represented by (3.11), exhibiting constant returns to scale. The parameters of the model are $\{\underline{m}, \bar{m}, \eta, F, r, \gamma, \alpha, \beta, b, C, A\}$, with the unknowns being $\{m_c(\eta), f, q(\theta), \theta, u\}$.

The parameters defined previously do not allow for the direct computation of the effect of firing costs on wages, as they do not represent elasticities. Therefore, to calibrate the model, I simplify the system of equations by expressing the firing costs as a fraction, Ψ , of the inside wage equation ($F = \Psi w(m_c(\eta), \eta)$).⁸ Furthermore, I define a system of equations ((3.12)-(3.13)) in terms of two unknowns, $\{\bar{m}, F\}$, by: (i) setting f and the job separation rate $\delta = \gamma \frac{m_c(\eta) - \underline{m}}{\bar{m} - \underline{m}}$; (ii) imposing $G(m)$ to be uniform with support in the interval $[0, \bar{m}]$; (iii) using the expression $m_c(\eta) = \frac{\delta}{\gamma} \bar{m} = \phi \bar{m}$; and (iv) using $\frac{F}{\Psi} = w_c(\eta)$.⁹

$$F = \frac{-\eta + b}{(r + f\beta)} - \frac{\left(\phi + \frac{\gamma}{r+\gamma} \frac{(1-\phi)^2}{2} - f\beta \frac{1-\phi}{r+\gamma}\right) \bar{m}}{(r + f\beta)} \quad (3.12)$$

$$F = \frac{-\beta\eta - (1 - \beta)b}{\left(-\frac{1}{\Psi} + \beta r - (1 - \beta)f\beta\right)} - \frac{\left(\beta\phi + (1 - \beta)f\beta \frac{1-\phi}{r+\gamma}\right) \bar{m}}{\left(-\frac{1}{\Psi} + \beta r - (1 - \beta)f\beta\right)} \quad (3.13)$$

Subsequently, it is possible to deduce the following expressions:

$$\begin{aligned} m_c(\eta) &= \phi \bar{m} \\ u &= \frac{\delta}{f + \delta} \\ q &= \frac{c}{(1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F\right)} \\ \theta &= \frac{f}{q} \\ A &= \frac{f}{\theta^\alpha} \end{aligned}$$

3.5.1 Benchmark Calibration

This chapter conducts a calibration exercise using the estimates of the job finding probability, $f = \theta q(\theta)$, and job separation rate, $\delta = \gamma \frac{m_c(\eta)}{\bar{m}}$, obtained for various educa-

8. $w(m_c(\eta), \eta)$ represents the inside wage equation evaluated at the minimum productivity level. Alternatively, average productivity wages can be used: $F = \Psi w\left(\frac{m_c(\eta) + \bar{m}}{2}, \eta\right)$.

9. For further details, refer to Appendix 3.I.

tion categories in the United States labor market by Cairo and Cajner (2018).¹⁰ This calibration exercise aims to compute the elasticity of wages with respect to variations in firing costs for each level of Ψ . Specifically, Ψ is held constant while F is perturbed to assess the resulting variations in wages.

The model calibration is based on the parameter values specified in Table 3.2, which are expressed on a monthly frequency. Results are presented in Figures 3.3 and 3.4. These figures illustrate numerical values of variables under varying firing costs for fixed Ψ values. Specifically, they depict elasticities across different educational categories of firing costs for average wages ($w_m = w\left(\frac{m_c(\eta) + \bar{m}}{2}\right)$), market tightness (θ), and dismissal threshold ($m_c(\eta)$). Furthermore, the figures provide numerical values across different educational categories for market equilibrium under different Ψ values, including θ , $m_c(\eta)$, the upper bound of the idiosyncratic productivity distribution (\bar{m}), wages evaluated at the dismissal threshold ($w_c = w(m_c(\eta), \eta)$), and average wages ($w\left(\frac{m_c(\eta) + \bar{m}}{2}, \eta\right)$). Figure 3.3 presents results for the benchmark economy, while Figure 3.4 reflects adjustments to align with empirical observations of the United States labor market, particularly based on the econometric findings outlined in Section 3.3 of this chapter.

The parameter values for the benchmark scenario, detailed in Table 3.2, are as follows: an interest rate fixed at 0.00333, equivalent to a 4% annual rate; α , the matching technology parameter, set to 0.5, satisfying the Hosios condition with $\beta = 1 - \alpha = 0.5$, representing the workers' wage bargaining power. The cost of creating a vacancy, C , is set to 0.1, and unemployment benefits, b , are set to 0.3. The arrival rate of idiosyncratic shocks (γ) is 0.1.

The parameter Ψ , of the firing costs, ranges between (0.1, 1). Job-finding and job-separation rates are determined based on the findings of Cairo and Cajner (2018). Individual productivity profiles increase with educational levels, with specific values set as follows: η is 1.2 for greater than college, 1.1 for college, 0.7 for some college, 0.5 for high school, and 0.4 for high school dropout.

The elasticities and equilibrium values depicted in Figure 3.3 for the benchmark scenario are consistent with theoretical and empirical predictions of this chapter. Notably, the elasticity of average wages decreases as firing costs increases across different educational categories, with a pronounced effect observed for high school dropouts. Consistent with Proposition 3.4.3, the elasticities of the dismissal threshold ($m_c(\eta)$) and labor market

10. Cairo and Cajner (2018) provides estimates for job finding probability and job separation rates for high school dropouts, high school graduates, individuals with some college education, and college graduates. Estimates for the 'greater than college' category are extrapolated based on observed trends.

tightness (θ) with respect to the firing costs are negative. Additionally, wages evaluated at the dismissal threshold and at the average productivity reflect increasing worker productivity levels (η) across different educational categories.

3.5.2 Matching the United States Labor Market

Using the benchmark calibration as a starting point, the parameters are adjusted to match the characteristics of the United States labor market, particularly those outlined in the econometrics section of this chapter (see Section 3.3). Figure 3.4 shows the elasticity of average wages with respect to firing costs for different values of the parameter Ψ . Notably, the negative slope is more pronounced for high school and individuals with education levels greater than college, while being less significant for other educational categories. For high school dropouts, average wages are expected to decrease by up to 4%, deviating in magnitude from previously presented empirical estimates (see Section 3.3). This marked negative slope can be attributed to a substantial decline in the dismissal threshold for individuals with greater than college education and a sharp decrease in labor market tightness for high school dropouts.

By adjusting the arrival rate of idiosyncratic shocks (γ), I manage to replicate the direction of the effects identified by the econometric strategy outlined in Section 3.3. This suggests that γ might exhibit a convex shape across various educational levels in the US labor market, being higher for high school dropouts and individuals with education levels beyond college. This finding closely aligns with the empirical estimates presented in this chapter. The non-linearities in γ seem to be a plausible feature of the US labor market.

The higher probability of firms being hit by idiosyncratic shocks in sub-markets for individuals with education levels beyond college and high school dropouts offers an explanation for the observed negative effects of increased employment protection on wages within these groups. Conversely, non significant effects are observed in the middle of the wage-educational distribution, resulting in a polarized effect. The rise in employment protection leads to a decrease in labor market tightness, which, in turn, can diminish job-finding probabilities. This reduction in job-finding probabilities restricts workers' outside options, thereby negatively impacting their wages. Additionally, higher firing costs contribute to a reduction in the dismissal threshold, average labor productivity, and subsequently, wages.

These findings are consistent with previous research, notably Cervini-Plá et al. (2014),

Table 3.2 – Parameters. Variation in Firing Costs

Parameter	Benchmark	US economy
Ψ : share of firing costs	(0.1, 1)	(0.1, 1)
b : unemployment benefits	0.3	0.3
\underline{m} : Lowest productivity level (uniform)	0	0
C : cost of posting	0.1	0.1
r : interest rate	0.00333	0.00333
α : parameter matching function	0.5	0.5
$\beta = 1 - \alpha$	0.5	0.5
Greater than college (GCOL)		
δ : job separation	0.01	0.01
η : labor productivity	1.2	1.2
$\theta q(\theta)$: Job finding probability	0.405	0.405
γ : idiosyncratic shocks	0.1	0.15
College (COL)		
δ : job separation	0.0108	0.0108
η : labor productivity	1.1	1.1
$\theta q(\theta)$: Job finding probability	0.4105	0.4105
γ : idiosyncratic shocks	0.1	0.02
Some College (SC)		
δ : job separation	0.0203	0.0203
η : labor productivity	0.7	0.7
$\theta q(\theta)$: Job finding probability	0.4434	0.4434
γ : idiosyncratic shocks	0.1	0.03
High School (HS)		
δ : job separation	0.0244	0.0244
η : labor productivity	0.5	0.5
$\theta q(\theta)$: Job finding probability	0.4318	0.4318
γ : idiosyncratic shocks	0.1	0.04
High School Dropout (HSD)		
δ : job separation	0.0437	0.0437
η : labor productivity	0.4	0.4
$\theta q(\theta)$: Job finding probability	0.4523	0.4523
γ : idiosyncratic shocks	0.1	0.1

