



# The Economics of Trade, Innovation and the Technology Revolution

Ismaeel Tharwat

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# The Economics of Trade, Innovation and the Technology Revolution

*L'économie du commerce, de l'innovation et de la révolution technologique*

## Thèse de doctorat de l'Université Paris-Saclay

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# Contents

<b>1</b>	<b>Trade and Innovation: A Survey of Patents and Trademarks</b>	<b>1</b>
1.1	Introduction . . . . .	1
1.2	Intellectual Property Background . . . . .	2
1.2.1	Innovation Measurement Issues . . . . .	2
1.2.2	Intellectual Property Rights Theory . . . . .	3
1.2.3	Patents . . . . .	4
1.2.4	Trademarks . . . . .	5
1.2.5	Indicator of Innovation . . . . .	7
1.3	Theory . . . . .	9
1.3.1	Schumpeterian Effect . . . . .	9
1.3.2	Escape-Competition Effect . . . . .	9
1.3.3	Preferences Effect . . . . .	9
1.3.4	Initial Productivity Issue . . . . .	9
1.4	Literature: Import Competition & Innovation . . . . .	10
1.4.1	Import Competition & Innovation in Developed Countries . . . . .	10
1.4.2	Import Competition & Innovation in Developing Countries . . . . .	12
1.4.3	Measurement Issues in Developing Country Studies . . . . .	13
1.4.4	Market Structure Competition & Innovation . . . . .	14
1.5	Empirical Estimations . . . . .	16
1.5.1	Data . . . . .	16
1.5.2	Methodology . . . . .	17
1.5.3	Results . . . . .	19
1.6	Conclusion . . . . .	22
1.7	Appendix . . . . .	24
1.7.1	Results . . . . .	24
<b>2</b>	<b>Import Competition and Innovation in Developing Countries: Evidence from Trademarks</b>	<b>30</b>
2.1	Introduction . . . . .	30
2.2	Trademark Background . . . . .	33

2.2.1	What is a Trademark? . . . . .	33
2.2.2	Trademarks as a Measure of Innovation . . . . .	33
2.2.3	Innovation Measures are Imperfect . . . . .	37
2.2.4	Trademarks are More Suitable for Developing Countries . . . . .	38
2.3	Data . . . . .	39
2.3.1	Trademarks . . . . .	39
2.3.2	Import Competition . . . . .	40
2.3.3	Control Variables . . . . .	40
2.4	Methodology . . . . .	40
2.4.1	Theoretical Framework . . . . .	40
2.4.2	Empirical Framework . . . . .	41
2.5	Results . . . . .	44
2.5.1	Trademark Applications . . . . .	44
2.5.2	Trademark Registrations . . . . .	45
2.5.3	Instrumental Variable Estimations . . . . .	46
2.5.4	Potential Policy Implications . . . . .	49
2.6	Conclusion . . . . .	49
2.7	Appendix . . . . .	51
2.7.1	Results . . . . .	51
2.7.2	First Stage Negative Effect . . . . .	56
<b>3</b>	<b>Importing Gender Equality: A Technological Revolution Effect</b>	<b>57</b>
3.1	Introduction . . . . .	57
3.2	Trade Mechanisms on Gender Inequality . . . . .	59
3.3	Data . . . . .	61
3.3.1	Trade Flows . . . . .	61
3.3.2	Gender Inequality Index . . . . .	61
3.3.3	World Bank . . . . .	62
3.3.4	Technology Classification . . . . .	63
3.4	Empirical Application . . . . .	64
3.4.1	Spatial Econometrics . . . . .	64
3.4.2	Empirical Strategy . . . . .	66
3.5	Empirical Results . . . . .	67
3.5.1	Trade as Transmission Channel for Gender Standards . . . . .	67
3.5.2	Technological Upgrading . . . . .	70
3.5.3	Technology Revolution Effects . . . . .	70
3.5.4	No Effect . . . . .	72

3.6	Concluding Remarks . . . . .	73
3.7	Appendix . . . . .	74
3.7.1	Migration . . . . .	74

# List of Figures

2.1	Binned Scatterplot Without Fixed Effects . . . . .	44
2.2	Binned Scatterplot With Fixed Effects . . . . .	44
3.1	Three Stages of Spatial Estimations . . . . .	65
3.2	Moran's Diagram of Bilateral Trade in 1997/1998 . . . . .	78
3.3	Moran's Diagram of Bilateral Trade in 1999/2000 . . . . .	78
3.4	Moran's Diagram of Bilateral Trade in 2001/2002 . . . . .	78
3.5	Moran's Diagram of Bilateral Trade in 2003/2004 . . . . .	79
3.6	Moran's Diagram of Bilateral Trade in 2005/2006 . . . . .	79
3.7	Moran's Diagram of Bilateral Trade in 2007/2008 . . . . .	79
3.8	Moran's Diagram of Bilateral Trade in 2009/2010 . . . . .	80
3.9	Moran's Diagram of Bilateral Trade in 2011/2012 . . . . .	80
3.10	Moran's Diagram of Bilateral Trade in 2013 . . . . .	80
3.11	Moran's Diagram of Import Trade in 1997/1998 . . . . .	81
3.12	Moran's Diagram of Import Trade in 1999/2000 . . . . .	81
3.13	Moran's Diagram of Import Trade in 2001/2002 . . . . .	81
3.14	Moran's Diagram of Import Trade in 2003/2004 . . . . .	82
3.15	Moran's Diagram of Import Trade in 2005/2006 . . . . .	82
3.16	Moran's Diagram of Import Trade in 2007/2008 . . . . .	82
3.17	Moran's Diagram of Import Trade in 2009/2010 . . . . .	83
3.18	Moran's Diagram of Import Trade in 2011/2012 . . . . .	83
3.19	Moran's Diagram of Import Trade in 2013 . . . . .	83
3.20	Moran's Diagram of Export Trade in 1997/1998 . . . . .	84
3.21	Moran's Diagram of Export Trade in 1999/2000 . . . . .	84
3.22	Moran's Diagram of Export Trade in 2001/2002 . . . . .	84
3.23	Moran's Diagram of Export Trade in 2003/2004 . . . . .	85
3.24	Moran's Diagram of Export Trade in 2005/2006 . . . . .	85
3.25	Moran's Diagram of Export Trade in 2007/2008 . . . . .	85
3.26	Moran's Diagram of Export Trade in 2009/2010 . . . . .	86
3.27	Moran's Diagram of Export Trade in 2011/2012 . . . . .	86
3.28	Moran's Diagram of Export Trade in 2013 . . . . .	86

# List of Tables

1.1	Patents vs. Trademarks . . . . .	8
1.2	Impact of China Shock on Patent Applications . . . . .	19
1.3	Impact of China Shock on Patent Grants . . . . .	20
1.4	Impact of China Shock on Patents In-Force . . . . .	21
1.5	Impact of Import Competition on Total & Local Applications . . . . .	25
1.6	Impact of Import Competition on Applications of Residents . . . . .	25
1.7	Impact of Import Competition on Total & Local Grants . . . . .	26
1.8	Impact of Import Competition on Grants of Residents . . . . .	26
1.9	Impact of Import Competition on Applications & Grants Abroad . . . . .	27
1.10	Impact of Import Competition on Patents In-Force of Locals . . . . .	27
1.11	Impact of Import Competition on Patents In-Force of Residents . . . . .	28
1.12	Pre-Trends Test of Patent Grant Variables . . . . .	28
1.13	Country List . . . . .	29
2.1	Impact of China Shock on Trademark Applications . . . . .	45
2.2	Impact of China Shock on Trademark Registrations . . . . .	46
2.3	Impact of Import Competition on Total & Local Applications . . . . .	47
2.4	Impact of Import Competition on Total & Local Registrations . . . . .	48
2.5	Impact of Import Competition on Applications of Residents & Non-Residents . . . . .	52
2.6	Impact of Import Competition on Registrations of Residents & Non-Residents . . . . .	52
2.7	Impact of Import Competition on Registrations In-Force . . . . .	53
2.8	Impact of China Shock on Trademark Applications . . . . .	53
2.9	Impact of Import Competition on Trademark Registrations . . . . .	54
2.10	Trademark Applications Class Counts by Goods & Services . . . . .	54
2.11	Pre-Trends Test of Trademark Application Variables . . . . .	55
2.12	Country List . . . . .	55
2.13	First Stage Regressions with Different Instruments . . . . .	56
3.1	Spatial Effect Estimation of Trade . . . . .	69
3.2	Countries Included in the Sample . . . . .	74
3.3	UNCTAD Technology Classification . . . . .	75
3.4	Summary Statistics of the Variables . . . . .	77
3.5	Spatial Autocorrelation of Bilateral Trade, Imports and Exports . . . . .	77
3.6	UNCTAD Trade Variables Correlation Matrix . . . . .	87
3.7	OECD Trade Variables Correlation Matrix . . . . .	87
3.8	Spatial Effect Estimation of UNCTAD Bilateral Trade . . . . .	88
3.9	Spatial Effect Estimation of UNCTAD Exports . . . . .	88
3.10	Spatial Effect Estimation of UNCTAD Imports . . . . .	89
3.11	Spatial Effect Estimations of UNCTAD High-Tech Product Imports . . . . .	89
3.12	Spatial Effect Estimation of UNCTAD Medium-Tech Product Imports . . . . .	90
3.13	Spatial Effect Estimation of UNCTAD Low-Tech Product Imports . . . . .	90
3.14	Spatial Effect Estimation of UNCTAD Resource-Intensive Product Imports . . . . .	91
3.15	Spatial Effect Estimation of UNCTAD Non-Fuel Product Imports . . . . .	91
3.16	Spatial Effect Estimations of UNCTAD Mineral-Fuel Product Imports . . . . .	92
3.17	Spatial Effect Estimation of OECD Technological Product Imports . . . . .	92

# Résumé

L'innovation est au cœur de la croissance économique fondamentale. La prospérité actuelle de l'ère moderne est en grande partie due à l'invention et à la diffusion continues de nouvelles technologies depuis la révolution industrielle. La "révolution verte" a permis aux pays d'éviter la faim à des millions de personnes et de réduire la pauvreté. En fait, le sort de notre avenir dépend également de l'innovation. Le besoin de technologies plus propres et plus efficaces pour lutter contre le changement climatique en est un exemple. Le monde a besoin de solutions nouvelles pour s'attaquer à l'éducation, aux soins de santé et à l'inégalité croissante des revenus.

Qu'est-ce que l'innovation ? L'innovation peut être décrite comme l'invention, le développement et la diffusion de nouveaux biens, services ou processus de production (Bryan and Williams, 2021). En d'autres termes, l'innovation est essentiellement la production de connaissances. L'innovation est indispensable pour comprendre comment nous pouvons élargir la frontière des possibilités de production, ce qui en fait l'une des plus grandes préoccupations économiques.

L'importance de l'innovation pour le développement économique est profonde. L'innovation est et restera un élément essentiel pour relever certains des plus grands défis du développement, tels que l'accès à l'eau potable, l'éradication des maladies, ainsi que la réduction de la faim et de la pauvreté. Les technologies construites et adaptées dans les pays développés ont déjà contribué à ces objectifs. En outre, l'innovation a stimulé la croissance économique des pays en développement. Les produits de haute technologie que l'on trouve dans les pays avancés ne sont pas la seule façon de mesurer l'innovation. Les innovations qui permettent de résoudre des problèmes spécifiques aux contextes locaux sont extrêmement importantes. Une stratégie de développement réussie doit intégrer de telles capacités d'innovation pour améliorer la croissance économique.

Dans un monde qui se globalise rapidement, l'impact du commerce international sur

l'innovation est une question qui gagne en importance. Déterminer la meilleure façon d'encourager l'innovation est un problème économique puisqu'il dépend des agents qui choisissent activement de répondre aux incitations économiques. Comprendre comment le commerce mondial affecte les incitations à innover est donc une question essentielle. Il est certain que les différentes activités et phénomènes commerciaux auront des effets complexes sur l'innovation, car ils affectent l'environnement d'une entreprise de multiples façons. Les niveaux de concurrence peuvent augmenter sur les marchés des intrants ou des extrants. L'objectif de cette thèse est de démêler cette complexité et de contribuer à la compréhension de la littérature sur l'impact du commerce sur les résultats liés à l'innovation.

Les deux premiers chapitres de cette thèse abordent directement la question de l'impact du commerce, et plus particulièrement de la concurrence des importations sur les résultats de l'innovation. Une attention particulière est également accordée à l'impact sur les pays en développement. Le chapitre 1 est une étude de la littérature économique théorique et empirique récente. Une analyse empirique est également menée pour examiner l'effet du commerce sur l'innovation, mesurée par l'activité de brevetage, dans les pays en développement. Le chapitre 2 aborde la même question tout en utilisant une nouvelle mesure de l'innovation qui est le dépôt de marque. L'étude fournit des preuves suggestives que la concurrence des importations affecte négativement les nouvelles innovations locales de produits ou de services dans les pays en développement.

En outre, le commerce international et l'intégration mondiale ont des répercussions non seulement sur l'innovation, mais aussi sur d'autres normes sociétales. En effet, il existe une littérature qui documente l'effet des épisodes de libéralisation sur l'inégalité de genres. Cependant, les études concernant les retombées des acteurs du commerce ont été largement ignorées. Par conséquent, le chapitre 3 est une étude qui tente de compléter notre compréhension de l'effet des relations commerciales sur les normes de genre. Nos résultats suggèrent qu'une révolution technologique affecte les entreprises, les ménages et les gouvernements en ayant un impact sur l'autonomisation des femmes.



## Résumé des chapitres

### Chapitre 1. Commerce et innovation : une enquête sur brevets et marques de commerce

L'expansion rapide de la mondialisation a été un phénomène économique important. C'est particulièrement vrai en ce qui concerne le commerce international, qui s'est développé pour atteindre près de 60 % du PIB mondial en 2019. De plus, l'entrée de la Chine dans l'Organisation Mondiale du Commerce en 2001 a modifié la dynamique du commerce international. L'intégration profonde de la Chine dans l'économie mondiale a largement dépassé les attentes. Cela a relancé un débat politique très important sur les avantages de la libéralisation du commerce, notamment en ce qui concerne l'innovation. Principalement parce que l'innovation est un résultat économique essentiel, car elle est considérée comme le principal catalyseur de la croissance économique à long terme et un outil important pour la réduction de la pauvreté (Aghion and Durlauf, 2005; P. M. Romer, 1990).

Alors que la plupart des économistes s'extasient depuis des années sur les avantages du commerce mondial en termes d'amélioration de la productivité et du bien-être, les mérites des économies ouvertes ont été remis en question. L'un des principaux objectifs de ce document est de s'attaquer à la question de savoir comment la libéralisation du commerce, en particulier la concurrence des importations, affecte les résultats liés à l'innovation. La littérature récente n'a pas encore apportée de réponse à cette question. Cette revue de littérature identifie des hétérogénéités notables dans la réponse à l'innovation au niveau de l'entreprise et du pays. Des preuves accablantes montrent que la concurrence des importations a un effet négatif sur l'innovation en Amérique du Nord (Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020; M.-J. Yang, N. Li, and Lorenz, 2021; Gutiérrez and Philippon, 2017; Hombert and Matray, 2018; Pierce and Schott, 2018; Xu and Gong, 2017). En Europe, il existe des preuves de l'effet de concurrence par évocation qui se traduit par un impact positif de la concurrence des importations sur l'innovation (Nicholas Bloom, Draca, and Van Reenen, 2016; Bombardini, B. Li, and R. Wang, 2017; C. Chen and Steinwender, 2019). D'autre part, la littérature ancienne trouve des preuves soutenant que la libéralisation du commerce affecte positivement différentes mesures de productivité. Par conséquent, il existe toujours une lacune dans la littérature concernant l'impact de la libéralisation du commerce, ou de la concurrence des importations, sur les résultats liés à l'innovation dans les pays en développement.

Enfin, une analyse empirique est menée pour examiner l'impact de la concurrence des importations chinoises sur l'innovation, mesurée par l'activité de brevetage, dans les pays en développement. Pour ce faire, nous utilisons un modèle de panel à effets fixes pour étudier cet effet de la concurrence des importations étrangères. Une stratégie de variable instrumentale de type shift-share est utilisée pour atténuer les problèmes d'endogénéité. Les résultats ne montrent aucun impact significatif de la concurrence des importations chinoises sur l'activité de brevetage dans les pays en développement. Cela n'est pas très surprenant car le système de brevetage est relativement peu important pour les entités nationales (Bronwyn H Hall, 2020). En outre, seule une très faible part des entreprises de ces pays utilisent le système des brevets (Bronwyn H. Hall and Helmers, 2019). Les brevets sont également plus pertinents pour s'approprier les rendements de l'innovation dans des industries spécifiques telles que les produits pharmaceutiques, la biotechnologie, les instruments médicaux et les produits chimiques (Cohen, R. R. Nelson, and Walsh, 2000). Ces industries sont aussi généralement des secteurs de haute technologie qui sont moins mis en avant dans les pays à revenu faible ou intermédiaire (OECD, 2012). Par conséquent, les résultats s'alignent sur la littérature existante concernant le brevetage et le développement.

## **Chapitre 2. Concurrence des importations et innovation dans les pays en développement : preuve des marques de commerce**

Le débat concernant l'impact de la mondialisation sur l'économie reste extrêmement important, notamment sur les économies en développement. La question de savoir comment l'innovation en particulier est affectée par la concurrence accrue due à la mondialisation est une question centrale en économie. Après tout, la théorie a bien documenté la notion que l'innovation est le moteur fondamental et primaire de la croissance économique (P. M. Romer, 1990; Aghion and Durlauf, 2005). Par conséquent, cette question est essentielle pour le progrès économique des pays en développement. La réponse à cette question comporte diverses implications au niveau des politiques concernant la libéralisation du commerce, la déréglementation des industries, l'allocation des ressources et autres. En outre, l'émergence de la Chine en tant que puissance économique significative dans le commerce mondial depuis son adhésion à l'OMC en 2001, a donné une importance renouvelée à cette question. La Chine a modifié la structure du commerce mondial et les économies du monde entier sont

confrontées à une concurrence croissante des importations. Malgré une littérature ancienne qui a abordé la question de l'impact de la concurrence des importations sur l'innovation dans les pays en développement, l'accent a été fortement mis sur l'Amérique latine en raison des multiples épisodes de libéralisation du commerce et a utilisé des mesures de la productivité qui sont maintenant considérées comme des mesures plutôt indirectes de l'innovation. Cette partie étudie comment la concurrence des importations en provenance de Chine affecte l'innovation, mesurée par l'activité de marquage, dans les pays en développement. Plus important encore, l'effet sur l'innovation locale et résidente est également analysé.

Alors que la littérature a trouvé des effets ambigus de la concurrence des importations sur l'innovation dans les pays développés, les preuves empiriques récentes pour les pays en développement sont assez rares. Une partie de la littérature antérieure s'est concentrée sur l'Amérique latine et les épisodes de libéralisation du commerce avant l'adhésion de la Chine à l'OMC. La majorité de ces études utilisaient différentes mesures de la productivité comme indicateur principal de l'innovation, qui sont aujourd'hui moins appréciées que d'autres mesures plus directes. Certaines études ont montré des effets mitigés de la concurrence des importations sur la productivité totale des facteurs. Lorsqu'il est possible de tenir compte de l'hétérogénéité des entreprises, les données du Mexique et de la Colombie ont montré un effet négatif de la concurrence des importations sur les entreprises les moins productives et un effet positif sur les entreprises les plus productives dans les industries moins compétitives (Iacovone, Keller, and Rauch, 2011; Fernandes, 2007). D'autre part, différentes études menées en Amérique latine documentent un effet positif de la libéralisation des échanges sur les mesures de productivité au Brésil, au Chili et au Mexique (Muendler, 2004a; Pavcnik, 2002; Teshima, 2008). En Asie, les recherches sur l'Inde et l'Indonésie ont également trouvé un effet positif sur la productivité globale des facteurs (Topalova and A. Khandelwal, 2011; Amiti and Konings, 2007). Cette revue de la littérature indique qu'il convient effectivement de réexaminer la question de l'impact de la concurrence des importations sur la mondialisation. Il est important de tenir compte de la montée rapide de la Chine en tant que partenaire commercial et d'utiliser une mesure plus directe de l'innovation.