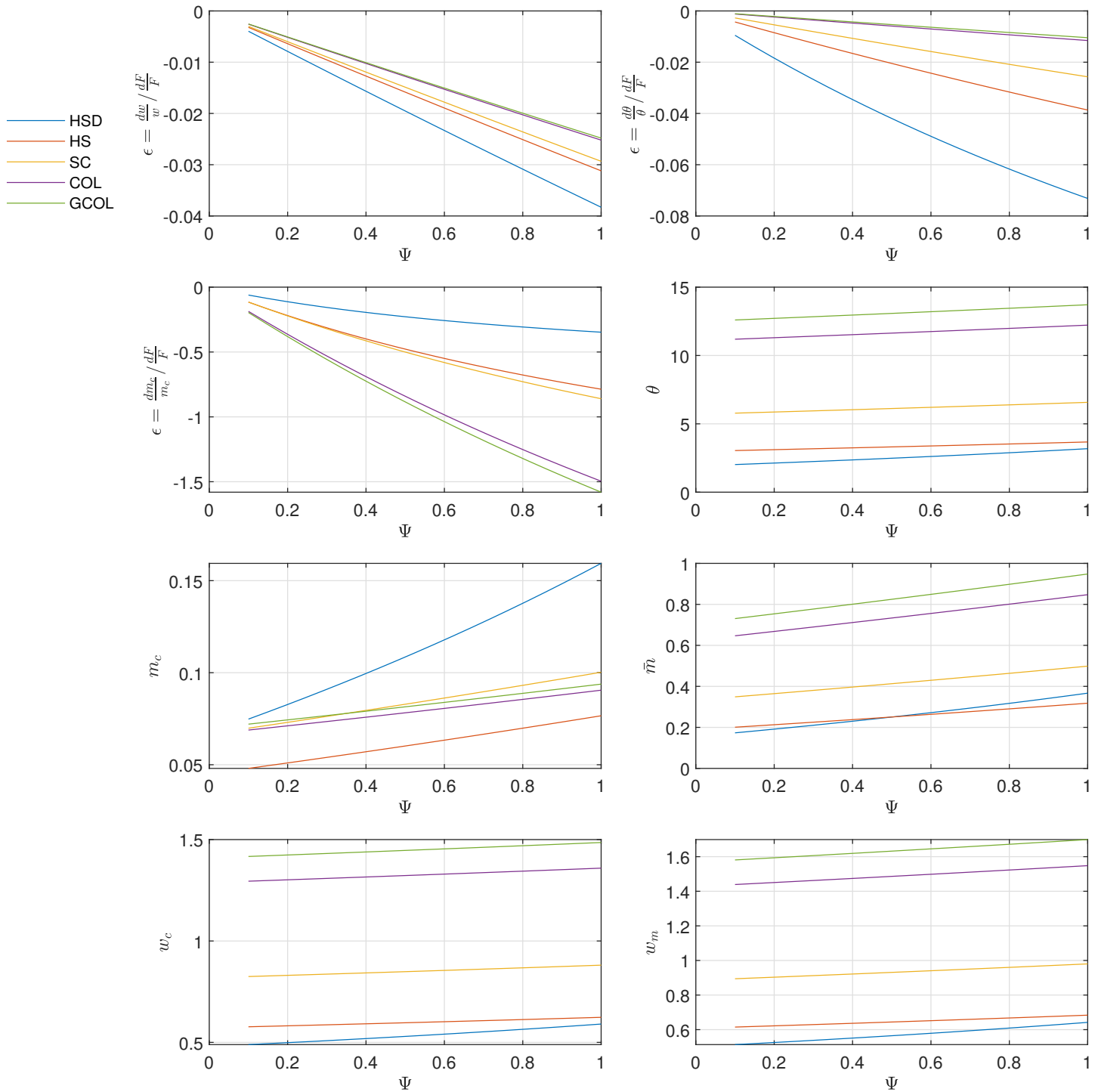


Figure 3.3 – Benchmark calibration

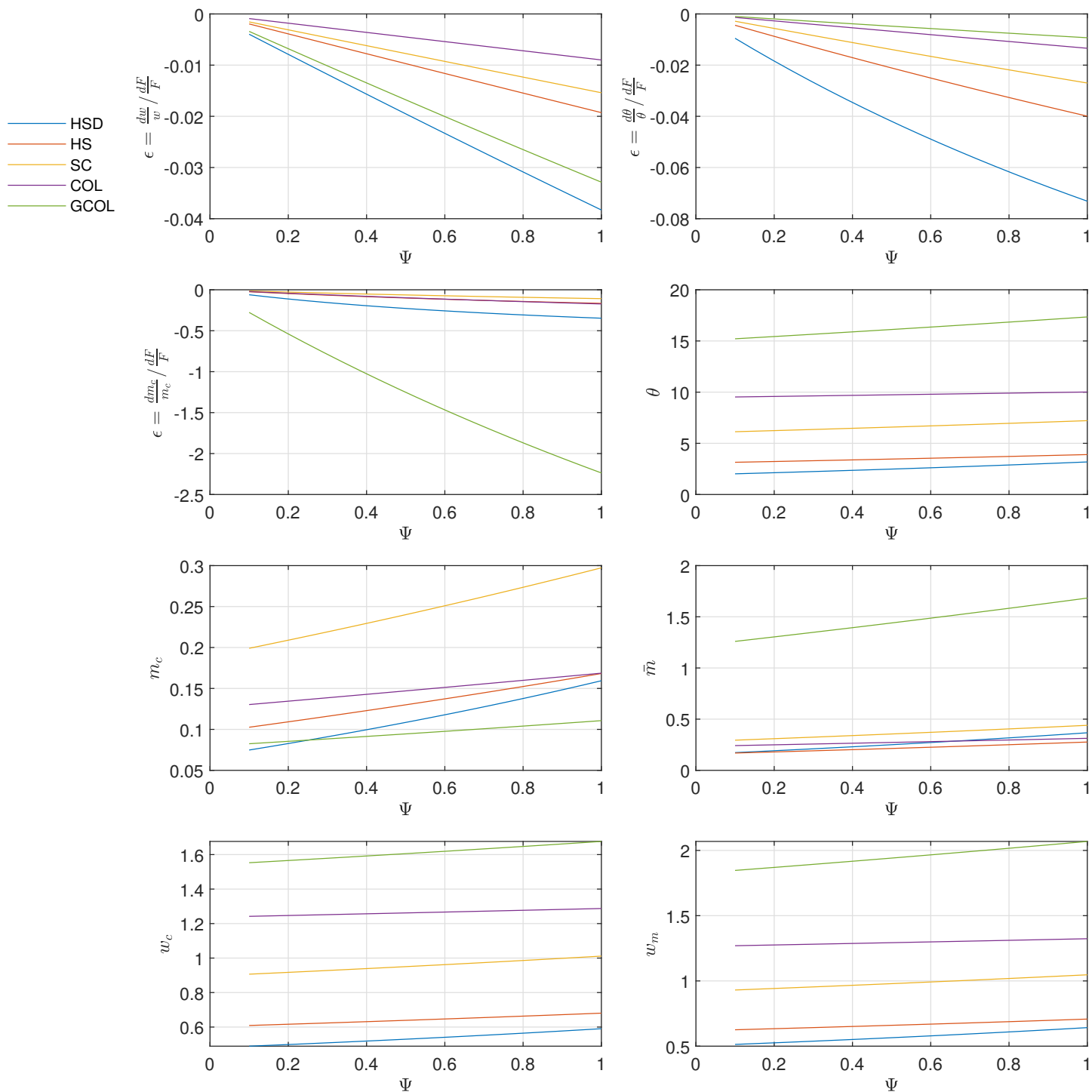


Figure 3.4 – The United States Labor Market

who found positive effects of reduced firing costs on wages for groups directly affected by labor market reforms in Spain. Cervini-Plá et al. (2014) focused on the effects of reductions in payroll taxes and firing costs using a matching model, highlighting the effects on entry wages of new entrants and incumbents. Their study highlights unclear effects of payroll taxes on wages and, akin to the results discussed here, negative effects of firing costs on new entry wages, as firms could transfer part of the firing costs to new jobs, thereby diminishing workers' bargaining power. For incumbent workers, increasing firing costs also reduced wages, as they anticipated lower match surplus when transitioning to another job. Using standard difference-in-difference estimations, Cervini-Plá et al. (2014) compare individuals affected by the reform (young and old workers) with those in the prime working age, and find estimations suggesting that reduced firing costs and payroll taxes increased wages for new entrants and incumbents.

The findings in this chapter are also echoed in the work of Doepke and Gaetani (2020), who identified a negative effect of firing costs on the wage premium under certain circumstances, albeit with a different approach. Doepke and Gaetani (2020) argued that employment protection is determinant in explaining the college wage premium due to its impact on the incentives of firms and workers to invest in productive relationships. Their framework, unlike the model presented here, implies on-the-job skill accumulation, driving income inequalities among workers: firms can create jobs conducive to skill accumulation or low-quality jobs where workers remain stagnant. Their analysis might elucidate differences in trends of the college wage premium between the United States and Germany. The underlying mechanism is as follows: the decrease in investment in specific human capital among less-educated workers leads to a reduction in average human capital, thereby lowering wages and increasing the college wage premium.

3.6 Conclusions

Wages in the United States have exhibited divergent trends alongside increasing employment protection in recent decades. The econometric analysis in this chapter, employing a difference-in-difference approach with staggered timing, reveals a negative impact of state policy reforms on the wages of high school dropouts and individuals with education levels beyond college. Conversely, there are no significant effects on wages for other educational categories, indicating a polarized effect. Specifically, wages for high school dropouts and those with education levels beyond college significantly declined in

states with stricter employment protection regulations, suggesting increased inequalities between these groups.

Future iterations of this chapter should consider including covariates, such as the political leaning of each state, which remains relatively constant over shorter periods, to address potential issues arising from the unconditional parallel trends assumption. Additionally, given the limited number of observations, conducting a county-level analysis could be beneficial.

Regarding the theoretical framework, this study highlights several novel findings that have received limited attention in the existing literature, particularly the negative effect of increased employment protection on labor market tightness and the dismissal threshold. These factors appear to be the driving forces behind the negative impact of firing costs on wages for individuals at the lower and upper ends of the wage-educational distribution. Moreover, the US labor market demonstrates a convex profile for the share of firms affected by idiosyncratic shocks across different education levels. Thus, a combination of idiosyncratic shocks, worker-productivity levels, labor market tightness, dismissal thresholds, job finding, and job separation rates explains why the adoption of exceptions to employment-at-will appears to negatively affect the tails of the wage-educational distribution.

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3.A Wages and Employment Protection

Taking into account the granular decomposition of the education variable, Figure 3.5 presents the evolution of the college wage premium and wages for a detailed classification of education levels. While Figure 3.5 shows similar patterns to those presented in Acemoglu and Autor (2011), the values do not entirely match due to differences in methodology and data used.¹¹

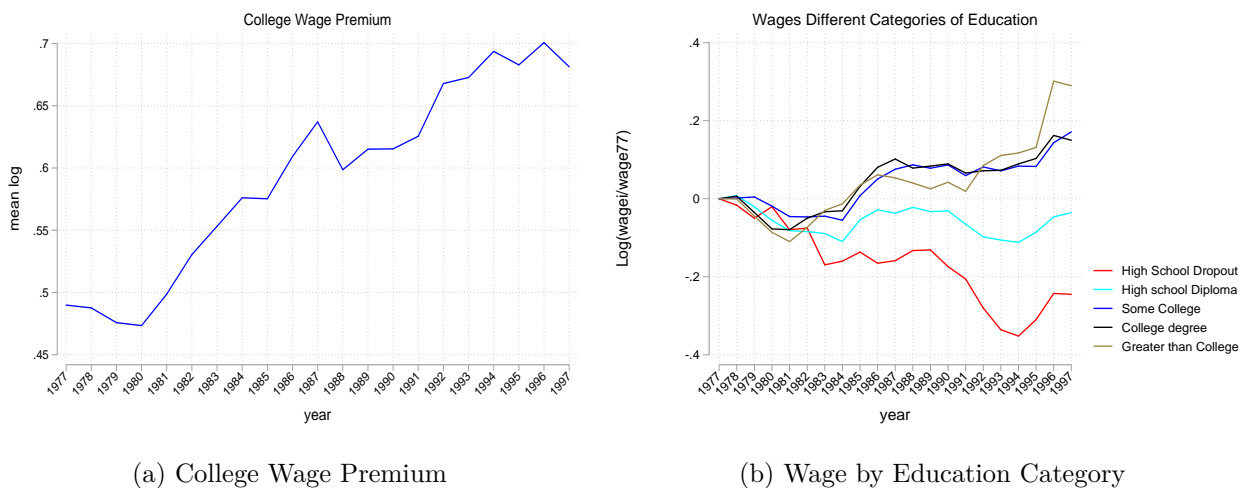


Figure 3.5 – College Decomposition and Wage Decomposition

The graphs depict information based on similar computations done by Acemoglu and Autor (2011) but using a restricted data sample. Panel (a) and (b) are computed using the entire territory of the United States. The college wage premium was computed as the ratio of the wages of individuals with a bachelor degree or four years of college degree over individuals with a high school diploma or 12 years of education.

Wage trends by educational category in the United States have displayed divergent patterns in recent decades. During the "Great Compression" of the 1940s, wage inequal-

11. Acemoglu and Autor (2011) measured the wage premium as the "adjusted log college/high school weekly wage premium in the US labor market ... for full-time, full-year workers." They used more observations over a larger period, and the normalization of the variables is done with respect to the year 1963, whereas here it is with respect to 1973.

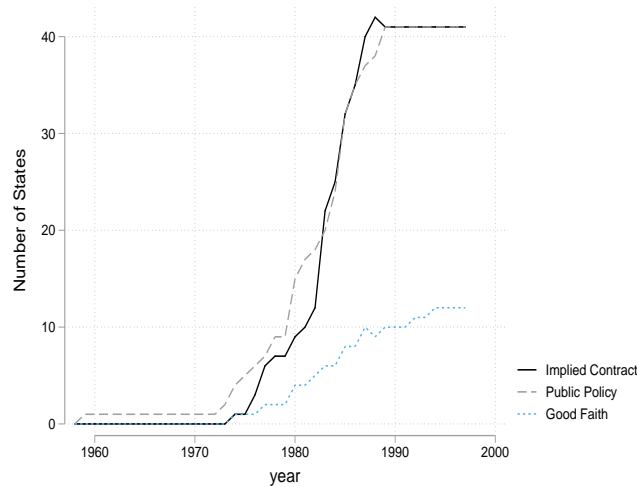
ity decreased due to higher demand for less skilled labor during wartime, wage-fixing approaches, and fluctuations in the supply and demand for educated workers. This period also saw a substantial increase in the supply of highly educated workers (Goldin & Margo, 1992). Despite documented wage convergence in the manufacturing sector later on (Blanchard & Katz, 1992), the college/high school wage premium has risen over the past decades.¹² This increase is primarily driven by the persistent decline in wages for high school diploma holders and high school dropouts, contributing to growing wage inequality and variations in wages based on educational attainment since the 1970s (Katz & Autor, 1999). These trends can also be partially attributed to increased productivity growth across states. Technological change has broadly heightened the relative demand for highly skilled and educated workers while reducing the demand for physically intensive labor, playing a pivotal role in explaining rising wage inequality (Katz & Murphy, 1992).

The "canonical model" of technical progress, as outlined by Tinbergen (1974), Tinbergen (1975), and Acemoglu and Autor (2011), predicts that wages for various educational categories should increase due to factor-augmenting technical change. However, considering detailed categories of education and empirical findings, this technological change hypothesis seems less relevant for individuals without university degrees. In this regard, Acemoglu and Autor (2011) identify the following key points: *(i)* significant reductions in real wages for low-skilled workers since the 1980s, *(ii)* heterogeneity in earnings levels, *(iii)* convex returns to education, *(iv)* diversity in the effects on the employment distribution across occupations with varying skill levels, and *(v)* the introduction of new technology that partially substitutes capital for tasks initially performed by middle-skill workers.

On the other hand, firing costs increased in the United States during 1977-1997 due to state enactments of laws, thereby constraining firms' optimal firing decisions. Starting in 1972, most states began implementing exceptions to the employment-at-will policy. Figure (3.6) illustrates the number of states adopting these exceptions over time. Specifically, the solid black line represents the adoption of the implied contract exception, the dotted blue line signifies states adopting the public policy exception, and the dotted gray line corresponds to the number of states adopting the good faith exception¹³. The graph indicates a rising trend in states regulating the employment-at-will doctrine, which consequently affects firms' optimal firing decisions.

12. For an extensive historical review of wage determinants, see Katz and Autor (1999)

13. Panel (a) of this graph is also presented in Autor (2003)



(a) Number of States Adopting Exceptions

Figure 3.6 – Adoption of Exceptions to the Employment-at-will

The graphs were computed using data provided by Autor (2003). (a) The slope of each line corresponds to the number of states adopting the respective reform, e.g. around 10 states implemented the implied contract exception in 1980.

3.B Further Details of the Data Set

3.B.1 Five Educational Categories

Wages The panel is based on data from the Current Population Survey (CPS), particularly individual-level information encompassing wages, educational attainment, household residence, and other pertinent demographic characteristics. The variable *wages*, central to this analysis and used throughout the paper, is based on `INCWAGE` from the CPS (IPUMS version), which provides information on the nominal total pre-tax wage and salary income received as an employee for the previous calendar year. The survey question related to this variable has slightly changed over the years. Specifically, from 1962-1968, respondents were asked how much they earned in wages and salary. Between 1969-1979, the interviewers asked about wages or salary before any deductions. Thereafter, respondents included overtime pay, tips, bonuses, and commissions from their primary employer, and money received from other employers. This might represent an overestimation of the latter trends, which is not corrected in the current analysis.

In terms of comparability, for the census waves of 1960 and 1970 and the CPS survey

between 1962-1979, individuals surveyed were 14 years old and above. For the 1980, 1990, and 2000 censuses, the minimum age was 16, while it was 15 for the CPS starting in 1980. The variables denoting wage information for the different educational categories reflect the average wage within each group for a specific state in a given year. To ensure accurate comparisons, nominal values are adjusted for inflation using the CPI index retrieved from the IMF website.

Education This paper constructs and analyzes five educational variables using the CPS (IPUMS version) variables `educ` and `higrade`. Workers were classified into five different groups: (*i*). High school dropouts, defined as individuals with 0 to 12 years of incomplete education; (*ii*). High school diploma holders, individuals with 12 years of education or who have certified holding a high school diploma; (*iii*). Individuals with some college education, those who completed one, two, or three years of college or did not finish four years of college; (*iv*). College-educated workers, individuals who have certified holding a college degree or completed four years of college education; and (*v*). Individuals with education beyond a college degree, including those who certify holding a master's or PhD or completed more than four years of college education. It is important to note that due to data availability, it is not always possible to verify if the individual holds the specific diploma.

States Included in the Sample

The final data set is a strongly balanced panel, including specific states that meet certain criteria. The states considered in the analysis are listed in Table 3.3. Some states were excluded from the final sample because it was not possible to obtain wage information prior to the implementation of exceptions for every state. To compare states that adopted the exceptions with those that did not across different decades, wage information must be available before the year of the reform implementation. The District of Columbia was also excluded due to the lack of available information on adopted exceptions to employment-at-will.

The final panel used in the empirical section of this chapter, which illustrates the effects of firing costs on wages, is summarized in Table 3.4.

Table 3.3 – States Considered in the Sample and First Year of Implementation of the Reforms

States considered	First year	States considered	First year
West Virginia	1978	Nebraska	1983
Arkansas	1980	Nevada	1983
Connecticut	1980	South Dakota	1983
Montana	1980	Virginia	1983
New Jersey	1980	North Dakota	1984
New Mexico	1980	Texas	1984
Wisconsin	1980	Iowa	1985
Kansas	1981	North Carolina	1985
Maryland	1981	South Carolina	1985
Tennessee	1981	Vermont	1985
Hawaii	1982	Wyoming	1985
New York	1982	Utah	1986
Ohio	1982	Alabama	1987
Alaska	1983	Mississippi	1987
Arizona	1983	Delaware	1992
Colorado	1983	Florida	0
Kentucky	1983	Georgia	0
Minnesota	1983	Louisiana	0
Missouri	1983	Rhode Island	0

Table 3.4 – Distribution of the Observations by Year

Survey year	Frequency	Percent	Survey year	Frequency	Percent
1977	38	4.76	1988	38	4.76
1978	38	4.76	1989	38	4.76
1979	38	4.76	1990	38	4.76
1980	38	4.76	1991	38	4.76
1981	38	4.76	1992	38	4.76
1982	38	4.76	1993	38	4.76
1983	38	4.76	1994	38	4.76
1984	38	4.76	1995	38	4.76
1985	38	4.76	1996	38	4.76
1986	38	4.76	1997	38	4.76
1987	38	4.76	Total	798	100

Table 3.5 – Starting Time of the Adoption of Exceptions

States enacted first regulation	year	States enacted first regulation	year
California	1959	Alaska	1983
Indiana	1973	Arizona	1983
Illinois	1974	Colorado	1983
New Hampshire	1974	Kentucky	1983
Pennsylvania	1974	Minnesota	1983
Oregon	1975	Missouri	1983
Michigan	1976	Nebraska	1983
Oklahoma	1976	Nevada	1983
Idaho	1977	South Dakota	1983
Maine	1977	Virginia	1983
Massachusetts	1977	North Dakota	1984
Washington	1977	Texas	1984
West Virginia	1978	Iowa	1985
Arkansas	1980	North Carolina	1985
Connecticut	1980	South Carolina	1985
Montana	1980	Vermont	1985
New Jersey	1980	Wyoming	1985
New Mexico	1980	Utah	1986
Wisconsin	1980	Alabama	1987
Kansas	1981	Mississippi	1987
Maryland	1981	Delaware	1992
Tennessee	1981	Florida	0
Hawaii	1982	Georgia	0
New York	1982	Louisiana	0
Ohio	1982	Rhode Island	0
		DC	NA

Information retrieved from Autor (2003)

3.C Evolution of the Wages Pre and Post Treatment

3.D Characteristics of the Selected States

Figures below present the main characteristics of the selected states figures 3.7 3.8 3.9

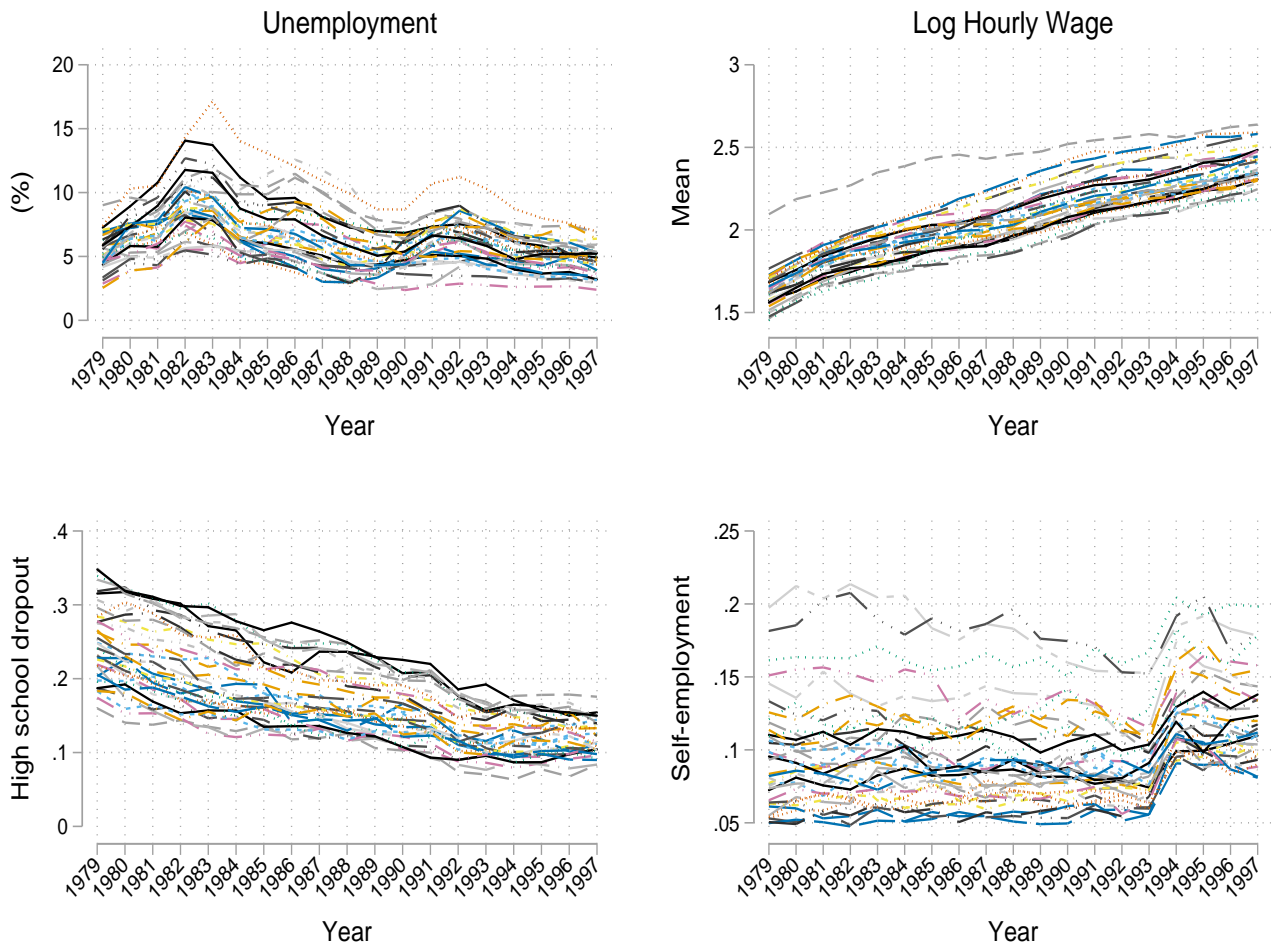


Figure 3.7 – Evolution Across Selected States of Certain Characteristics

The graphs used data from Autor (2003). Each line on the graph corresponds to a specific state.

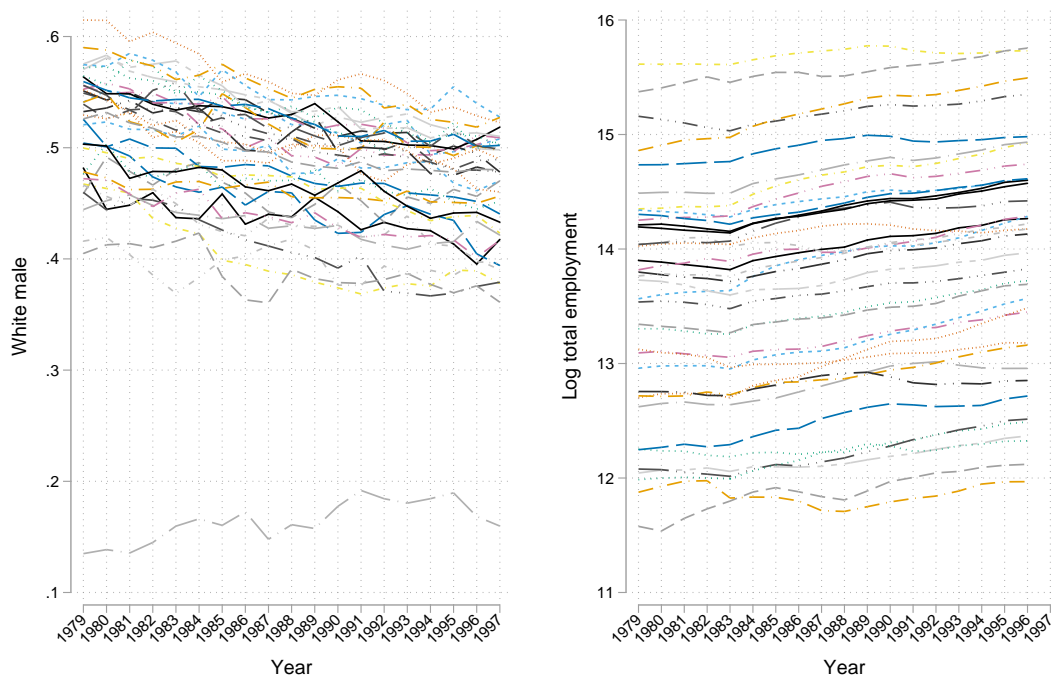


Figure 3.8 – **Evolution Across Selected States of Certain Characteristics**
The graphs used data from Autor (2003). Each line on the graph corresponds to a specific state.