Les marques commerciales peuvent en effet capturer des aspects importants du phénomène de l'innovation, ce qui les rend essentielles pour mieux comprendre la croissance. En fait, Bronwyn H Hall (2020) soutient que les marques commerciales sont une forme plus im-

portante de propriété intellectuelle, en particulier pour les entités nationales, au cours du développement. Alors que la théorie suggère que les marques commerciales peuvent jouer un rôle essentiel dans le processus d'innovation, la littérature empirique existante utilisant les marques commerciales est rare. En fait, les marques reflètent l'innovation de multiples façons. Premièrement, les marques commerciales peuvent permettre aux entreprises de récupérer les investissements passés dans l'innovation tout en encourageant des investissements similaires dans la RD à l'avenir (Gangjee, 2020). Deuxièmement, les marques commerciales peuvent également servir d'indicateurs indirects et complémentaires de l'innovation, tout en aidant à identifier les modèles généraux d'innovation. De multiples études ont constaté que les marques commerciales sont corrélées à l'activité d'innovation des entreprises (Brahem, El Harbi, and Grolleau, 2013; Mendonça, Tiago Santos Pereira, and M. Godinho, 2004; Schmoch, 2003; M. J. Flikkema, Man, Wolters, et al., 2010; Christine Greenhalgh and Longland, 2005; Malmberg, 2005; Michalisin, 2001). Une idée sous-jacente de cette recherche est que les données de marque peuvent capturer la valeur de la production d'innovation des entreprises qui ne sont pas couvertes par des brevets. Cela comprendrait les innovations dans le domaine de la vente au détail, des services, des relations avec la clientèle et d'autres produits à forte intensité de connaissances. En outre, les marques sont corrélées aux avancées technologiques (M. M. Godinho, Mendonca, and Tiago SANTOS Pereira, 2003; Gotsch and Hipp, 2012). Les marques commerciales peuvent également se comporter comme des compléments ou des substituts aux brevets (Millot and Llerena, 2012; Jensen and Webster, 2009). Enfin, les marques commerciales peuvent refléter l'activité d'innovation qui n'est pas prise en compte par d'autres indicateurs, comme les innovations de service et de marketing, tout en mesurant mieux les innovations de stade avancées (Dinlersoz, Goldschlag, Fila, and Zolas, 2018; M. J. Flikkema, Man, Wolters, et al., 2010; Gangjee, 2020). Les marques commerciales peuvent également rendre compte des innovations organisationnelles qui ont un haut degré de complémentarité avec la révolution numérique construite sur les technologies de l'information et de la communication (Mohnen, Polder, and Van Leeuwen, 2018). Cela est de plus en plus vital car le secteur des services a augmenté en importance économique dans la majorité des économies industrielles. Par conséquent, il serait perspicace d'utiliser les marques commerciales comme mesure pour comprendre l'impact sur la dynamique de l'innovation.

Cette partie étudie comment la concurrence des importations affecte l'innovation dans les pays en développement en estimant l'impact d'une plus grande exposition au commerce sur les marques commerciales. L'innovation est mesurée à la fois par les demandes et les enregistrements de marques. Comme dans la littérature récente étudiant la concurrence et l'innovation, l'exposition au commerce est mesurée par la pénétration des importations en provenance de Chine dans les pays en développement. Le modèle empirique utilisé analyse la marge de l'activité innovatrice à l'intérieur du pays comme résultat de la concurrence des importations en utilisant un modèle de données de panel à effets fixes avec des erreurs standard groupées. Les estimations contrôlent pour le PIB, la population, l'éducation tertiaire et la croissance de l'emploi. La stratégie empirique choisie traite les problèmes d'endogénéité potentiels des chocs technologiques inobservables corrélés à la croissance des importations chinoises en utilisant la stratégie d'identification de Autor, Dorn, and Gordon H. Hanson (2016). Une approche de variable instrumentale de type shift-share est adoptée, par laquelle la pénétration des importations de la Chine dans un pays en développement spécifique est instrumentée par la pénétration des importations dans d'autres pays en développement. Les résultats montrent que la concurrence des importations a un effet négatif faiblement significatif sur les demandes de marques locales. Toutefois, l'effet est positif pour le total des demandes, ce qui semble être le fait de l'activité des non-résidents. Les résultats de l'étude suggèrent que la concurrence des importations chinoises augmente le marquage global mais affecte négativement l'activité d'innovation non technologique locale.

### **Chapitre 3. Importer l'égalité des sexes : un effet de révolution technologique**

Un important débat politique est en cours concernant l'impact de la mondialisation sur l'inégalité des genres dans le monde. La théorie identifie quatre canaux principaux par lesquels la libéralisation du commerce peut affecter l'égalité des genres : la discrimination, la révolution technologique, l'avantage comparatif et l'intensité du capital. La littérature présente actuellement des résultats contradictoires quant à l'effet du commerce sur l'égalité des genres. Certaines études ont montré un impact négatif du commerce en réduisant les opportunités du marché du travail féminin (Keller and Utar, 2018), en réduisant la croissance des salaires (Hakobyan and McLaren, 2018) et en augmentant l'écart salarial entre les genres (Sauré and Zoabi, 2014). D'autre part, certaines études trouvent un impact positif à travers

une réduction de l'inégalité salariale entre les genres (Black and Brainerd, 2004) et une augmentation de l'emploi féminin dans le secteur manufacturier (Ederington, Minier, and Troske, 2009), en particulier dans les industries où les réductions tarifaires sont les plus importantes (Juhn, Ujhelyi, and Villegas-Sanchez, 2014).

Alors que la littérature examine l'effet du commerce sur l'égalité des genres, la présente étude met en lumière l'effet d'entraînement transnational de l'égalité des genres via le commerce. À cette fin, nous adoptons une approche économétrique spatiale pour identifier un canal de transmission des normes de genre entre les partenaires commerciaux. Cela nous permet de considérer les liens commerciaux comme une notion économique de distance en utilisant les échanges commerciaux en quantité. Nous utilisons le jeu de la majorité pondérée avec externalités qui implique que les décisions prises par les partenaires commerciaux affectent les utilités qu'ils génèrent de leurs propres actions (Genschel and Plumper, 1997). Nos résultats indiquent un effet de débordement des normes de genre par le biais du commerce, spécifiquement par les importations de produits de haute et moyenne technologie.

Nous utilisons un panel de données au niveau national de 1997 à 2013 dans 129 pays pour estimer l'impact des échanges commerciaux sur l'indice d'inégalité de genre (IIG). L'IIG est une mesure composite basée sur trois dimensions : l'autonomisation des femmes, l'activité économique et la santé reproductive. Nous utilisons une méthode d'estimation économétrique spatiale pour modéliser simultanément le temps et l'espace. Les variables spatiales sont standardisées en fonction de l'importance des partenaires commerciaux dans le commerce du pays d'observation, c'est-à-dire le jeu de la majorité pondérée. Ici, les variables de décalage spatial standardisées sont interprétées comme l'effet moyen de l'inégalité de genre des partenaires commerciaux, pondéré par les liens commerciaux, sur l'inégalité de genre domestique. Pour identifier un canal de transmission de la technologie, nous utilisons la classification de la CNUCED en matière de compétences et d'intensité technologique pour toutes les variables d'échanges commerciaux spatiaux. Nous effectuons des estimations de type système-GMM car les estimateurs système-GMM sont plus performants que les autres estimateurs pour les données de panel dynamiques spatiales avec des variables endogènes (Kukenova, Monteiro, Monte, and Monteiro, 2009). Les régressions à effets fixes du panel sont utilisées comme estimations de robustesse. Afin d'éviter les problèmes de multicollinéarité, nous effectuons plusieurs régressions spatiales avec une seule variable relative aux échanges commerciaux

spatiaux. Nous exécutons d’abord un modèle avec les accords commerciaux spatiaux et le commerce bilatéral spatial. Ensuite, nous recommençons deux fois avec les importations et les exportations spatiales au lieu du commerce bilatéral spatial. Enfin, nous décomposons les importations et les exportations par chaque catégorie de produits selon la CNUCED et nous répétons l’opération pour toutes les catégories spatiales de produits. Les relations commerciales sont désagrégées par produits de niveau technologique car on sait que la mise à niveau technologique au sein des entreprises a une incidence sur l’inégalité entre les genres (Juhn, Ujhelyi, and Villegas-Sanchez, 2014).

Nos résultats indiquent qu’un phénomène d’entraînement de l’égalité des genres est observé à partir des importations de produits de haute technologie, de technologie moyenne et de produits minéraux provenant de partenaires plus égalitaires en termes de genre. Ces résultats sont cohérents avec un phénomène de mise à niveau technologique puisque les machines de bureau/industrie et agricoles importées augmentent la productivité relative des femmes. Cependant, les résultats suggèrent qu’un phénomène plus large est à l’œuvre. Une révolution technologique se produit au sein des ménages et des gouvernements. Premièrement, l’importation de technologies avancées modifie le coût d’opportunité pour les femmes d’avoir des enfants. L’accès aux méthodes contraceptives permet une maîtrise de la fécondité dans les économies en retard tandis que l’utilisation croissante des appareils ménagers permet aux femmes de réallouer leur temps en dehors du foyer dans les économies avancées (Goldin and L. F. Katz, 2000; Greenwood, Seshadri, and Yorukoglu, 2005). Les femmes sont donc encouragées à étudier ou à travailler. Deuxièmement, les dépenses gouvernementales dans la technologie militaire nécessitent des investissements élevés dans la RD publique qui se répercutent sur la RD privée (Moretti, Steinwender, and Van Reenen, 2019). Nos résultats sont intuitifs et cohérents avec la tendance à la baisse des inégalités entre les genres observée dans le monde entier (Stotsky, Shibuya, Kolovich, and Kebhaj, 2016). Ce chapitre montre que les caractéristiques des partenaires commerciaux comptent pour réduire les inégalités de genre au sein d’un pays.





# Introduction

Innovation is at the core of fundamental economic growth. The current prosperity of the modern era is in large part due to the continuous invention and diffusion of novel technologies since the Industrial Revolution. The “Green Revolution” enabled countries to avert hunger for millions and reduce poverty. In fact, the fate of our future is also dependent upon innovation. One example is the need for cleaner and more efficient technologies to combat climate change. The world is in need of novel solutions to tackle education, healthcare and growing income inequality.

So what is innovation? Innovation can be described as the invention, development and diffusion of new goods, services or production processes (Bryan and Williams, 2021). In other words, innovation is essentially the production of knowledge. Innovation is imperative to understanding how we can expand the production possibilities frontier which makes it one of the biggest economic concerns.

The importance of innovation for economic development is profound. Innovation is and will continue to be a pivotal component of addressing some of the greatest development challenges such as access to clean water, eradication of diseases, as well as reducing hunger and poverty. The technologies built and adapted in developed countries have already contributed to these goals. Furthermore, innovation has boosted the economic growth of developing countries. High-technology products found in advanced countries are not the only way to measure innovation. Innovations which can solve challenges specific to local contexts are extremely important. A successful development strategy must incorporate such innovation capacities to improve economic growth.

In a rapidly globalizing world, the impact of international trade on innovation is a question that increases in importance. Identifying how best to encourage innovation is an economic problem since it depends on agents actively choosing to respond to economic incentives.

This makes understanding how global trade affects incentives to innovate a critical question. Certainly, the different trade activities and phenomena will have complex effects on innovation as it affects a firm's environment in multiple ways. Levels of competition can increase in the markets of inputs or outputs. The goal of this thesis is to unpack this complexity and contribute to the literature's understanding of the impact of trade on innovation related outcomes.

The first two chapters of this thesis directly address the question regarding the impact of trade, more specifically import competition, on innovation outcomes. A specific focus is also taken on the impact developing countries. Chapter 1 is a survey of the recent theoretical and empirical economic literature. An empirical analysis is also conducted to examine the effect of trade on innovation, measured by patenting activity, in developing countries. Chapter 2 tackles the same question while using a new measure of innovation which is trademarking. The study provides suggestive evidence that import competition negatively affects new local product or service innovations in developing countries.

Moreover, international trade and global integration has implications on not just innovation, but other societal norms. Indeed, a literature exists which documents the effect of liberalization episodes on gender inequality. However, studies regarding the spillovers from trade actors has been largely ignored. As a result, Chapter 3 is a study which attempts to add our understanding of the effect of trade relationships on gender norms. Our results suggest that a technological revolution affects firms, households and governments in impacting female empowerment.