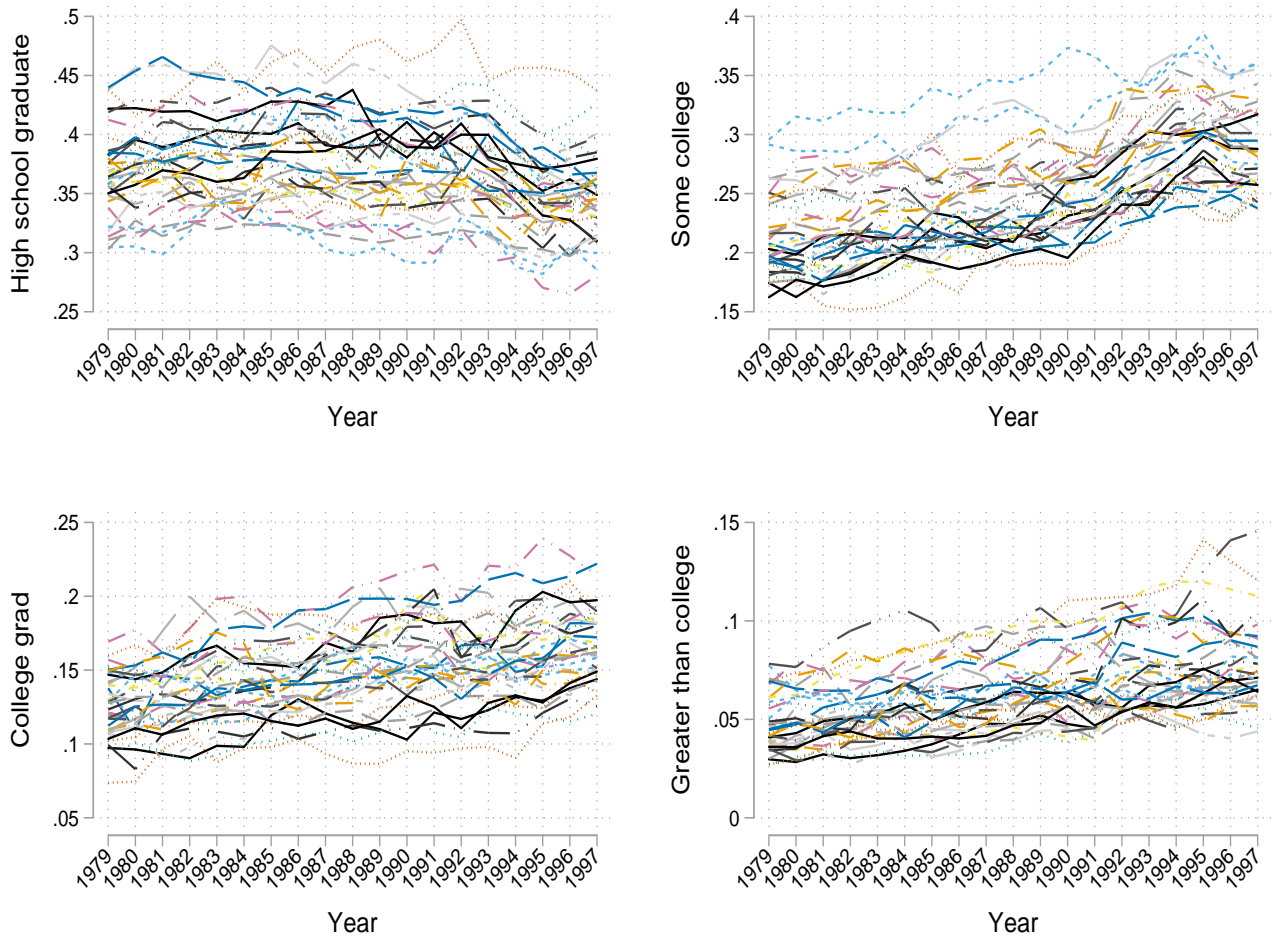


Figure 3.9 – Evolution Across Selected States of Certain Characteristics
 The graphs used data from Autor, 2003. Each line on the graph corresponds to a specific state.

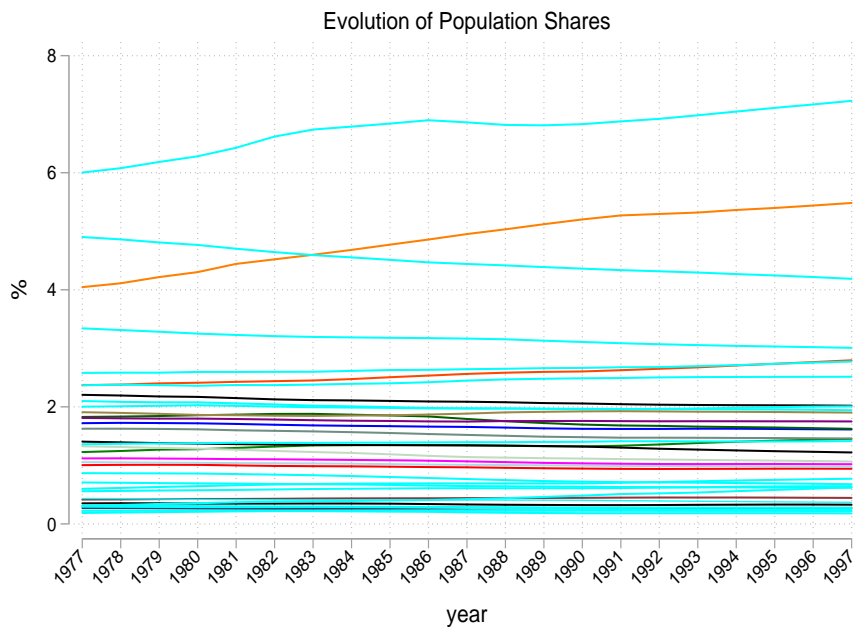


Figure 3.10 – **Population shares**

The figure presents the evolution of the population shares for the selected states used in the analysis. Each line represents a different state. Total shares have been computed as the population in that particular state for a specific year over the total United States population. These computations use data from the United States Census Bureau accessible on <https://www2.census.gov/programs-surveys/popest/datasets/>

3.E Complete Estimates

Table 3.6 – High School Dropout Wages Aggregated Treatment Effects Estimates

Unconditional Parallel Trends (without covariates. Not yet as comparison)										
Partially Aggregation of the Parameters										
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992
Simple Weighted Average										Agg Parameter -0.0882238 (0.014)
Group-Specific Effects	-0.3451157 0	-0.0948199 (0.935)	-0.0448734 (0.058)	-0.0755454 (0.19)	-0.038531 (0.688)	-0.1461078 (0.037)	-0.1281563 (0.301)	-0.1121024 (0.024)	-0.0286139 (0.051)	-0.2934989 0
Unconditional Parallel Trends (without covariates. Never treated as comparison)										
Partially Aggregation of the Parameters										
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992
Simple Weighted Average										Agg. Parameter -0.0770333 (0.038)
Group-Specific Effects	-0.3442755 0	-0.089353 (0.057)	-0.048383 (0.342)	-0.0530072 (0.551)	-0.0206341 (0.747)	-0.1401262 (0.002)	-0.1135065 (0.015)	-0.1037717 (0.149)	-0.0153071 (0.771)	-0.2934989 0

Table 3.7 – High School Wages Aggregated Treatment Effects Estimates

Unconditional Parallel Trends (without covariates. Not yet as comparison)										
Partially Aggregation of the Parameters										
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992
Simple Weighted Average										Agg Parameter -0.0159317 (0.496)
Group-Specific Effects	-0.185928 0	-0.0028143 (0.954)	-0.04037 (0.006)	-0.0644322 (0.011)	-0.008811 (0.771)	-0.019861 (0.652)	0.0349364 (0.298)	0.0250069 (0.015)	0.0390874 (0.659)	-0.013271 -0.0840252 0
Unconditional Parallel Trends (without covariates. Never treated as comparison)										
Partially Aggregation of the Parameters										
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992
Simple Weighted Average										Agg Parameter -0.0138913 (0.593)
Group-Specific Effects	-0.1950205 0	0.0065667 (0.907)	-0.0505405 0	-0.0684348 (0.03)	-0.004599 (0.887)	-0.0141721 (0.772)	0.0353487 (0.315)	0.030545 (0.001)	0.0407151 (0.647)	-0.0112408 -0.0840252 0

Table 3.8 – Some College Wages Aggregated Treatment Effects Estimates

Unconditional Parallel Trends (without covariates. Not yet as comparison)											
Partially Aggregation of the Parameters											
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter
Simple Weighted Average											-0.0321528 (0.341)
Group-Specific Effects	-0.1620597 0	-0.0170282 (0.66)	-0.0637595 (0.202)	-0.047706 (0.305)	-0.045784 (0.318)	-0.1350985 (0.001)	0.0797272 (0.133)	-0.0053679 (0.85)	0.0148047 (0.781)	-0.094875 0	-0.0293724 (0.352)
Unconditional Parallel Trends (without covariates. Never treated as comparison)											
Partially Aggregation of the Parameters											
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter
Simple Weighted Average											-0.0257788 (0.478)
Group-Specific Effects	-0.1836681 0	0.0027898 (0.95)	-0.059593 (0.257)	-0.0531167 (0.317)	-0.0448593 (0.37)	-0.1417716 (0.003)	0.0985685 (0.094)	0.0231681 (0.28)	0.0180238 (0.735)	-0.094875 0	-0.0229415 (0.499)

Table 3.9 – College Wages Aggregated Treatment Effects Estimates

Unconditional Parallel Trends (without covariates. Not yet as comparison)											
Partially Aggregation of the Parameters											
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter
Simple Weighted Average											-0.0246264 (0.501)
Group-Specific Effects	-0.156009 0	-0.0447818 (0.268)	0.0095987 (0.864)	-0.0472113 (0.39)	-0.0320007 (0.545)	-0.0599452 (0.279)	0.0104617 (0.881)	0.1440697 0	-0.0755059 (0.095)	0.4840993 0	-0.0131756 (0.679)
Unconditional Parallel Trends (without covariates. Never treated as comparison)											
Partially Aggregation of the Parameters											
	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter
Simple Weighted Average											-0.0407847 (0.268)
Group-Specific Effects	-0.1951841 0	-0.043869 (0.351)	0.0033894 (0.964)	-0.0714694 (0.172)	-0.0602414 (0.269)	-0.0839769 (0.17)	-0.0044821 (0.952)	0.1381697 0	-0.0811235 (0.095)	0.4840993 0	-0.0292763 (0.384)

Table 3.10 – Greater than College Wages Aggregated Treatment Effects Estimates

Unconditional Parallel Trends (without covariates. Not yet)												
Partially Aggregation of the Parameters												
Simple Weighted Average	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter	
Group-Specific Effects	0.0695677 (0.017)	-0.0105801 (0.896)	-0.0401812 (0.465)	-0.0126935 (0.562)	-0.1148469 (0.02)	-0.1393085 (0.079)	-0.0077066 (0.907)	0.0158697 (0.318)	-0.1303625 (0.084)	-0.189695 0	-0.0603737 (0.006)	-0.054616 (0.029)
Unconditional Parallel Trends (without covariates. Never treated as comparison)												
Partially Aggregation of the Parameters												
Simple Weighted Average	1978	1980	1981	1982	1983	1984	1985	1986	1987	1992	Agg Parameter	
Group-Specific Effects	0.0752623 (0.053)	-0.0273693 (0.783)	-0.0627009 (0.359)	-0.0365957 (0.101)	-0.1444209 (0.011)	-0.1648735 (0.032)	-0.0240632 (0.713)	0.0163435 (0.279)	-0.1212052 (0.113)	-0.189695 0	-0.0793199 (0.00)	-0.0742299 (0.002)

3.F Complete Solution to the Model

There exists two wages in the presence of firing costs: inside $w(m, \eta)$ and outside $w_0(\bar{m}, \eta)$. Initially, when the job is created, the productivity is at the maximum level ($m = \bar{m}$) and the firing costs are not operative. The **outside** wages are set to maximize the Nash rule.

$$S_0 = (E(\bar{m}, \eta) - U(\eta))^\beta (J(\bar{m}, \eta) - V)^{1-\beta}$$

β is the bargaining power of the worker with $\beta \in (0, 1)$.

Therefore,

$$\frac{\partial S_0}{\partial w_0(\bar{m}, \eta)} = \beta \frac{\partial E(\bar{m}, \eta)}{\partial w_0(\bar{m}, \eta)} [J(\bar{m}, \eta) - V] + (1 - \beta) \frac{\partial J(\bar{m}, \eta)}{\partial w_0(\bar{m}, \eta)} [E(\bar{m}, \eta) - U(\eta)]$$

In order to find the **inside** wage, we need to take into account the firing costs in the Nash rule.

$$S = (E(m, \eta) - U(\eta))^\beta (J(m, \eta) - V + F)^{1-\beta}$$

Therefore,

$$\frac{\partial S}{\partial w(m, \eta)} = \beta \frac{\partial E(m, \eta)}{\partial w(m, \eta)} [J(m, \eta) + F] + (1 - \beta) \frac{\partial J(m, \eta)}{\partial w(m, \eta)} [E(m, \eta) - U(\eta)]$$

Assuming free entry of the firms $V = 0$ and using the expressions above, we can obtain the following expression given the outside wages.

$$\begin{aligned} \frac{\beta}{r + \gamma} (J(\bar{m}, \eta) - V) &= \frac{(1 - \beta)}{r + \gamma} [E(\bar{m}, \eta) - U(\eta)] \\ -\beta J(\bar{m}, \eta) + (1 - \beta) E(\bar{m}, \eta) &= (1 - \beta) U(\eta) \\ \frac{\beta}{1 - \beta} J(\bar{m}, \eta) &= E(\bar{m}, \eta) - U(\eta) \end{aligned}$$

In the case of the **inside** wages, expression above becomes:

$$\begin{aligned}\frac{\beta}{r + \gamma}(J(\bar{m}, \eta) + F) &= \frac{(1 - \beta)}{r + \gamma}[E(\bar{m}, \eta) - U(\eta)] \\ \beta J(m, \eta) - (1 - \beta)E(m, \eta) &= -(1 - \beta)U(\eta) - \beta F\end{aligned}$$

Using the previous expressions we are able to find outside w_0 and inside w wages. Replacing by its respective asset value equations:

$$\begin{aligned}&\beta \left\{ \bar{m} + \eta - w_0(\bar{m}, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} J(x, \eta)g(x) dx - G(m_c(\eta))F \right] \right\} = \\ &(1 - \beta) \left\{ w_0(\bar{m}, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} E(x, \eta)g(x) dx + G(m_c(\eta))U(\eta) \right] - (r + \gamma)U(\eta) \right\}\end{aligned}$$

$$\begin{aligned}\beta(\bar{m} + \eta - \gamma G(m_c(\eta))F) &= w_0(\bar{m}, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} [(1 - \beta)E(x, \eta) - \beta J(x, \eta)]g(x) dx \right] + \\ &(1 - \beta)U(\eta)[G(m_c(\eta))\gamma - \gamma - r] \\ \beta(\bar{m} + \eta - \gamma G(m_c(\eta))F) &= w_0(\bar{m}, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} [(1 - \beta)U(\eta) + \beta F]g(x) dx \right] + (1 - \beta)U(\eta)[G(m_c(\eta))\gamma - \gamma - r] \\ \beta(\bar{m} + \eta - \gamma G(m_c(\eta))F) &= w_0(\bar{m}, \eta) + \gamma[(1 - \beta)U(\eta) + \beta F](1 - G(m_c(\eta))) + (1 - \beta)U(\eta)[G(m_c(\eta))\gamma - \gamma - r] \\ w_0(\bar{m}, \eta) &= \beta(\bar{m} + \eta - \gamma F) + (1 - \beta)b + f\beta J(\bar{m}, \eta)\end{aligned}$$

Hence, we need now to determine $J(\bar{m}, \eta)$. But let us before find **inside** wages. Following a similar procedure as previously, we obtain:

$$\begin{aligned}&\beta \left\{ m + \eta - w(m, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} J(x, \eta)g(x) dx - G(m_c(\eta))F \right] + (r + \gamma)F \right\} = \\ &(1 - \beta) \left\{ w(m, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} E(x, \eta)g(x) dx + G(m_c(\eta))U(\eta) \right] - (r + \gamma)U(\eta) \right\}\end{aligned}$$

$$\begin{aligned}
 \beta(m + \eta - \gamma G(m_c(\eta))F + (r + \gamma)F) &= w(m, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} [(1 - \beta)E(x, \eta) - \beta J(x, \eta)]g(x) dx \right] + \\
 &\quad (1 - \beta)U(\eta)[G(m_c(\eta))\gamma - \gamma - r] \\
 \beta(m + \eta - \gamma G(m_c(\eta))F + (r + \gamma)F) &= w(m, \eta) + \gamma[(1 - \beta)U(\eta) + \beta F](1 - G(m_c(\eta))) + \\
 &\quad (1 - \beta)U(\eta)[G(m_c(\eta))\gamma - \gamma - r] \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)rU(\eta) \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)[b + f(E(\bar{m}, \eta)) - U(\eta)] \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta fJ(\bar{m}, \eta)
 \end{aligned}$$

3.F.1 Finding $J(\bar{m}, \eta)$

Having the wages in function of $J(\bar{m}, \eta)$, then let us find firstly $J(m, \eta)$:

$$\begin{aligned}
 w(m, \eta) - w(m_c(\eta), \eta) &= \beta(m - m_c(\eta)) \\
 rJ(m, \eta) - rJ(m_c(\eta), \eta) &= (1 - \beta)(m - m_c(\eta)) - \gamma J(m, \eta) + \gamma J(m_c(\eta), \eta) \\
 r(J(m, \eta) - J(m_c(\eta), \eta)) + \gamma(J(m, \eta) - J(m_c(\eta), \eta)) &= (1 - \beta)(m - m_c(\eta)) \\
 (r + \gamma)(J(m, \eta) - J(m_c(\eta), \eta)) &= (1 - \beta)(m - m_c(\eta)) \\
 J(m, \eta) &= \frac{1 - \beta}{(r + \gamma)}(m - m_c(\eta)) - F
 \end{aligned}$$

Now, in order to find $J(\bar{m}, \eta)$ we need to correct for the discontinuity around \bar{m} . Indeed, we are going to show that $J(\bar{m}, \eta) = J(\bar{m}, \eta)^- + \beta F$

— $m \in [m_c(\eta), \bar{m})$

$$\begin{aligned}
 (r + \gamma)(J(m, \eta) + F) &= m + \eta + rF - w(m, \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} (J(x, \eta) + F)g(x) dx \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta fJ(\bar{m}, \eta) \Rightarrow \\
 (r + \gamma)(J(m, \eta) + F) &= (1 - \beta)(m + \eta + rF - b) - \beta fJ(\bar{m}, \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} (J(x, \eta) + F)g(x) dx
 \end{aligned}$$

— $m = \bar{m}$

$$\begin{aligned}
 (r + \gamma)J(\bar{m}, \eta) &= \bar{m} + \eta - \gamma F - w(\bar{m}, \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} (J(x, \eta) + F)g(x) dx \\
 w(\bar{m}, \eta) &= \beta(\bar{m} + \eta - \gamma F) + (1 - \beta)b + \beta fJ(\bar{m}, \eta) \Rightarrow \\
 (r + \gamma)J(\bar{m}, \eta) &= (1 - \beta)(\bar{m} + \eta - \gamma F - b) - \beta fJ(\bar{m}, \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} (J(x, \eta) + F)g(x) dx
 \end{aligned}$$

Then taking the limit by the left of $J(m, \eta)$ and replacing with \bar{m}

$$\begin{aligned} (r + \gamma)(J(\bar{m}, \eta)^- + F) &= (1 - \beta)(\bar{m} + \eta + rF - b) - \beta f J(\bar{m}, \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} (J(x, \eta) + F)g(x) dx \Rightarrow \\ (r + \gamma)(J(\bar{m}, \eta) - J(\bar{m}, \eta)^- - F) &= -(1 - \beta)(\gamma + r)F \\ J(\bar{m}, \eta) &= J(\bar{m}, \eta)^- + \beta F \end{aligned}$$

Hence, using the value $J(m, \eta) = \frac{1-\beta}{r+\gamma}(m - m_c(\eta)) - F$. We are able to determine $J(\bar{m}, \eta)$ and the different wages:

$$J(\bar{m}, \eta) = (1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

The Inside wage

$$w(m, \eta) = \beta(m + \eta + rF) + (1 - \beta)b + \beta f(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

The Outside wage

$$w_0(\bar{m}, \eta) = \beta(\bar{m} + \eta - \gamma F) + (1 - \beta)b + f\beta(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

3.F.2 The Effect of the Firing Costs

What is the impact of F on wages (assuming f exogenous)?

$m_c(\eta)$ is endogenous:

$$\begin{aligned}
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} J(x, \eta)g(x) dx - G(m_c(\eta))F \right] + \gamma F \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} J(x, \eta)g(x) dx + \gamma(1 - G(m_c(\eta)))F \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \int_{m_c(\eta)}^{\bar{m}} \left(\frac{1-\beta}{r+\gamma}(x - m_c(\eta)) - F \right) g(x) dx + \gamma(1 - G(m_c(\eta)))F \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} xg(x) dx \\
 &\quad - \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} m_c(\eta)g(x) dx - \gamma \int_{m_c(\eta)}^{\bar{m}} Fg(x) dx + \gamma(1 - G(m_c(\eta)))F \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} xg(x) dx \\
 &\quad - \gamma \frac{1-\beta}{r+\gamma} (1 - G(m_c(\eta)))m_c(\eta) - \gamma(1 - G(m_c(\eta)))F + \gamma(1 - G(m_c(\eta)))F \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} xg(x) dx - \gamma \frac{1-\beta}{r+\gamma} (1 - G(m_c(\eta)))m_c(\eta) \\
 -Fr &= m_c(\eta) + \eta - w(m_c(\eta), \eta) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} (x - m_c(\eta))g(x) dx \\
 -Fr &= (1 - \beta)(m_c(\eta) + \eta) - \beta(r + f)F - (1 - \beta)b \\
 &\quad - \beta f \left((1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \right) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} (x - m_c(\eta))g(x) dx \\
 0 &= (1 - \beta)(m_c(\eta) + \eta + rF - b) \\
 &\quad - \beta f(1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) + \gamma \frac{1-\beta}{r+\gamma} \int_{m_c(\eta)}^{\bar{m}} (x - m_c(\eta))g(x) dx \\
 0 &= m_c(\eta) + \eta + rF - b - \beta f \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) + \frac{\gamma}{r + \gamma} \int_{m_c(\eta)}^{\bar{m}} (x - m_c(\eta))g(x) dx \quad (3.14)
 \end{aligned}$$

This condition, implies that avoiding dismissals, i.e. $m_c(\eta) \rightarrow 0$, there is the need that η is above a certain level, above which there won't be any dismissal.

Exogenous Meeting Rates

Proof. With exogenous meeting rates the effect of the firing costs can be found using the inside wage equation:

$$w(m, \eta) = \beta(m + \eta + rF) + (1 - \beta)b + \beta f(1 - \beta) \left[\frac{m - m_c(\eta)}{r + \gamma} - F \right]$$

$$\begin{aligned} \frac{dw(m, \eta)}{dF} &= -\beta f \frac{1 - \beta}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta r - \beta(1 - \beta)f \\ &= -\beta f \frac{1 - \beta}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta(r - (1 - \beta)f) \end{aligned}$$

Differentiating (3.14), we obtain $\frac{dm_c(\eta)}{dF}$ i.e.

$$\begin{aligned} 0 &= dm_c(\eta) + rdF + \frac{\beta f}{r + \gamma} dm_c(\eta) + \beta f dF - \frac{\gamma}{r + \gamma} (1 - G(m_c(\eta))) dm_c(\eta) \\ -(r + \beta f)dF &= \left(1 + \frac{\beta f}{\gamma + r} - \frac{\gamma}{\gamma + r} (1 - G(m_c(\eta))) \right) dm_c(\eta) \\ -(r + \beta f)dF &= \left(\frac{r + \beta f + \gamma G(m_c(\eta))}{\gamma + r} \right) dm_c(\eta) \\ \frac{dm_c(\eta)}{dF} &= -\frac{(r + \beta f)(r + \gamma)}{r + \beta f + \gamma G(m_c(\eta))} < 0 \end{aligned}$$

Since,

$$\frac{d}{dm_c(\eta)} \int_{m_c(\eta)}^{\bar{m}} (x - m_c(\eta))g(x) dx = -(m_c(\eta) - m_c(\eta))g(m_c(\eta)) - \int_{m_c(\eta)}^{\bar{m}} 1g(x) dx = -\int_{m_c(\eta)}^{\bar{m}} g(x) dx = -(1 - G(m_c(\eta)))$$

Therefore,

$$\begin{aligned} \frac{dw(m, \eta)}{dF} &= \beta f \frac{1 - \beta}{r + \gamma} \left(\frac{r + \beta f + \gamma G(m_c(\eta))}{(\gamma + r)(r + \beta f)} \right) + \beta(r - (1 - \beta)f) \\ &= \frac{\beta f(1 - \beta)[(r + \beta f)(1 + \gamma + r)(1 - \gamma - r) + \gamma G(m_c(\eta))] + (\gamma + r)^2 r^2 \beta}{(r + \gamma)^2 (r + \beta f)} > 0 \end{aligned}$$

The expression is then positive as long as $1 - (\gamma + r) > 0$.