## **Summary of Chapters**

### **Chapter 1: Trade and Innovation: A Survey of Patents and Trademarks**

The rapid expansion of globalization has been a significant economic phenomenon. This is especially true when it comes to international trade which has grown to reach almost 60 percent of global GDP in 2019. Moreover, China's entry into the World Trade Organization in 2001 altered international trade dynamics. China's deep integration into the global economy has greatly exceeded expectations. This has reignited a very important policy debate regarding the benefits of trade liberalization, specifically in regards to innovation. Primarily because innovation is a critical economic outcome as it is considered to be the principle

catalyst of long term economic growth and an important tool for poverty reduction (Aghion and Durlauf, 2005; P. M. Romer, 1990).

While most economists have been raving about the productivity and welfare improving benefits of global trade for years, the merits of open economies have been called into question again. One of the main goals of this paper is to tackle the question regarding how trade liberalization, specifically import competition, affects innovation-related outcomes. The recent literature deems this puzzle unsolved. This review identifies noteworthy heterogeneities in the innovation response at the firm and country level. The overwhelming evidence points to import competition having a negative effect on innovation in North America (Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020; M.-J. Yang, N. Li, and Lorenz, 2021; Gutiérrez and Philippon, 2017; Hombert and Matray, 2018; Pierce and Schott, 2018; Xu and Gong, 2017). In Europe, there is evidence of the escape-competition effect resulting in a positive impact of import competition on innovation (Nicholas Bloom, Draca, and Van Reenen, 2016; Bombardini, B. Li, and R. Wang, 2017; C. Chen and Steinwender, 2019). On the other hand, the early literature finds evidence supporting trade liberalization positively affecting different productivity measures. As a result, there is still an existing gap in the literature regarding the impact of trade liberalization, or import competition, on innovation-related outcomes in developing countries.

Lastly, an empirical analysis is conducted to examine the impact of Chinese import competition on innovation, measured by patenting activity, in developing countries. This is done using a panel fixed effects model to study this effect of foreign import competition. A shift-share instrumental variable strategy is used to mitigate endogeneity issues. The results show no significant impact of Chinese import competition on patenting activity in developing countries. This is not too surprising as the patenting system is of relative unimportance to domestic entities (Bronwyn H Hall, 2020). Moreover, only a very small share of firms in those countries use the patent system at all (Bronwyn H. Hall and Helmers, 2019). Patents are also more relevant for appropriating returns to innovation in specific industries such as pharmaceuticals, biotechnology, medical instruments and chemicals (Cohen, R. R. Nelson, and Walsh, 2000). These industries are also generally high-tech sectors which are less of a focus in low and middle-income countries (OECD, 2012). Hence, the results align with the existing literature regarding patenting and development.

## **Chapter 2: Import Competition and Innovation in Developing Countries: Evidence from Trademarks**

The debate regarding the impact of globalization on the economy remains extremely important, especially in the developing world. The question of how innovation in particular is affected by increased competition due to globalization is a central one in economics. After all, theory has well documented the notion that innovation is the fundamental and primary driver of economic growth (P. M. Romer, 1990; Aghion and Durlauf, 2005). Therefore, this question is critical to the economic progress of developing countries. The answer to this question carries various implications at the policy level concerning the liberalization of trade, deregulation of industries, resource allocation and others. Moreover, China's emergence as a significant economic power in world trade since joining the WTO in 2001, has given renewed importance to this question. China has shifted patterns of global trade and economies around the world are facing rising import competition. Despite an early literature which tackled the question of the impact of import competition on innovation in developing countries, the focus was heavily on Latin America due to multiple trade liberalization episodes and used measures of productivity which are now considered rather indirect measures of innovation. This paper explores how import competition from China affects innovation, measured by trademarking activity, in developing countries. More importantly, the effect on local and resident innovation is also analyzed.

While the literature has found ambiguous effects of import competition on innovation in developed countries, the recent empirical evidence for developing countries is quite sparse. An earlier body of literature focused on Latin America and trade liberalization episodes predating China joining the WTO. The majority of these studies used different measures of productivity as their primary indicator of innovation which are now less preferred than other more direct measures. Some studies have shown mixed effects of import competition on total factor productivity. When able to consider firm heterogeneity, evidence from Mexico and Colombia has shown a negative effect of import competition on less productive firms and a positive effect on more productive firms in less competitive industries (Iacovone, Keller, and Rauch, 2011; Fernandes, 2007). On the other hand, different studies in Latin America document a positive effect of trade liberalization on productivity measures in Brazil, Chile and Mexico (Muendler, 2004a; Pavcnik, 2002; Teshima, 2008). In Asia, research on India

and Indonesia has also found a positive effect on TFP (Topalova and A. Khandelwal, 2011; Amiti and Konings, 2007). This brief summary of the literature indicates that indeed a revisit to the question of the impact of import competition on globalization is in order. It is important to account for China's rapid rise as a trade partner and use a more direct measure for innovation.

Trademarks can indeed capture important aspects of the innovation phenomena making it essential to better understanding growth. In fact, Bronwyn H Hall (2020) argues that trademarks are a more important form of IP, especially for domestic entities, in the course of development. While theory suggests that trademarks can play a critical role in the innovation process, the existing empirical literature using trademarks is sparse. In fact, there are multiple ways in which trademarks reflect innovation. Firstly, trademarks can enable firms to recoup past investments in innovation while also encouraging similar R&D investments in the future (Gangjee, 2020). Second, trademarks can also serve as indirect and complementary indicators of innovation, while helping to identify overall patterns of innovation. Multiple studies have found trademarks to be correlated with firm innovation activity (Brahem, El Harbi, and Grolleau, 2013; Mendonça, Tiago Santos Pereira, and M. Godinho, 2004; Schmoch, 2003; M. J. Flikkema, Man, Wolters, et al., 2010; Christine Greenhalgh and Longland, 2005; Malmberg, 2005; Michalisin, 2001). An underlying idea of this research is that trademark data can capture the value of the innovation output of firms which are not covered by patents. This would include innovations in retail, services, customer relations and other knowledge intensive products. Moreover, trademarks are correlated with technological advancements (M. M. Godinho, Mendonca, and Tiago SANTOS Pereira, 2003; Gotsch and Hipp, 2012). Trademarks can also behave as complements or substitutes for patents (Milot and Llerena, 2012; Jensen and Webster, 2009). Lastly, trademarks can reflect innovation activity not accounted for by other indicators such as service and marketing innovations, while also best measure late-stage innovations (Dinlersoz, Goldschlag, Fila, and Zolas, 2018; M. J. Flikkema, Man, Wolters, et al., 2010; Gangjee, 2020). Trademarks can also account for organizational innovations which have a high degree of complementary with the digital revolution built on information and communication technology (Mohnen, Polder, and Van Leeuwen, 2018). This is increasingly vital as the service sector has increased in economic importance across the majority of industrial economies. Hence, it would be insightful to use

trademarks as a measure to understand the impact on innovation dynamics.

This paper studies how import competition affects innovation in developing countries by estimating the impact of greater exposure to trade on trademarking. Innovation is measured by both trademark applications and trademark registrations. As in recent literature studying competition and innovation, trade exposure is measured by the import penetration from China in developing countries. The empirical model used analyzes the within country margin of innovative activity as a result of import competition using a panel fixed effects data model with clustered standard errors. The estimations control for GDP, population, tertiary education and employment growth. The empirical strategy chosen deals with potential endogeneity issues of unobservable technology shocks correlated with the growth of Chinese imports using the identification strategy in Autor, Dorn, and Gordon H. Hanson (2016). A shift-share instrumental variable approach is taken whereby import penetration from China in a specific developing country is instrumented by import penetration in other developing countries. The results show that import competition has a weakly significant negative effect on local trademarking applications. However, the effect is positive for total applications which appears to be led by non-resident activity. The study's outcomes suggest that Chinese import competition increases overall trademarking but negatively affects local non-technological innovation activity.

### **Chapter 3: Importing Gender Equality: A Technological Revolution Effect**

An important political debate is in progress regarding the impact of globalization on gender inequality across the world. Theory identifies four main channels by which trade liberalization can affect gender equality: discrimination, technological revolution, comparative advantage and capital intensity. The literature currently presents conflicting results on the effect of trade on gender equality. Some studies have shown a negative impact of trade by reducing female labor market opportunities (Keller and Utar, 2018), reduced wage growth (Hakobyan and McLaren, 2018) and increasing the gender wage gap (Sauré and Zoabi, 2014). On the other hand, some studies find a positive impact through a reduction in gender wage inequality (Black and Brainerd, 2004) and increased female employment in manufacturing (Ederington, Minier, and Troske, 2009), especially in industries with the largest tariff reductions (Juhn, Ujhelyi, and Villegas-Sanchez, 2014).

While the literature examines the effect of trade on gender equality, the present study sheds light on the cross-country spillover effect of gender equality via trade. For that purpose, we take a spatial econometric approach to identify a transmission channel of gender standards between trading partners. This allows us to consider trade linkages as an economic notion of distance using trade exchanges in quantity. We use the weighted majority game with externalities which implies that decisions carried out by trading partners affect the utilities they generate from their own actions (Genschel and Plumper, 1997). Our results indicate a spillover effect of gender standards via trade, specifically through the imports of high and medium technological products.

We use a panel of country level data from 1997-2013 across 129 countries to estimate the impact of trade exchanges on the Gender Inequality Index (GII). The GII is a composite measure based on three dimensions: women’s empowerment, economic activity and reproductive health. We use a spatial econometric estimation method to simultaneously model time and space. Spatial variables are standardized according to the importance of trading partners in the country of observation’s trade, ie. weighted majority game. Here, the standardized spatial lag variables are interpreted as the average effect of the trading partners’ gender inequality, weighted by trade linkages, on the domestic gender inequality. To identify a technology transmission channel, we use the UNCTAD skill and technology intensity classification for all spatial trade exchanges variables. We run system-GMM estimations since system-GMM estimators outperform other estimators for spatial dynamic panel data with endogenous variables (Kukenova, Monteiro, Monte, and Monteiroy, 2009). Panel fixed effects regressions are used as robustness estimations. In order to avoid multicollinearity issues, we run several spatial regressions with only one spatial trade exchanges variable. First we run a model with spatial trade agreements and spatial bilateral trade. Then, we do this twice again with spatial import and spatial export instead of spatial bilateral trade. Finally we decompose imports and exports by each product category according to UNCTAD and repeat the operation for all spatial product categories. Trade relationships are disaggregated by technology-level products since technological upgrading within firms is known to affect gender inequality (Juhn, Ujhelyi, and Villegas-Sanchez, 2014).

Our results indicate that a spillover phenomenon of gender equality is observed from the imports of high tech, medium tech and mineral products from more gender-equal partners.

Such findings are consistent with a technological upgrading phenomenon since imported office/industry and agricultural machines increase the relative productivity of women. However, results suggest that a larger phenomenon is at hand. A technological revolution occurs within households and governments. First, the importation of advanced technologies changes the female opportunity cost for having children. The access to contraceptive methods allows a fertility control in laggard economies while the increasing use of household appliances enables women to reallocate their time outside the home in advanced economies (Goldin and L. F. Katz, 2000; Greenwood, Seshadri, and Yorukoglu, 2005). Women are therefore encouraged to study or work. Second, government spending in military technology requires high investments in public R&D which spill over onto private R&D (Moretti, Steinwender, and Van Reenen, 2019). Our results are intuitive and consistent with the observed declining trend of gender inequality around the world (Stotsky, Shibuya, Kolovich, and Kebhaj, 2016). This paper shows that the characteristics of trading partners matter for reducing gender inequality within a country.



# Chapter 1

## Trade and Innovation: A Survey of Patents and Trademarks

### 1.1 Introduction

The continuous rise in international trade over the past half century has been a significant economic phenomenon. Since 1965 up until 2016, the share of global trade as a percentage of world GDP has risen from 24 percent to 57 percent in 2016, peaking at 61 percent in 2008 before the financial crisis. A substantial change in the dynamics of international trade came in 2001 when China entered the World Trade Organization. Following the rapid economic expansion of the 1980s and 1990s, China became a member of the WTO to become deeply integrated in the world economy. In 2000, according to the World Bank, the total value of China's exports and imports was 249.2 million dollars and 225 million dollars, respectively. By 2016, the corresponding figures were 2.1 trillion dollars and 1.59 trillion dollars reflecting the explosive growth of China's integration into the global economy.

Despite mainstream economists raving about the productivity and welfare improving benefits of global trade for years, the merits of open economies have been called into question again. The recent literature has generally documented positive effects of trade and open economies on welfare (Bombardini, Orefice, and Tito, 2019; Alessandria, Choi, and Ruhl, 2021; Galiani, Paz y Miño, and Torrens, 2021; Montinari, 2013). However, critics of open trade policy have pointed out the increased competition from China that has plagued the US manufacturing industry, which is one of the main sources of innovation (Autor, Dorn, and Gordon H. Hanson, 2016). The immediate counter argument is the increased access to low-cost and abundant labor forces in Asia. The increase in global economic disparities, fueled by crises, has reinitiated a heated debate on trade policy. Perhaps the most critical question that arises is: How does trade affect innovation? The recent literature on this topic deems this puzzle unsolved. One of the main papers which reignited the debate is by Nicholas Bloom, Draca, and Van Reenen (2016) which showed a positive effect of the Multi-Fiber Agreement on patents, investments in IT and TFP in 12 European countries. Dorn, Gordon H Hanson, G. Pisano, Shu, et al. (2020) countered with a paper highlighting the negative effect of China's import penetration on patents, sales, employment and RD expenditure. M.-J. Yang, N. Li, and Lorenz (2021) also showed a negative effect of Chinese import competition in Canada on survival, self-reported

product and process innovation outcomes. It is safe to say that the literature is divided on the effect of trade on innovation in developed economies, even though it may be slightly skewed towards the negative. As a result, this research question remains critical to our understanding of economic growth and effective policy making.

The goal of this paper is to add to the growing body of literature discussing the impact of trade, specifically import competition, on innovation. This paper contributes to the literature in four main ways. First, a background on patents and trademarks as innovation indicators is presented, as well as a comparison between the two. The former being the innovation measure of choice in recent economic studies while the latter has been established as an important proxy for innovation but seldom used in empirical studies. Second, a discussion of the intuitions behind the theory of how import competition may affect innovation. To summarize, there are three key mechanisms from the literature: a Schumpeterian effect, an escape-competition effect and a preferences effect. The first has a negative impact on firm innovation while the others positive. Third, a survey of the recent empirical economic literature analyzing the link between trade, specifically import competition, on innovation-related outcomes. This review identifies noteworthy heterogeneities in the innovation response at the country level. Recent studies on developed economies find evidence of import competition negatively affecting innovation. On the other hand, the early literature finds evidence supporting trade liberalization positively affecting different productivity measures. As a result, there is still an existing gap in the literature regarding the impact of trade liberalization, or import competition, on innovation-related outcomes in developing countries. Lastly, an empirical analysis is conducted to examine the impact of Chinese import competition on innovation, measured by patenting activity, in developing countries.

Thus, the paper is organized as follows. Section 2 provides a background on patents and trademarks as innovation indicators. Section 3 provides the theoretical mechanism behind the impact of import competition on innovation. Section 4 reviews the empirical economic literature discussing the impact of trade on innovation-related outcomes. Section 5 presents the empirical economic analysis, results and findings. Finally, section 6 concludes.

## **1.2 Intellectual Property Background**

### **1.2.1 Innovation Measurement Issues**

Innovation is not easy to capture as Krugman stated that "knowledge flows are invisible; they leave no paper trail by which they may be measured and tracked". Griliches was the first to tackle this challenge by using patent data as an indicator of innovative activity. Griliches summarized that patent statistics could be useful, in part because of their availability and by definition their relation to inventiveness (Griliches, 2007).

Patent statistics have indeed been successful measures of innovation but even Griliches himself was a critic of patent data in recognizing its limitations. At the NBER conference in 1962, he stated that "[I]nventions may be the wrong unit of measurement. What we are really interested in is the stock of useful knowledge or

information and the factors that determine its rate of growth. Inventions may represent only one aspect of that process and may be a misleading quantum at that.” The propensity to patent varies greatly by industry and that is if they ever get patented (Cohen, R. Nelson, and Walsh, 2000). Moreover, the quality of a patent may vary tremendously from one patent to the next, which would make a simple count a less meaningful measure (Pakes, 1984).

Other proxies for innovation have been used but they are not without their limitations either. Scientific publications are one alternative but they are usually governed by the norms and institutions where a specific discovery was made. There are also strong incentives for academics to publish in order to receive credit for their work. On the contrary, non-academics are much less likely to publish their discoveries and are more selective when they do so (Murray and Stern, 2007). Another alternative proxy for innovation is R&D investments. While it has been proven to be insightful in some contexts, this publicly reported data is not able to shine a light on the types and value of inventions being pursued by firms. This data is also sometimes manipulated by firms in the pursuit of some specific R&D tax credits.

The issue of innovation measurement is even trickier for some more than others, such as spillovers from new ideas. Inventions from innovative firms may be copied or learned from by other firms in the industry, meanwhile costing them less than the full R&D cost of the original inventor. This could create spillovers without ever providing compensation for the original inventor. In recent years, researchers have used patent citations as a measurement to trace that spillover trail. While viewed as insightful, patent citations are still certainly thought to be an incomplete metric of innovation spillovers (Jaffe, Trajtenberg, and Fogarty, 2000).

## **1.2.2 Intellectual Property Rights Theory**

Intellectual property (IP) is simply a set of governmental policies in place to allow the original inventor to benefit from his/her invention. It grants a special right to exclude all other parties from producing, selling or licensing the products of the innovator thereby decreasing the free market competition. In simple terms, it gives the innovator the right to exclude others from economically benefiting from their invention for a limited period of time. This is in exchange for publicly disclosing how the invention functions. While taxes and subsidies have a direct effect on R&D costs, intellectual property affects both the cost as well as the reward of innovating. Costs may be incurred to license ideas they wish to build on and the potential rewards increase by limiting competition after the invention has been made. While the IP world is large, patents are among the most commonly used and featured in many recent economic studies.

From a theoretical perspective, IP rights such as patents have four main benefits (Bryan and Williams, 2021). First, they grant the original inventors the right to appropriate the value of their own invention. Second, they serve as a reward to inventors for any future inventions enabled by their idea. Third, they allow for clear licensing markets. Lastly, they force inventors into public disclosure of their invention.

## **Context in Developing Countries**

There is an important debate on intellectual property rights in developing countries and whether or not they should be enforced. Is it beneficial to overall welfare to enforce patents from abroad, or any patents at all? Intuition dictates that lesser innovative countries would only be harming themselves should they prevent local firms from copying foreign ideas or products. History shows examples of countries not enforcing protection of foreign ideas in order to catch up to the innovation frontier. In the late nineteenth century, Germany limited foreign patent rights when they were trying to make up ground with respect to their American counterparts (Richter and Streb, 2011). From the point of view of developing countries, Deardorff (2011) suggests that increasing global patent protection is not welfare improving. He implies that inventors are already incentivized by monopoly protection of their invention in their home country so international protection will not increase the propensity to invent. However, Diwan and Rodrik (1991) caution against a lack of intellectual property rights protection as it may deter innovators from technologies that are beneficial to those countries. Such things are important for policy makers to keep in mind in understanding innovation dynamics.

### **1.2.3 Patents**

The majority of the large economic literature on technological progress and innovative activity tend to measure innovation using patents (Cohen, 2010; C. Chen and Steinwender, 2019). Economists find patent data useful as it provides an appropriate proxy for the precise year in which an invention occurs (Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020). The patents in turn are used to protect the firm's technical knowledge as they provide an exclusive right as well as an incentive for investment in innovation activities. Thus, patents convey information about technical knowledge or advancement as well as the intention to protect such inventions. Moreover, the innovation literature survey-based data consistently show that patents are more often associated with product innovations as opposed to process innovations. Patenting has been consistently found to be correlated with production innovations in regression models (Brouwer and Kleinknecht, 1999; Arundel, Paal, and Soete, 1995; Bronwyn H. Hall, Helmers, Rogers, and Sena, 2013). The underlying logic is that a product innovation is more likely to contain patentable subject matter and also decrease the uncertainty surrounding the grant process. Moreover, product innovations are on average more valuable which lowers the burden of the financial costs of patenting. Another important factor regarding patents is that the majority of investment in a specific invention is undertaken before the patent is granted. This patent grant will then be given for a fixed duration, which is usually twenty years.

### **Sector Differences**

Given the product nature of patents, it is not surprising that patenting is associated with RD intensity. When it comes to protecting innovations, innovative firms that invest in RD are more likely to patent than other innovating firms as they are more likely to have patentable inventions (ibid.). This is especially true

for manufacturing firms who expend on R&D, as they were found to be positively correlated with patents (Bound and Cummins, 1984). A survey of US firms in 2009 showed that 21 percent of RD performing companies filed for a patent (Jankowski, 2012). Moreover, the shares vary significantly across industry with over 60 percent of companies patenting in basic chemicals and less than 10 percent in food.