□

Effects of Firing Costs on Wages. Endogenous Meeting Rates

Differentiating wages with respect to the firing costs with endogenous meeting rates.

$$\begin{aligned}
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta\theta q(\theta)(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right] \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta\theta q(\theta)(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} \right] - \beta\theta q(\theta)(1 - \beta)F \\
 w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta\theta q(\theta)(1 - \beta) \left[\frac{\bar{m}}{r + \gamma} \right] - \beta\theta q(\theta)(1 - \beta) \left[\frac{m_c(\eta)}{r + \gamma} \right] - \beta\theta q(\theta)(1 - \beta)F \\
 \\
 \frac{dw(m, \eta)}{dF} &= \beta r + \beta(1 - \beta) \left[\frac{\bar{m}}{r + \gamma} \right] (\theta q'(\theta) + q(\theta)) \frac{d\theta}{dF} - \beta(1 - \beta) \left[\frac{m_c(\eta)}{r + \gamma} \right] (\theta q'(\theta) + q(\theta)) \frac{d\theta}{dF} \\
 &\quad - \beta(1 - \beta)\theta q(\theta) \left[\frac{1}{r + \gamma} \right] \frac{dm_c(\eta)}{dF} - \beta(1 - \beta)\theta q(\theta) - \beta(1 - \beta)(\theta q'(\theta) + q(\theta))F \frac{d\theta}{dF} \\
 &= \beta r + (\beta(1 - \beta)(\theta q'(\theta) + q(\theta))) \left[\frac{\bar{m}}{r + \gamma} \frac{d\theta}{dF} - \frac{m_c(\eta)}{r + \gamma} \frac{d\theta}{dF} - F \frac{d\theta}{dF} \right] \\
 &\quad - \beta(1 - \beta)\theta q(\theta) \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right] \\
 &= \beta r + \beta(1 - \beta)(\theta q'(\theta) + q(\theta)) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right] \frac{d\theta}{dF} - \beta(1 - \beta)\theta q(\theta) \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right] \\
 &= \beta r + \beta(\theta q'(\theta) + q(\theta)) \frac{c}{q(\theta)} \frac{d\theta}{dF} - \beta(1 - \beta)\theta q(\theta) \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right]
 \end{aligned}$$

Before, when meeting rates were exogenous, the effect of the firing costs on wages was defined as follows:

$$\frac{dw(m, \eta)}{dF} = -\beta f \frac{1 - \beta}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta(r - (1 - \beta)f)$$

Therefore, re-expressing the effect of the firing costs on wages with endogenous meeting rates in terms of the last expression, we have:

$$\frac{dw(m, \eta)}{dF} = \underbrace{-\beta(1 - \beta)\theta q(\theta) \frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + \beta(r - (1 - \beta)\theta q(\theta))}_{\text{Expression 3.2}} + \underbrace{\beta(\theta q'(\theta) + q(\theta)) \frac{c}{q(\theta)} \frac{d\theta}{dF}}_{\text{New Expression}}$$

Endogenous Meeting Rates

Proof. Now consider endogenous meeting rates, hence

$$\begin{aligned} H &= (u, v) \\ q(\theta) &= \frac{H(u, v)}{v} = H\left(\frac{1}{\theta}, 1\right) \\ f &= \theta q(\theta) \end{aligned}$$

Job Destruction Condition

The asset value equation of a filled job and the wage equation (inside) are:

$$\begin{aligned} rJ(m, \eta) &= m + \eta - w(m, \eta) + \gamma \left[\int_{m_c(\eta)}^{\bar{m}} J(x, \eta) g(x) dx - G(m_c(\eta))F \right] - \gamma J(m, \eta) \\ w(m, \eta) &= \beta(m + \eta + rF) + (1 - \beta)b + \beta\theta q(\theta)(1 - \beta) \left[\frac{m - m_c(\eta)}{r + \gamma} - F \right] \end{aligned}$$

Using the fact that $J(m_c(\eta), \eta) = -F$

$$\begin{aligned} -F(r + \gamma) &= m_c(\eta) + \eta - \beta(m_c(\eta) + \eta + rF) - (1 - \beta)b - \beta\theta q(\theta)(1 - \beta) \left[\frac{m - m_c(\eta)}{r + \gamma} - F \right] + \\ &\quad \gamma(1 - \beta) \int_{m_c(\eta)}^{\bar{m}} \frac{x - m_c(\eta)}{\gamma + r} g(x) dx - \gamma G(m_c(\eta))F - \gamma F(1 - G(m_c(\eta))) \\ 0 &= m_c(\eta) + \eta - b - \beta\theta q(\theta) \frac{m - m_c(\eta)}{r + \gamma} + F(r + \beta\theta q(\theta)) + \gamma \int_{m_c(\eta)}^{\bar{m}} \frac{x - m_c(\eta)}{\gamma + r} g(x) dx \end{aligned}$$

Job Creation Condition

— Consider $w_0(\bar{m}, \eta) - w(m_c(\eta), \eta)$

$$\begin{aligned} w_0(\bar{m}, \eta) - w(m_c(\eta), \eta) &= \beta(\bar{m} - m_c(\eta)) - \beta F(r + \gamma) \Rightarrow \\ (J(\bar{m}, \eta) - J(m_c(\eta), \eta))(r + \gamma) &= (1 - \beta)(\bar{m} - m_c(\eta)) + \beta F(r + \gamma) \end{aligned}$$

— If we consider initially a segmented market (directed search) and the free entry condition:

$$\frac{C}{q(\theta)} = J(\bar{m}, \eta)$$

Hence, the Job creation condition (η_i , with i the level of education) using the version previously found for $J(\bar{m}, \eta)$

$$\frac{c}{q(\theta)} = (1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{\gamma + r} - F \right)$$

Total Differential Job Creation and Job Destruction Condition Now, to find the effects of the firing costs, let us compute the total differential of the job creation and job destruction conditions. The total differential of the job destruction is:

$$0 = \frac{dmc}{dF} \left[1 + \frac{\beta\theta q(\theta)}{r + \gamma} - \frac{\gamma}{\gamma + r} (1 - G(m_c(\eta))) \right] + \frac{d\theta}{dF} \left[(\theta q'(\theta) + q(\theta)) \left(-\frac{\beta\bar{m}}{r + \gamma} + \frac{\beta m_c(\eta)}{r + \gamma} + F\beta \right) \right] + r + \theta q(\theta)\beta$$

Subsequently, the differential total with respect to the firing cost is (derived from the job creation):

$$\frac{d\theta}{dF} = \frac{q(\theta)^2}{cq'(\theta)} (1 - \beta) \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right] = \theta q(\theta) \frac{q(\theta)}{cq'(\theta)\theta} (1 - \beta) \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right] = -\frac{(1 - \beta)f}{c\varepsilon_{q|\theta}} \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right]$$

$$\text{with } \varepsilon_{q|\theta} = -q'(\theta) \frac{\theta}{q(\theta)}$$

Which yields a system of 2 equations with two unknowns. By solving the system, we obtain:

$$\frac{dm_c(\eta)}{dF} = \frac{(-\varepsilon_{q|\theta}r - \beta q(\theta)\theta)(r + \gamma)}{\varepsilon_{q|\theta}(r + \gamma G(m_c(\eta))) + \beta q(\theta)\theta} < 0$$

$$\frac{d\theta}{dF} = -\frac{(1 - \beta)q(\theta)\theta\gamma G(m_c(\eta))}{\varepsilon_{q|\theta}(r + \gamma G(m_c(\eta))) + \beta q(\theta)\theta} < 0$$

□

3.G Deriving the Expression for $\frac{dw}{dF}$

Based on the proof 3.F.2. We can derive an expression to find $\frac{dw}{dF}$. Let us recall the equation for the wages:

$$w(m, \eta) = \beta(m + \eta + rF) + (1 - \beta)b + \beta f(1 - \beta) \left[\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right]$$

Then, the total differential can be expressed as:

$$\begin{aligned} \frac{dw(m, \eta)}{dF} &= r\beta + (\theta q'(\theta) + q(\theta))\beta \frac{c}{q(\theta)} \frac{d\theta}{dF} - \beta(1 - \beta)\theta q(\theta) \left[\frac{1}{\gamma + r} \frac{dm_c(\eta)}{dF} + 1 \right] \\ &= r\beta + (1 - \varepsilon_{q\theta})\beta c \frac{d\theta}{dF} - \beta(1 - \beta)f \left[\frac{1}{\gamma + r} \frac{dm_c(\eta)}{dF} + 1 \right] \end{aligned}$$

$$\begin{aligned} \frac{dw}{dF} &= r\beta - (1 - \varepsilon_{q\theta})\beta \frac{(1 - \beta)f}{\varepsilon_{q\theta}} \left[\frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} + 1 \right] - \beta(1 - \beta)f \left[\frac{1}{\gamma + r} \frac{dm_c(\eta)}{dF} + 1 \right] \\ &= r\beta - \beta(1 - \beta)f \frac{1}{\varepsilon_{q\theta}} - \beta(1 - \beta)f \frac{1}{\varepsilon_{q\theta}} \frac{1}{r + \gamma} \frac{dm_c(\eta)}{dF} \end{aligned}$$

Observe that in this case $f = \theta q(\theta)$. And after several transformations and replacing the respective derivatives, we find

$$\frac{dw}{dF} = \beta \left(\frac{r\varepsilon_{q\theta}(r + \gamma G(m_c(\eta))) + q(\theta)\theta(-(1 - \beta)\gamma G(m_c(\eta)) + r\beta)}{\varepsilon_{q\theta}(r + \gamma G(m_c(\eta))) + \beta q(\theta)\theta} \right)$$

The sign and therefore the direction of the effects is not possible to be determined.

3.H Determining the Effects of Firing Costs on $m_c(\eta)$

$$\begin{aligned}
 \frac{dm_c(\eta)}{dF} &= -\frac{q(\theta)\theta \left(r \frac{q'(\theta)}{(q(\theta))^2} - \beta \right) (r + \gamma)}{q(\theta)\theta \left(\frac{q'(\theta)}{(q(\theta))^2} (r + \gamma G(m_c(\eta))) - \beta \right)} \\
 &= -\frac{\left(r \frac{q'(\theta)}{(q(\theta))^2} - \beta \right) (r + \gamma)}{\left(\frac{q'(\theta)}{(q(\theta))^2} (r + \gamma G(m_c(\eta))) - \beta \right)} \\
 &= -\frac{(r q'(\theta) - \beta (q(\theta))^2) (r + \gamma)}{q'(\theta) (r + \gamma G(m_c(\eta))) - \beta (q(\theta))^2} \\
 &= -\frac{q'(\theta) \left(r - \beta \frac{q(\theta)^2}{q'(\theta)} \right) (r + \gamma)}{q'(\theta) \left(r + \gamma G(m_c(\eta)) - \beta \frac{q(\theta)^2}{q'(\theta)} \right)} \\
 &= -\frac{\left(r - \beta \frac{q(\theta)^2}{q'(\theta)} \right) (r + \gamma)}{\left(r + \gamma G(m_c(\eta)) - \beta \frac{q(\theta)^2}{q'(\theta)} \right)} \\
 &= -\frac{\left(r + \beta f \frac{1}{\varepsilon_{q|\theta}} \right) (r + \gamma)}{\left(r + \gamma G(m_c(\eta)) + \beta f \frac{1}{\varepsilon_{q|\theta}} \right)}
 \end{aligned}$$

Where $\frac{q(\theta)^2}{q'(\theta)} = \theta q(\theta) \frac{q(\theta)}{\theta} \frac{1}{q'(\theta)} = -f \frac{1}{\varepsilon}$, with $\varepsilon = |q'(\theta) \frac{\theta}{q(\theta)}|$.

3.I Calibration of the General Equilibrium Model

The system of equations can be presented as follows

$$0 = m_c(\eta) + \eta + rF - b + \frac{\gamma}{r + \gamma} \frac{(\bar{m} - m_c(\eta))^2}{2(\bar{m} - \underline{m})} - f\beta \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \quad (3.15)$$

$$\frac{c}{q} = (1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \quad (3.16)$$

$$fu = \gamma \frac{m_c(\eta) - \underline{m}}{\bar{m} - \underline{m}} (1 - u) \quad (3.17)$$

$$f = A\theta^\alpha \quad (3.18)$$

$$q = A\theta^{\alpha-1} \quad (3.19)$$

Therefore, the parameters of the model are $\{\underline{m}, \bar{m}, \eta, F, r, \gamma, \alpha, \beta, b, c, A\}$. And the unknowns are $\{m_c(\eta), f, q, \theta, u\}$.