Another one of the most robust findings of the patenting literature is the heterogeneity of patent use across industries. Studies have shown that industries which specialize in the production of “discrete” products, such as pharmaceuticals and chemicals, regard patents as their preferred means of protecting IP. Various survey studies over the years have confirmed the importance of patents in the pharmaceutical and chemical industries. In a study of US manufacturing firms from 1981 to 1983, at least 30 percent of inventions in those industries required a patent (Mansfield, 1986). Patent protection was necessary for about 10-20 percent of inventions in the petroleum, machinery and fabricated metals industries. A follow up study of Swiss firms found similar results showing that patenting was most important in the chemicals, pharmaceuticals and some parts of the machinery industry (Harabi, 1995). These results were also confirmed in later studies in the Netherlands, Germany, Luxembourg, Denmark, Ireland, Norway and the UK (Brouwer and Kleinknecht, 1999; Arundel, 2001; Bronwyn H. Hall, Helmers, Rogers, and Sena, 2013).

## **Firm Size**

One of the important findings of the literature is that intellectual property strategies vary across firm size. It is certainly true that larger firms find patents as a more critical part of their appropriability strategy than smaller ones. This has been confirmed in a large number of studies using survey data (Brouwer and Kleinknecht, 1999; Arundel, Paal, and Soete, 1995; Bronwyn H. Hall, Helmers, Rogers, and Sena, 2013). The main reason behind this phenomenon is clearly related to the financial component of patenting as larger firms will certainly find the cost per patent lower than smaller firms due to the associated fixed costs. Moreover, Small and Medium Enterprises (SMEs) will likely have more challenging financial constraints making the decision to apply for a patent too risky or burdensome. A recent study regarding the returns of RD for SMEs found that patents did not hold much importance in this process (Holgersson, 2013).

## **1.2.4 Trademarks**

The recent economic literature on trademarks has repeatedly stressed the argument that trademarks are a useful proxy of innovative activity (Mendonça, Tiago Santos Pereira, and M. Godinho, 2004; Allegrezza and Guarda-Rauchs, 1999; Crass, 2014; Hugo, Ferreira, and M. M. Godinho, 2011). Trademarks tend to protect a firm’s marketing assets by providing an exclusion right which provides an incentive for the firm to invest in further innovative activities (Christine Greenhalgh and Rogers, 2010). Trademarks are regarded as a signal of the firm’s new product development as it may require intellectual property protection. They are also seen as particularly valuable measures of service innovation (Millot, 2009). With regards to timing, trademarks refer to product and service innovations in the latter stages of the innovation process. Hence they resolve

some of the drawbacks of other innovation indicators, as illustrated by Kleinknecht (2000), as they better measure service innovations and innovations in later stages.

Furthermore, evidence shows that trademarks provide information on multiple types of innovation including technology-based product innovation and non-technological innovation. Non-technological innovations reflect product innovations that occur in sectors with low technological content, especially the service sector. These types of service innovations are not accounted for by patents, as they are not patentable matter, nor by R&D expenses (Milot, 2009). Therefore, service innovations are almost entirely absent from most innovation studies (Cainelli, Evangelista, and Savona, 2005). Thus, trademarking provides a significant amount of information to fill the gap on innovation in the service sector.

Moreover, non-technological innovations go beyond just the service sector. The Oslo Manual, the international reference guide for reporting and using data on innovation, identifies two other categories of innovation besides product and process innovations which are organizational and marketing innovations. An organizational innovation is defined as “the implementation of a new organisational method in the firm’s business practices, workplace organisation or external relations”. Whilst a marketing innovation is “the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing with the aim of reaching new customers and improving the sales.” Both organizational and marketing innovations are usually not patentable and are not associated with R&D expenses either, since they generally originate in non-technological departments. Hence, the existing innovation indicators being used such as patents and R&D expenses would not account for such innovations.

In summary, trademarks can be tremendously insightful as an innovation indicator at two different levels. Firstly, they can provide a proxy for product innovations as trademarks often go hand in hand with the commercial launch of a new product. This is complementary to other indicators which account for the technological change and not the commercial component. This makes it extra relevant for more economic sectors, especially services. Secondly, trademarks provide valuable information about organizational and marketing innovation which are not appropriated in other indicators.

## **Sector Differences**

In contrast to other popular innovation indicators such as patents and RD, the spectrum of trademarks is indeed very vast. They are largely present in all sectors of the economy, especially services. Since customers cannot try a service without buying it first, this makes trademarks especially important and requiring specific guarantees which are likely provided by brands (Rosenbaum-Elliott, Percy, and Pervan, 2015). For example, in a study of Australian firms from 1994 to 1996, trademarks were found to have more importance for non-manufacturing firms (Derek Bosworth and Rogers, 2001). However, the non-technological nature of trademarks also plays a complementary role in the manufacturing sector (Milot, 2009). This can be in the form of an organizational or marketing innovation which can be a new process, design, package, etc. Hence, trademarks are certainly important for service innovations but they do affect all sectors of the economy.

## **Firm Size**

The approach to intellectual property protection certainly differs by firm size with trademarking the preferred choice of smaller sized firms. In fact, in many analyses, SMEs account for the majority of overall trademark applications (Milot and Llerena, 2012). While patents are commonly used intellectual property tools, SMEs usually neglect using them (Thomä and Bizer, 2013). This aligns with previous findings in the literature stating that SMEs would only patent innovations that are likely to be successful, unlike the larger firms (Spithoven, Vanhaverbeke, and Roijakkers, 2013). Moreover, the lack of resources and intellectual property management practices present barriers for SMEs in their choice of IP strategy (Eppinger and Vladova, 2013).

Moreover, not all firms engage in both types of innovation, technological and non-technological. Some innovative firms may choose to narrow their focus on one or the other, some may conduct both and others none at all. An analysis of the unique SP 500 firms between 1993 and 2010 shows that over 32 percent have never filed for a patent but owned trademarks. On the other hand, only 6.5 percent had never filed for a trademark but owned patents. This illustrates that trademarks are also pertinent for capturing innovation activities among large firms. More importantly, this interesting finding that trademarks are more utilized than patents among SP 500 shows that product and marketing innovation is more prevalent than technological innovation.

### **1.2.5 Indicator of Innovation**

Economists have studied the innovation activities of companies, industries and countries for a long time. However, there is yet to be established a generally accepted indicator or set of indicators for innovative performance (Kleinknecht, 2000; Hagedoorn and Cloodt, 2003). In the most recent literature, patents have emerged as the indicator of choice (Nicholas Bloom, Draca, and Van Reenen, 2016; Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020; Bombardini, B. Li, and R. Wang, 2017). However, trademarks have also emerged as an innovation proxy as well (Gotsch and Hipp, 2012; Schmoch, 2003; Schmoch and Gauch, 2009). The reality is that both patents and trademarks transmit valuable information about innovation activity and should be taken equally seriously. While patents are more indicative of technology-based product innovations, trademarks were also found to reflect product innovations which were not combined with patent usage (Milot, 2009). However, trademarks are also essential in identifying service innovations as well as marketing and organizational innovations.

Furthermore, patents and trademarks capture innovative activity at different times in the innovation timeline (Milot and Llerena, 2012). Patents will refer to product innovations very early in their creation. Trademarks indicate product or service innovations in the more later stages of the innovation process as they are likely associated with the commercialization of the new product or service.

Financial constraints also play a role in the intellectual property choices a firm makes. The application for a patent as well as managing a patent portfolio is expensive. A firm would need to cover the application's monetary expenses and monitor the market for any potential infringement activity to take any necessary

legal action. This can be especially impactful for smaller firms and startups who tend to avoid patents for cost reasons, even those in high tech sectors such as biotech and software (Graham, Merges, Samuelson, and Sichelman, 2009). The expensive nature of patenting is an added burden on top of the upfront investment already put into bringing the innovation to life. Trademarks are cheaper than most other statutory intellectual property tools and hence more likely to be adopted by financially constrained firms and smaller enterprises (Mendonça, Tiago Santos Pereira, and M. Godinho, 2004). Moreover, a patent has a limited duration which is usually 20 years while trademarks can essentially be extended for an unlimited time period.

There have also been some studies which have posited that trademarks are complementary to patents (Rujas, 1999; Schwiebacher and Müller, 2010). The underlying theory is that a patent can be complemented by a trademark by providing exclusivity for a product which was built while the patent was in force (Llerena and Millot, 2013). On the other hand, they may also act as substitutes when a patent is in force because competition is essentially prohibited even without the protection of a trademark. This relationship is also industry- dependent as they may act as complements in the pharmaceutical sector but substitutes in the computer and electrical equipment industry. Nonetheless, the empirical evidence with regards to such complementarities is rather weak.

Lastly, it is apparent that both patents and trademarks are useful and necessary indicators of innovation in order to analyze the complete picture. They can both capture different aspects of innovation dynamics and thus enrich the current empirical literature studying innovative activities. Table 1.1 below provides a brief comparison of the two innovation indicators.

Table 1.1: Patents vs. Trademarks

	<b>Patents</b>	<b>Trademarks</b>
Purpose	Embody an exclusion right and provide an incentive for the firm to invest in innovation and marketing activities	Embody an exclusion right and provide an incentive for the firm to invest in innovation and marketing activities
Information	Transmit information about the firm's technical knowledge and the intention to protect its inventions	Transmit information about the firm's marketing strategy and its willingness to protect its marketing assets
Indicator	Indicates technological innovation: new product development or invention.	Indicates technological or non-technological innovation: new product, service, organizational or marketing innovation.
Stage	Captures early stage of innovation.	Captures later stage of innovation.
Investment Timing	Majority of investments are undertaken before it is granted.	Majority of investments undertaken after it is granted.
Duration	Granted for a certain period, usually 20 years.	In principle granted for an unlimited time period.
Cost	Expensive: entail high application and maintenance costs .	Cheap: Less costly than most other intellectual property tools.



## **1.3 Theory**

Import competition implies that domestic firms will face increased competition from foreign competitor firms who are looking to penetrate a new market. This does not alter the size of the market for a domestic firm but rather increases the competitive pressure. The industrial organization literature in economics has identified three important effects which drive firm incentives to innovate.

### **1.3.1 Schumpeterian Effect**

The first is known as the “Schumpeterian” effect which was brought forth by the renown Austrian economist, Schumpeter, who stated that import competition would lead to a negative impact on firm innovation. He argued that the reduction of a firm’s market share meant that there were less profits to extract from innovating. This was later reaffirmed by Dasgupta and Stiglitz (1980) who showed that increased competition affects profit margins and results in less investment in RD, thereby less innovation.

### **1.3.2 Escape-Competition Effect**

The second mechanism is known as the “escape-competition” effect stated by Arrow in 1962 where he argued that import competition would have a positive impact on firm innovation. Arrow claimed that by innovating, a firm could reap into the profits of its competitors. Unlike a scenario where there are no new entrants, firms would not have any incentives to innovate. Aghion, Nick Bloom, Blundell, Griffith, and Howitt (2005) introduced a model that outlined the different competition conditions that were most conducive to innovation. The model suggests that firms with the same technological capacity will enjoy increasing returns to innovation due to competition since it can drive a firm to leapfrog its competitors.

### **1.3.3 Preferences Effect**

The third mechanism at play is known as the “preferences” effect which was introduced by Hart in 1983 where he challenges the idea that firms are profit maximizing and implies that import competition would have a positive impact on firm innovation. The assumption is that firm managers may have private benefits to extract in addition to the firm’s financial profits which will affect their executive decisions on deciding to invest in innovation. C. Chen and Steinwender (2019) elaborate on this idea illustrating that private benefits may only be extracted in the case where firms actually exist, which incentivizes innovation efforts upon increased competitive pressure. Even the efficiency literature states that competitive pressure has a positive effect on the management of firms.

### **1.3.4 Initial Productivity Issue**

It is also important to mention that a firm’s level of productivity or efficiency may dictate its innovation efforts. The Schumpeterian effect may be stronger for firms which are initially less productive than for those

who are technologically advanced. On the other hand, the escape competition effect will likely be more pronounced for the firms that are on the technological frontier and hence more productive to begin with. The preferences effect may be more poignant with the less productive firms initially which face a higher risk of exiting and less managerial discipline. The important take away is that there are many ways firms can react to import competition, some of which are not captured entirely with these mechanisms. The empirical evidence can thus help us deduce which of the key mechanisms are at play in order to understand innovation drivers.

## **1.4 Literature: Import Competition & Innovation**

### **1.4.1 Import Competition & Innovation in Developed Countries**

The literature regarding the impact of import competition on innovation has gained renewed importance in recent years. This due in large part to the increase in international trade over the past several decades and China's rapid integration into the world economy. Since China's joining of the World Trade Organization in 2001, the country has become a sudden and extremely important player in international trade which has generated much discussion. While it has long been the stance of economists that trade is indeed welfare-improving, China's recent explosive surge has once again brought this question into light. The empirical literature studying the impact of import competition on innovation-related outcomes have mainly adopted reduced-form strategies while using different trade liberalization episodes as the sources of variation. Despite a growing literature in recent years, there has been no clear consensus on whether import competition encourages or discourages innovation.

Most recently, some empirical studies have found a negative effect of trade on innovation outcomes. Recent studies have used more direct measures of innovation such as patents and R&D expenditure, which accounts for the input into innovation. One notable study is Dorn, Gordon H Hanson, G. Pisano, Shu, et al. (2020) which documents a negative impact of rising import competition from China on firm-level and technology class-level patent production using data for US firms from 1975-2007. Their analysis states that approximately 40 percent of the slowdown in patenting can be attributed to accelerated import competition. This effect was found to be significant for public and private firms, and had negative effects on other firm outcomes such as global sales, profit growth, global employment, and global R&D spending. M.-J. Yang, N. Li, and Lorenz (2021) study the Canadian manufacturing sector from 1999 to 2005, employing data on both large and small, privately-owned firms, to find a negative impact as well. The increased import competition from China led to systematically reduced innovations which was driven by a drop in process rather than product innovations. A similar result was found in Xu and Gong (2017), using a database of US manufacturing industries from 1995 to 2009, showing that firms exposed to more import competition from China incur a reduction in R&D. This induces a reallocation of R&D to more product firms with initial market power.

Other studies on the US in particular also find mixed effects of import competition using indirect innovation-related outcomes such as investment, sales growth, profitability and product differentiation (Gutiérrez and Philippon, 2017; Hombert and Matray, 2018). They do confirm the overall negative effect of Chinese import competition. However, the findings in their studies also note that the effect may differ depending on how far along a firm is on the technology frontier. There is some suggestive evidence of positive effects for firms which are more capital intensive, productive and engage in more R&D activities.

Moreover, another strand of the empirical literature finds a positive effect of import competition on innovation. In a recent study conducted by Nicholas Bloom, Draca, and Van Reenen (2016), using firm-level data for 12 European countries for the period 1996-2007, a positive effect of Chinese import competition was found on innovation. Innovation increased at the intensive margin with firms facing higher levels of import competition would patent more, have higher R&D expenditures, raise their IT intensity as well as their Total Factor Productivity (TFP). The impact also differs firm level of technology, with low-tech firms being more likely to shrink or exit in response to increased competition. A study of Spain by C. Chen and Steinwender (2019) using firm-level data from 1993-2007 finds a positive effect of EU-level tariff reductions on initially unproductive family firms, negative for initially productive family firms and insignificant for non-family firms. Recent studies outside of Europe also find similar results. In the Gorodnichenko, Svejnar, and Terrell (2010) study of 27 transition countries, a self-reported measure of foreign competition was found to have a positive effect on the development and upgrading of new products, and adoption of new technologies. The Bombardini, B. Li, and R. Wang (2017) analysis of China shows a positive effect of the WTO accession tariff on patenting for the most productive firms.

Hoberg, Y. Li, and G. M. Phillips (2020) take a novel approach to this question by examining competition in innovation itself. They propose that global competition can impact innovation in two different ways: in the market for existing products and in the market for innovation and intellectual property. They introduce a new shock to the innovation capabilities of Chinese firms using the cost changes in accessing information over the internet. They do so by using the staggered internet roll out in China across its provinces. Then they examine the effect on U.S. firms and their complaints about competition from China and intellectual property theft after the increase in Chinese internet penetration. They stipulate that greater internet penetration at the provincial level in China will allow firms to cheaply access information and challenge U.S. firm innovation.

Their findings show that intellectual property competition from China significantly impacts U.S. firms as they reduce their R&D investments. Furthermore, these firms come to have a decrease in patents while China realizes a meaningful increase in patents in the same intellectual property markets. More profoundly, the new patents of Chinese inventors directly cite the U.S. technologies affected by the shock. The negative effect on U.S. firms is even greater with higher internet penetration and their focal industry being supported in the Chinese government’s five year plan. They attribute this crowding out effect to the competition between Chinese firms and their U.S. counterparts.

In regards to firm performance and production strategies in the face of increasing Chinese innovation competition, U.S. firms witness a decrease in sales growth over the long run while increasing their inputs

sourced from China. Therefore, increased intellectual property competition allows U.S. firms to purchase cheaper inputs from offshore sources. This study provides new insights in understanding the impact of competition on innovation. Competition in intellectual property markets can explain some of the varying effects found in the empirical literature.

Another new approach is taken by Huang and B. Yang (2018) in studying the import competition and innovation relationship using a new proxy for innovation. They investigate the impact of competition on innovation of U.S. firms, using trademarks as their measure of product development innovation. Stating that the commercialization of most new products is accompanied by a new trademark, they justify its use as a measure of product innovation. Their findings show that import competition has a positive effect on newly launched trademarks by U.S. manufacturing firms.

Furthermore, they go on to examine the success rate of these newly launched products by observing the renewal status of each trademark filed. Their results find import competition to have a negative effect on the survival rate of the newly filed trademarks. This suggests that firms launch more new products in the face of import competition but that these products will be likely be abandoned in the future. They also investigate the diversity of the new trademarks and find that it is lower for those facing greater foreign import competition. In other words, the number of unique product/service classes filed for are less. Their findings also highlight the fact that firms tend to launch new products in their own expertise or in familiar areas as a response to this increased competition. In regards to firm performance, this study finds that trademarking in the face of import competition limits the negative impact of increased competition on performance.

### **1.4.2 Import Competition & Innovation in Developing Countries**

While the recent literature has a greater focus on developed economies, the empirical literature prior to 2012 paid more attention to developing countries, particularly in Latin America which experienced multiple trade-liberalization episodes. The overwhelming majority of these studies used total factor productivity (TFP) as the primary measure of innovation. Moreover, these studies covered time periods predating the incredible surge of China after joining the WTO in 2001. Studies which considered firm heterogeneity found differing effects of import competition on innovation depending on firm size and level of technological advancement. Iacovone, Keller, and Rauch (2011) study Mexican plant-level data from 1998-2004 to find that import competition from China does not significantly affect levels of productivity. However, they do find a positive effect on firms with higher levels of productivity and negative on initially less productive firms. A similar study of Colombia by Fernandes (2007) using manufacturing plant-level data from 1977-1991 shows trade liberalization having a positive impact on plant productivity, with a stronger effect on larger plants and those in less competitive industries.

Further studies in Latin American countries document a positive effect of import competition on different productivity measures. A Latin American study of Brazil conducted by Muendler (2004b) using data from 1986-1998 reports that trade liberalization raises productivity for medium-sized & large firms, and the

shutdown probability of firms rises with competition from abroad. Similar findings were made in the Schor (2004) study of Brazil reporting a positive effect of unilateral trade liberalization on TFP for a data sample covering the time period between 1986 and 1998. Outside of Latin America, the positive effect of import competition is documented in a couple studies in Asia. A study of trade liberalization in both India and Indonesia find a positive effect on TFP (Topalova and A. Khandelwal, 2011; Amiti and Konings, 2007). Overall, the evidence from the early empirical literature on productivity for developing countries is consistent with an escape-competition effect mechanism, though the effect appears to vary by firm size and technological level. On the other hand, the evidence for developed countries seems less conclusive.

### **1.4.3 Measurement Issues in Developing Country Studies**

As previously mentioned, the earlier literature on import competition conducted on Latin American economies suggested that the evidence is consistent with the escape competition mechanism. Studies conducted on developing countries such as Mexico, Colombia, Chile, Brazil and India have revolved around the impact of the trade liberalization period on different measures of productivity as the innovation outcome. The various measures included productivity, average production cost, Olley-Pakes productivity, Levinsohn-Petrin total factor productivity, direct approach total factor productivity, quality control and labor productivity. In each of the studies conducted, a generally positive effect was found as a result of import competition.

The use of productivity as a measurement of innovation also presents its issues. The literature is still trying to navigate what is the best way to measure innovation. As with most things in life, there are certain advantages and disadvantages to using different measurables. Productivity is definitely a measurable which reflects upon the performance, efficiency and profitability of a firm, but not necessarily on its innovation. Improved productivity can be a result of markup changes due to wielding market power and not necessarily innovative practices. In fact, this was verified by Loecker (2011) who found that only twenty five percent of estimated productivity gains were rooted in real productivity changes. It becomes more confusing because it's hard to identify the real cause for these productivity gains. They can be a result of genuinely innovative activities or a simple reallocation of a firm resources. Atkin, A. K. Khandelwal, and Osman (2017) followed up by determining that a reallocation towards higher quality products with higher prices were the real driver of productivity gains. Mayer, Melitz, and Ottaviano (2021) actually showed that gains of productivity for exporters were simply due to a reallocation towards more productive products.

These issues have led to the use of different and perhaps closer measures of innovation such as R&D expenditure and patenting. However, they do not come without their own drawbacks. As stated by Dasgupta and Stiglitz (1980), R&D expenditure will not always result in innovative output due to the complexity and uncertainty of the process. Even patents have their issues as they are most often a result of a very long RD process and can not really be associated with specific trade shocks. Furthermore, patenting could be incentivized by certain legal or regulatory changes and thus must be controlled for as well. One must also be careful to control for patenting trends across different sectors and over time.