The inside wage is

$$w(m) = \beta(m + \eta + rF) + (1 - \beta)b + (1 - \beta)f\beta \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right)$$

We impose f and the job separations rate $\delta = \gamma \frac{m_c(\eta) - m}{\bar{m} - m}$. We can re-calculate A and \bar{m} .

Imposing Ψ and hence $F = \Psi w_c$ with:

$$w_c = \beta(m_c(\eta) + \eta + rF) + (1 - \beta)b + (1 - \beta)f\beta \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right) \quad (3.20)$$

We can alternatively use the average productivity wage

$$\bar{w} = \beta \left(\frac{m_c(\eta) + \bar{m}}{2} + \eta + rF \right) + (1 - \beta)b + (1 - \beta)f\beta \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right)$$

With $F = \Psi \bar{w}$. Imposing $\underline{m} = 0$. We can obtain $\delta = \gamma \frac{m_c(\eta)}{\bar{m}}$ the relation $m_c(\eta) = \frac{\delta}{\gamma} \bar{m} = \phi \bar{m}$.

Replacing the expression $m_c(\eta) = \phi \bar{m}$ in (3.15), we obtain:

$$\left(\phi + \frac{\gamma}{r + \gamma} \frac{(1 - \phi)^2}{2} - f\beta \frac{1 - \phi}{r + \gamma} \right) \bar{m} + (r + f\beta)F = -\eta + b \quad (3.21)$$

Using $\frac{F}{\Psi} = w_c$ and $m_c(\eta) = \phi \bar{m}$ in (3.20), we obtain:

$$\left(\beta\phi + (1 - \beta)f\beta \frac{1 - \phi}{r + \gamma} \right) \bar{m} + \left(-\frac{1}{\Psi} + \beta r - (1 - \beta)f\beta \right) F = -\beta\eta - (1 - \beta)b \quad (3.22)$$

The expressions (3.21) and (3.22) are a system of equations in function of two unknowns

$\{\bar{m}, F\}$, which is possible to solve. Therefore:

$$\begin{aligned} m_c(\eta) &= \phi \bar{m} \\ u &= \frac{\delta}{f + \delta} \\ q &= \frac{c}{(1 - \beta) \left(\frac{\bar{m} - m_c(\eta)}{r + \gamma} - F \right)} \\ \theta &= \frac{f}{q} \\ A &= \frac{f}{\theta^\alpha} \end{aligned}$$

The two lines of the program are those representing graphically the solutions to equations (3.21) et (3.22):

$$\begin{aligned} F &= \frac{-\eta + b}{(r + f\beta)} - \frac{\left(\phi + \frac{\gamma}{r + \gamma} \frac{(1 - \phi)^2}{2} - f\beta \frac{1 - \phi}{r + \gamma} \right)}{(r + f\beta)} \bar{m} \\ F &= \frac{-\beta\eta - (1 - \beta)b}{\left(-\frac{1}{\Psi} + \beta r - (1 - \beta)f\beta \right)} - \frac{\left(\beta\phi + (1 - \beta)f\beta \frac{1 - \phi}{r + \gamma} \right)}{\left(-\frac{1}{\Psi} + \beta r - (1 - \beta)f\beta \right)} \bar{m} \end{aligned}$$

CONCLUDING REMARKS

The evolution of the educational attainment across generations is key for understanding the interplay between income inequalities, social mobility, the sustainability of the pension system and employment protection policies. This thesis finds this relationship is not ambiguously unidirectional. Indeed, increasing educational attainment across time has contributed to maintaining upward mobility, as indicators of income mobility has remained constant over the last decades in the United States. On the other hand, increasing educational levels might amplify the effects of savings accumulation on wealth transmission and income inequality within and between age groups, induced by pressures on the pension system. Furthermore, active employment protection policies might result in lower levels of dismissal thresholds and increases in the probability of negative productivity shocks among the very low and very high educated, driving up wage inequalities across different educational groups.

The first chapter concludes that educational mobility is a determining force to maintain the prospects of upward mobility in the United States. Universities have open up and this has resulted in large increases in educational levels of the population, and might have translated into increases in income prospects for the youths compared to their parents. Indeed, for children whose parents have had a tertiary education, the probability of attaining a bachelor's degree has remained stable for cohorts born between 1957 and 1964, but has increased for those born between 1980 and 1984.

Educational transition might amplify the reproduction of the elites as having highly educated parents has strong effects on the earnings of their children. This result is consistent with the view that highly educated parents invest more in their children and send them to better quality schools, increasing their cognitive skills and completing more years of schooling, which ultimately affects the children's earnings. This being said, increasing access to education for all has kept the plausibility of the "American dream" but at the same time, it has also reinforced the reproduction of elites.

Another prominent point raised by this thesis is the interaction between educational skills and savings, underlying in the model with heterogeneous agents developed in chapter two. Indeed, the distribution of skills plays a role in determining the effects of the increase

in savings- and hence on wealth inequalities-, induced by pressures on the pensions system from demographic transformations. Higher savings rates among the highly educated, rise up wealth inequalities not only between age group but also intergenerational, as the highly educated might inherit higher bequests to their children. The educational transition might not be enough to reduce the risk of lower earnings for the children of less educated parents as analyzed in chapter one; therefore, less educated parents are also pressured to increase their savings not only to smooth consumption later in life but also, to insure their children against low labor earnings.

In addition to the interplay between the savings and the level of education, the need for savings also varies in function of the instrument used to recover the sustainability of the pensions system. This sustainability implies either changes in labor income tax rate, variations in pensions or changes in the retirement age. If the sustainability of the pension system is made through variations in taxes then, at the beginning of the adjustment period, households will work more and increase their savings that will finance their lifespan lengthening and those of their children. Subsequently after various adjustment years, households will reduce their labor supply. At the same time, the rising educational levels overcompensates the distortions caused by increases in the labor income tax rate, inducing wealth to increase and subsequently, GDP gains. Without an increase in the level of education, the US GDP would stagnate. This adjustment tends to magnify between age inequality, as it increases the probability of being financially constrained, affecting the youths, who may be less insured due to lower levels of wealth among their parents making smaller bequests.

If the sustainability of the PAYG system is ensured by pensions adjustments, the need for savings is greater and the distortion on the labor supply lower: the effort at work is then always higher than initially, and the gains in GDP, also supported by the rise in the level of education, are higher because the accumulation of savings is greater. In this case, inequalities are also strong because retirees may have retired without sufficient savings after poor employment histories and can't rely on generous pensions.

Finally, the extension of the lifespan activity allows a greater increase in the US GDP. Allocating the extension of lifespan to the labor market, leads to the maximum use of investments in education; however, the increase in inequality is the greatest. Indeed, by promoting economic activity which is increasingly carried out by increasingly educated individuals, strong gaps are widening between those with high wage income and high savings rates and those who remain at the bottom of the social ladder.

The interplay between wages across different educational categories and employment protection policies, highlighted in the third chapter, is also a relevant point for the understanding of the role of education on income inequalities. Indeed, employment protection policies can potentially amplify the effects of search frictions on employment and wages, because firms are intended to lower their dismissal thresholds if employment protection regulations are increasing. In this scenario, chapter three finds that labor market tightness is also lower. These results together with a non linear profile for the arrival rate of the idiosyncratic shocks, led to negative effects of firing costs on wages for individuals at the lower and upper ends of the wage-educational distribution in the United States.

Having a better understanding of the interaction between the increase in the educational levels among individuals in the United States and income inequalities, permits to disentangle the the optimal mechanisms needed for the design of policies to ensure the sustainability of the pensions system, the employment protection and the access to the educational system.

Title: Three Essays on Macroeconomics and Income Inequality

Keywords: Income Inequality, Education, Pensions, Macroeconomics, Heterogeneous agents, Employment protection, Wages, Income mobility.

Abstract: This thesis examines intergenerational income mobility, the sustainability of the pension system, and labor protection policies in the United States. Despite covering seemingly different topics, they are all analyzed through the lens of income and wealth inequalities using macroeconomic tools. Furthermore, education emerges as a crucial determinant across all three chapters, shaping the results. The link between education, income, and wealth inequalities is indeed fundamental.

Chapter one, measures the evolution of intergenerational income and educational mobility and whether access to opportunities in the American economy has become more open over time. We provide estimates for intergenerational income elasticities, rank-rank income correlations, and educational-income transition matrices using the two cohorts of the National Longitudinal Survey of Youth (1979, 1997) administered by the Bureau of Labor Statistics of the United States. We find that since the 1980s, educational mobility, both upward and downward, has increased. This suggests that the American system manages to provide the same educational opportunities to all children regardless of their parents' education level. We also find that the impact of the income rank of parents without a university degree is very low on the income rank of their children.

Chapter two addresses the latent issue of pension sustainability in the United States. It looks into the necessary reforms to counter the effects of an aging population on the sustainability of the pension system in an economy with increasing levels of education. It also explores whether rising educational attainment can mitigate the strain on the pen-

sion system. The increase in life expectancy at 65 years old, from 14.5 years in 1960 to 21.5 years in 2100, has placed significant pressure on the dependency ratio, expected to surge from 2.6% in 2010 to 38.6% in 2060. Ensuring pension sustainability has thus become a priority on the political agenda. Concurrently, there has been an increasing trend in education levels, as discussed in Chapter one. Might this increasing trend in educational attainment affect the effectiveness of instruments implemented to ensure pension sustainability?

Chapter two introduces a heterogeneous agent model to understand pension system sustainability in the context of increasing life expectancy and a lowering dependency ratio. We explore various reform options, including adjustments to income tax rates, pension levels, and retirement age. We take into account the evolution of educational attainment and the average career development linked to employment experience, distinguishing between the labor market for graduates and non-graduates.

We find that variations in income tax and pension rates increase distortions in labor supply, reducing work-related remuneration. These adjustments also tend to increase the probability for youths to be financially constrained. However, the distortions in labor supply vanish when increasing the retirement age, but this raises the problem of optimal time allocation between work and leisure over the life cycle. The increase in education level does not significantly affect fiscal budget sustainability, even though it allows a significant increase in GDP. Adjustments via tax increases or pension reductions increase wealth inequalities, which are higher when raising the

retirement age.

Chapter three addresses how variations in employment protection regulations across US states affect wage differentials between educational categories. These effects appear influenced by workers' education levels. Labor market policies play a determinant role in intergenerational income mobility but may also amplify labor income gaps across educational categories. On one hand, employment policies that increase worker skills allow easier job changes, augmenting earnings prospects, increasing income mobility, and reducing intra-wage inequality. On the other hand, existing skill gaps among the population create a skill premium driving wage inequality dynamics.

The evolution of the college-wage premium, a measure of education returns, has shown a fluctuating trend in the United States. State-level time series data on total pre-tax wage and salary income reveal divergent trends across educational categories from 1977 to 1997. Individuals with some college, college, and greater-than-college education saw steep wage increases from the early 1980s to 1997, while those with only lower or high school education experienced significant decreases or stagnation from 1977 to 1997. Alongside the steep increase in the college-wage premium, the US also experienced a

rise in firing costs from 1977 to 1997. Several exceptions to the employment-at-will policy were introduced during this period. The employment-at-will policy allows employers to discharge or retain employees at will, with or without cause. There are three main exceptions to this policy: the implied contract, public policy, and "good faith" exceptions.

Increasing employment protection may prompt firms to lower their dismissal threshold, potentially reducing average job productivity and wages. Furthermore, the arrival of idiosyncratic shocks may be higher for less and highly educated workers due to deteriorating labor market conditions and high volatility, respectively.

I find that rising firing costs negatively affect wages within selected states, with the extent of these effects varying by education level. There is a particularly strong negative effect for individuals with greater-than-college education and high school dropouts. From a theoretical perspective, firing costs negatively impact equilibrium wages for incumbent workers. The results suggest a negative effect of increasing employment protection regulation on the top and bottom wages across various education levels. Idiosyncratic shocks emerge as a dominant explanatory factor in the theoretical findings.

Titre : Trois essais sur la macroéconomie et les inégalités de revenu

Mot clés : Inégalités de revenu, éducation, retraites, macroéconomie, agents hétérogènes, protection de l'emploi, salaires, mobilité des revenus.

Résumé :

Cette thèse examine la mobilité intergénérationnelle des revenus, la soutenabilité du système de retraite et les politiques de protection de l'emploi aux États-Unis. Bien qu'elle couvre des sujets apparemment différents, tous sont analysés à travers le regard des inégalités de revenus et de richesse en utilisant des outils macroéconomiques. De plus, l'édu-

cation émerge comme un déterminant crucial dans les trois chapitres, influençant les résultats. Le lien entre l'éducation, les revenus et les inégalités de richesse est en effet fondamental.

Le premier chapitre explore comment les changements dans le niveau d'éducation impactent la mobilité intergénérationnelle des revenus et, par conséquent, les inégalités. Il

souligne que le système éducatif en évolution peut soit atténuer, soit exacerber les inégalités de revenus. En revanche, le chapitre deux suggère que l'augmentation du niveau d'éducation peut accentuer les inégalités de richesse par un effet d'épargne. Enfin, le chapitre trois présente l'éducation comme une variable clé influençant l'effet des politiques de protection de l'emploi sur les salaires.

Le chapitre un aborde des questions telles que : L'augmentation du nombre de places à l'université garantit-elle un meilleur accès et améliore-t-elle la mobilité intergénérationnelle ? Comment les inégalités de revenus sont-elles liées à la mobilité intergénérationnelle ? La mobilité des revenus est-elle plus faible ou plus élevée chez les jeunes ayant des parents très éduqués ? Les niveaux d'éducation en hausse perpétuent-ils les élites sociales ? Pour répondre efficacement à ces questions, il est crucial de revisiter le débat central sur la mobilité intergénérationnelle des revenus et son lien avec le niveau d'éducation. Les résultats de la recherche concernant ce lien restent ambigus. Une croyance de longue date suggère de se concentrer sur la progression de l'éducation à travers les générations comme clé pour échapper à la pauvreté et réduire les disparités de revenus. Les écoles peuvent jouer un rôle important en compensant les inégalités sociales et environnementales initiales. Cependant, si le système éducatif ne parvient pas à offrir des opportunités égales à tous les élèves, les inégalités sociales pourraient être renforcées plutôt que réduites.

Le travail conjoint avec Ekkehard Ernst, François Langot et Rossana Merola, présenté dans le chapitre un, mesure l'évolution de la mobilité intergénérationnelle des revenus et de l'éducation et si l'accès aux opportunités offertes par l'économie américaine est devenu plus ouvert au fil du temps. Nous fournissons des estimations des élasticités des revenus intergénérationnels, des corrélations de rang de revenus et des matrices de transition éducation-revenus en utilisant les deux cohortes de l'Enquête Nationale Longitudinale de la Jeunesse (National Longitudinal Survey of Youth) (1979, 1997) administrée

par le Bureau of Labor Statistics des États-Unis. Nous constatons que depuis les années 1980, la mobilité éducative, à la fois ascendante et descendante, a augmenté. Cela suggère que le système américain parvient à offrir les mêmes opportunités éducatives à tous les enfants, quel que soit le niveau d'éducation de leurs parents. Nous constatons également que l'impact du rang de revenu des parents sans diplôme universitaire est très faible sur le rang de revenu de leurs enfants. La transition éducative pourrait amplifier la reproduction des élites, car avoir des parents très éduqués a de forts effets sur les revenus de leurs enfants. Ce résultat est cohérent avec l'idée que les parents très éduqués investissent davantage dans leurs enfants, les envoyant dans des écoles de meilleure qualité, augmentant leurs compétences cognitives et complétant plus d'années de scolarité, ce qui affecte finalement les revenus de leurs enfants. L'augmentation de l'accès à l'éducation pour tous a maintenu la plausibilité du "rêve américain" mais a également renforcé la reproduction des élites.

Le chapitre deux aborde la question latente de la soutenabilité des pensions aux États-Unis. Il examine les réformes nécessaires pour compenser les effets du vieillissement de la population sur la soutenabilité du système de retraite dans une économie avec des niveaux croissants d'éducation. Il explore également si l'augmentation du niveau d'éducation peut atténuer la pression sur le système de retraite. L'augmentation de l'espérance de vie à 65 ans, de 14,5 ans en 1960 à 21,5 ans en 2100, a exercé une pression significative sur le ratio de dépendance, qui devrait passer de 2,6 % en 2010 à 38,6 % en 2060. Assurer la soutenabilité des pensions est donc devenu une priorité sur l'agenda politique. Parallèlement, il y a eu une tendance croissante des niveaux d'éducation, comme discuté au chapitre un. Cette tendance croissante du niveau d'éducation pourrait-elle affecter l'efficacité des instruments mis en place pour assurer la soutenabilité des pensions ?

Le chapitre deux, un travail conjoint avec Xavier Fairise, François Langot et Alexandre Popier, introduit un modèle à agents hétéro-

gènes pour comprendre la soutenabilité du système de retraite dans le contexte d'une espérance de vie croissante et d'un ratio de dépendance en baisse. Nous explorons diverses options de réforme, y compris des ajustements des taux d'imposition sur le revenu, des niveaux de pensions et de l'âge de la retraite. Nous prenons en compte l'évolution du niveau d'éducation et le développement moyen de carrière lié à l'expérience professionnelle, en distinguant le marché du travail des diplômés et des non-diplômés.

Nous constatons que les variations des taux d'imposition sur le revenu et des pensions augmentent les distorsions de l'offre de travail, réduisant la rémunération liée au travail. Ces ajustements tendent également à augmenter la probabilité pour les jeunes d'être financièrement contraints. Cependant, les distorsions de l'offre de travail disparaissent en augmentant l'âge de la retraite, mais cela soulève le problème de l'allocation optimale du temps entre le travail et les loisirs au cours du cycle de vie. L'augmentation du niveau d'éducation n'affecte pas significativement la soutenabilité budgétaire, bien qu'elle permette une augmentation significative du PIB. Les ajustements par l'augmentation des impôts ou la réduction des pensions augmentent les inégalités de richesse, qui sont plus élevées lorsqu'on augmente l'âge de la retraite.

Un autre point important soulevé par le chapitre deux est l'interaction entre les compétences éducatives et l'épargne. La distribution des compétences joue un rôle dans la détermination des effets de l'augmentation de l'épargne - et donc des inégalités de richesse -, induite par les pressions sur le système de retraite dues aux transformations démographiques. Des taux d'épargne plus élevés chez les plus éduqués augmentent les inégalités de richesse, à la fois entre les groupes d'âge et entre les générations, car les plus éduqués peuvent léguer des héritages plus élevés à leurs enfants. La transition éducative pourrait ne pas suffire à réduire le risque de revenus plus faibles pour les enfants de parents moins éduqués. Par conséquent, les parents moins éduqués sont également contraints d'augmenter leurs épargnes

pour lisser leur consommation plus tard dans la vie et assurer leurs enfants contre des revenus de travail faibles.

Le besoin d'épargne varie en fonction de l'instrument utilisé pour assurer la soutenabilité du système de retraite. Si la soutenabilité est assurée par des variations fiscales, les ménages travailleront initialement plus et augmenteront leurs épargnes, finançant ainsi l'allongement de leur durée de vie et celle de leurs enfants. Au fil du temps, les ménages réduiront leur offre de travail. Les niveaux d'éducation en hausse peuvent compenser les distorsions causées par les taux d'imposition sur le revenu du travail, conduisant à une augmentation de la richesse et des gains de PIB. Sans augmentation du niveau d'éducation, le PIB des États-Unis stagnerait. Cet ajustement amplifie les inégalités entre les âges, car il augmente la probabilité d'être financièrement contraint, affectant particulièrement les jeunes qui peuvent être moins assurés en raison de niveaux de richesse parentale plus faibles.

Si la soutenabilité des retraites est assurée par des ajustements des pensions, le besoin d'épargne est plus grand et la distorsion de l'offre de travail est plus faible. Cela entraîne un effort de travail plus élevé et des gains de PIB plus importants, soutenus par des niveaux d'éducation en hausse. Les inégalités restent fortes parce que les retraités avec des épargnes insuffisants après des carrières professionnelles pauvres ne peuvent pas compter sur des pensions généreuses.

Allouer l'extension de la durée de vie au marché du travail maximise l'utilisation des investissements dans l'éducation, mais augmente également les inégalités. En favorisant l'activité économique parmi des individus de plus en plus éduqués, des écarts importants se creusent entre ceux ayant des revenus élevés et des taux d'épargne élevés et ceux au bas de l'échelle sociale.

Enfin, le chapitre trois de cette thèse examine comment les variations des réglementations de protection de l'emploi entre différents États américains affectent les différences de salaire entre catégories éducatives différentes. Les politiques du marché du travail jouent un rôle déterminant dans la mobilité

intergénérationnelle des revenus, mais elles peuvent également amplifier les écarts de revenus du travail entre les catégories éducatives. D'une part, les politiques de l'emploi qui augmentent les compétences des travailleurs leur permettent de changer plus facilement d'emploi, augmentant ainsi leurs perspectives de gains, la mobilité des revenus et réduisant les inégalités intra-salaire. D'autre part, les écarts de compétences existants parmi la population créent une prime de compétence qui alimente la dynamique des inégalités salariales.

L'évolution de la prime salariale liée à l'éducation, une mesure des rendements de l'éducation, a montré une tendance fluctuante aux États-Unis. Les données de séries temporelles au niveau des États sur les revenus totaux avant impôts et les salaires révèlent des tendances divergentes entre les catégories éducatives de 1977 à 1997. Les individus ayant un certain niveau d'études universitaires, un diplôme universitaire ou plus ont vu leurs salaires augmenter fortement du début des années 1980 à 1997, tandis que ceux n'ayant qu'un niveau d'études inférieur au baccalauréat ont connu des diminutions ou une stagnation significative de leurs revenus de 1977 à 1997. Parallèlement à cette forte augmentation de la prime salariale liée à l'éducation, les États-Unis ont également connu une hausse des coûts de licenciement de 1977 à 1997. Plusieurs exceptions à la politique d'emploi à volonté (*employment-at-will*) ont été introduites au cours de cette période. La politique d'emploi à volonté permet aux employeurs de licencier ou de retenir les employés à leur volonté, avec ou sans motif. Il existe trois principales exceptions à cette politique : le contrat implicite, la politique publique et les exceptions de "bonne foi".

Le chapitre trois analyse si les variations des exceptions à la politique d'emploi à volonté et les tendances salariales sont liées. J'examine comment les variations au niveau des États des exceptions à la politique d'emploi à volonté affectent les salaires des individus avec différents niveaux d'éducation. L'augmentation de la protection de l'emploi peut amener les entreprises à abaisser leur

seuil de licenciement, réduisant potentiellement la productivité moyenne des emplois et les salaires. En outre, l'arrivée de chocs idiosyncratiques peut être plus élevée pour les travailleurs peu éduqués et très éduqués en raison de la détérioration des conditions du marché du travail et de la forte volatilité, respectivement.

Dans le chapitre trois, je construis un panel en utilisant des données provenant de sources telles que l'Enquête sur la Population Active, les enquêtes du Bureau of Economic Analysis, l'Enquête sur l'Emploi du Bureau of Labor Statistics et Autor (2003). Le panel contient des informations au niveau des États sur les salaires des individus avec différents niveaux d'éducation, les États adoptant des exceptions à la politique d'emploi à volonté, le PIB, l'emploi et d'autres covariables. Cela permet de fournir des preuves empiriques du lien entre les coûts de licenciement et les salaires en utilisant divers modèles économétriques. De plus, j'estime l'effet moyen du traitement de la mise en œuvre de ces réglementations sur les salaires dans différentes catégories éducatives en utilisant des méthodes quasi-expérimentales récentes qui étendent le cadre de la différence en différences à des contextes décalés avec des effets de traitement hétérogènes. J'offre également des explications théoriques des résultats empiriques.

Je constate que l'augmentation des coûts de licenciement affecte négativement les salaires dans certains États, avec des effets variables selon le niveau d'éducation. Il y a un effet particulièrement négatif pour les individus ayant un niveau d'éducation supérieur à celui du « bachelor » et pour les « high school dropouts ». D'un point de vue théorique, les coûts de licenciement affectent négativement les salaires d'équilibre des travailleurs en poste. Les résultats suggèrent un effet négatif de l'augmentation de la réglementation de la protection de l'emploi sur les salaires au sommet et à la base des différentes catégories éducatives. Les chocs idiosyncratiques émergent comme un facteur explicatif dominant dans les résultats théoriques.

Comprendre l'interaction entre l'augmentation des niveaux d'éducation et les inégali-

tés de revenus aux États-Unis aide à démêler les mécanismes optimaux nécessaires pour la conception des politiques visant à assurer la soutenabilité du système de retraite, la protection de l'emploi et l'accès à l'éducation.