The existing literature, summarized so far, indicates the need to revisit the study of import competition on innovation-related outcomes in developing countries. Given the documented weakness of total factor productivity as a measure of innovation as it is a rather indirect measure, it is imperative to use a better suited indicator to conduct such an analysis. It is also important to undertake an empirical effort to understand the impact of the relatively recent rise in Chinese import competition.

#### **1.4.4 Market Structure Competition & Innovation**

Given the ambiguity in the relationship between import competition and innovation, it is worth dwelling on the relationship between market structure and innovation as well. In similar fashion, the impact of market structure on innovation is complex from theoretical and empirical point of view. Schumpeter's argument is that perfect competition, where markups are driven to zero, is inherently bad for innovative sectors. If there are no profits to be made from innovation, there will be no incentive to innovate.

Aghion, Nick Bloom, Blundell, Griffith, and Howitt (2005) added a very important theoretical link between competition and innovation in their now famous "inverted-U" model. For firms with a similar technology level in a specific market, small inventions are not profitable enough. This is because they can not charge a high enough price for such an invention, nor does it give them a big enough technological advantage to dominate their competition. For firms with a big technological advantage, their incentive to innovate is low as their products are already profitable and they have no competition in their technology level. However, in the intermediate range of competitive parity, profits can be high for firms with some market power and innovation costs are low. This can encourage maximum innovation from firms as they will try to separate from their competition.

The early empirical literature regarding competition and R&D activities found no meaningful relationship between them. R. Gilbert (2006) review of these studies shows most misinterpreted their findings as an argument that more R&D is done by bigger firms, rather than the more precise finding that firms in more competitive markets do. Cohen (2010) details that R&D does increase with firm size but it's productivity decreases. An explanation for this finding is offered by Cohen and Klepper (1996) who show that this is due to the cost spreading of big firms so that R&D becomes less productive on the margin. Sutton (2001) made the theoretical and empirical argument that a minimum scale of efficiency is required for firms to find it worthwhile to conduct R&D. He notes that this scale varies across industries and thus affects market structure.

Furthermore, even recent studies do not find an unambiguous relationship between competition and innovation. Kang (2020) investigated colluding cartels in the US to understand if such firms in concentrated industries would innovate more or less. His findings show that while price-fixing took place, cartel members filed 48 percent more patents and 33% more top quality patents than similarly matched firms. They also conduct 18 percent more RD, and have greater breadth of innovation patenting in 30 percent more technology classes. On the other hand, Lampe and Moser (2016) show that collusion from the R&D side, through shared

patent pools, have a negative effect on R&D intensity. These findings may not be contradictory but they show different effects of market concentration on innovation activities.

Competition can also encourage or force inefficient firms to catch up to the technology frontier (Leibenstein, 1966). Syverson (2004) shows that competitive industries cause inefficient firms to fail. Meanwhile, competition can also drive firms to implement better management practices (Nicholas Bloom and Van Reenen, 2007). Moreover, there is a small subset of the competition and innovation literature which argues that moderate competition leads to higher-variance invention. One such study is Gross and Sampat (2020) who use the variation in the level of competition in logo design contests to illustrate the idea that low expected returns decrease the R&D "effort" made, while a high probability of winning the contest leads to very conventional designs. Thus, it is the intermediate level of competition which yields the best and most creative results among innovators.

A series of papers tackle this question further by estimating dynamic structural models of R&D. Goettler and Gordon (2011) dynamically model the competition between AMD and Intel and suggest that if Intel was a monopolist, it would have had more innovation given the prices it would have been able to charge. Meanwhile, Igami (2017) shows that the innovation gap among hard disk drive manufacturers, between incumbents and entrants, is due to the dulled incentives of market leaders. Igami and Uetake (2020) study the same industry using a dynamic structural model and find that the incentive to innovate greatly increases when going from one to three or more competitors.

Another important nuance in studying the relationship between competition and innovation is the difference between technology competition and product market competition. As Nicholas Bloom, Schankerman, and Van Reenen (2013) point out, firms may conduct similar R&D while actually producing and selling products in completely different markets. This area in the literature is still relatively unstudied, especially in relation to how acquisitions and licensing can impact innovation. One such empirical study of the famous Bell Labs in the 1950s shows that licensing, which was made mandatory by the government, led to a large increase in forward citations to Bell patents (Watzinger, Fackler, Nagler, and Schnitzer, 2020).

In summary, the impact of competition on innovation is difficult to assess and affected by the behavior of firms with each other. If firm interaction is unrestricted, firms will collude to maximize their profitability (R. J. Gilbert and Newbery, 1982). There is also great theoretical and empirical variability across industries depending on the technological opportunity, rents of incumbents and entrants, acquisition regulations and complementary assets (Bryan and Williams, 2021). Moreover, the gap between pre- and post-innovation returns will most likely determine the level of innovative activity. When the gap is large, more innovation will take place, and vice versa. Accordingly, monopolistic industries will see little innovation and so will highly competitive industries with low returns to innovation.

## 1.5 Empirical Estimations

This section is conducted in an effort to fortify the empirical literature tackling the impact of trade on innovation, specifically in developing countries. As previously highlighted, the most recent economic literature has focused heavily on developed countries using new innovation indicators, but not in the developing world. Many studies came out regarding the trade liberalization phase in South America during the nineties but not as of recent. Moreover, the innovation indicators of choice were various productivity measures, which are not immune to weaknesses.

Therefore, here an empirical analysis of the impact of trade on innovation in developing countries, using patents as the measure of innovation. Trade is reflected in the sense of import competition measured by the China shock or imports coming from China. This research question investigates the impact of Chinese import competition on patenting activities in developing countries.

### 1.5.1 Data

The goal of this analysis is to empirically assess the impact of import competition on innovation in developing countries, with patents as the proxy for innovation. To do so, a database is built using patent data from the WIPO (World Intellectual Property Office), trade data from the UN COMTRADE and further control variables from the World Bank open database.

#### Patents

The patenting data is collected from the World Intellectual Property Office (WIPO) for over 80 developing countries covering the time period from 1995 to 2018. This data is aggregated at the country level which creates a database with more than 2000 observations. However, the challenge in studying developing countries is the lack of complete data as there are missing values. This is primarily due to the fact that the WIPO itself is aggregating such data from intellectual property offices around the world and not collecting them directly. This leads to an unbalanced panel but due to the random nature of the attrition, it does not hinder the study.<sup>1</sup> Since estimations suffer less bias without the missing values, especially when using clustered standard errors, the results with the extrapolated patent data are presented. There are three principal measures of patenting: applications, grants and in-force. An application represents the first stage of the patenting process. Once an application is filed, it can then be granted or rejected depending on its merit as judged by the IP office. Lastly, in-force represents the number of patents renewed/maintained in order to preserve the protection rights. For each of the three patenting measures, different count breakdowns are available. For example, consider patent applications, we observe: the overall total number of applications, the number of applications by locals, the number of applications by residents and the number of applications by non-residents. This breakdown of total, local, resident and non-resident is available for all three measures of patenting. This allows us to assess patenting dynamics at a more refined level.

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<sup>1</sup>No systemic difference in results is found between extrapolated patent data estimations and existing data estimations.



## Trade

The trade data is sourced from the UN Comtrade data system and the MIT Observatory of Economic Complexity. Their international database provides information on bilateral imports and exports between any given pair of countries at the product level. In order to harmonize with the level of the patent data, the data is aggregated at the country level. The key measure of trade or import competition is exposure to Chinese trade which is calculated using the value of imports originating from China ( $M^{China}$ ) as a share of total world imports ( $M^{World}$ ) in a country. Therefore,  $IMP^{CH} = (M^{China}/M^{World})$  in an effort to follow this “value share” approach (Bernard, 2002; Jensen and Schott 2006).

## Controls

Control variables are also utilized in all estimations which have all been collected from the World Bank Open database. These include GDP, population, and education. In order to account for the education status of a country, the number of tertiary education graduates per year was chosen.

### 1.5.2 Methodology

The empirical approach taken analyzes the impact of import competition on the within country innovation activity in developing countries. The proxy of innovation here is the level of patenting activity. The main innovation indicator variables here are patent applications, grants and in-force.

The empirical strategy here involves the use of a panel data model with country and year fixed-effects and clustered standard errors. The basic equation for the growth of patent activity in country  $i$  at time  $t$  is:

$$\Delta \ln(PAT)_{i,t} = \alpha_i + \gamma_t + \beta_1^{PAT} \Delta \ln(IMP)_{it}^{CH} + \beta_2 GDP_{it} + \beta_3 \ln(population)_{it} + \beta_4 Tertiary\ education_{it} + \epsilon_{it} \quad (1.1)$$

Following the Bloom et al. (2016) methodology, the specification is estimated in long five year differences to control for unobserved heterogeneity between countries denoted by the operator DELTA. Import competition is proxied by the China shock or the increase in the share of Chinese imports. Here,  $IMP_{it}^{CH}$  measures the share of imports generating from China in country  $i$  ( $M_{it}^{CH}/M_{World}^{CH}$ ). If indeed, import competition spurs innovation then we expect  $\beta_1^{PAT} > 0$ . Across all estimations, a common set of control variables are used which are GDP, population tertiary education.

The above empirical strategy in equation 1 is adopted for both patent applications and patent grants. The patent application count is an apt measure of the propensity for technical innovation while patent grants reflects the quality of this technical innovation.

On the other hand, using the patents in-force count as an indicator requires a slightly different estimation equation due to its contemporaneous nature. The long 5-year differences are appropriate for patent appli-

cations and grants as firms take multiple years to churn out innovation from their R&D activity (Nicholas Bloom, Draca, and Van Reenen, 2016). However, patents in-force is not a function of multiple years but rather an immediate decision to renew the exclusive rights already granted to a patent. As a result, a simple contemporaneous equation is more appropriate to capture the dynamics of patents in-force as shown below:

$$\begin{aligned} \ln(PAT)_{i,t} = & \alpha_i + \gamma_t + \beta_1^{PAT} (IMP)_{it}^{CH} + \beta_2 GDP_{it} \\ & + \beta_3 \ln(population)_{it} + \beta_4 Tertiary\ education_{it} + \epsilon_{it} \quad (1.2) \end{aligned}$$

In equation 2, patents in-force is the innovation indicator, and long 5-year differences are not used. Instead, a standard contemporaneous estimation is conducted. Similarly, if trade induced import competition has an effect on patents in-force then we should find  $\beta_1^{PAT} > 0$ .

### Instrumental Variable

In order to remedy potential endogeneity issues which may be induced by unobserved shocks due to Chinese import growth, an instrumental variable approach is used. This is because China's import growth may be a result of unobserved technology shocks. Moreover, China's liberalization strategy has been led by its policy makes and exports grew particularly in industries where China already benefitted from a comparative advantage.

Therefore, a shift-share instrumental variable approach is implemented where past exposure to Chinese trade is instrumented for the growth of Chinese imports. More specifically, exposure to Chinese imports prior to it joining the WTO in 1999, will instrument for subsequent growth in China's import share in a specific country. In other words, this variable represents the share of Chinese exports in 1999 in respect to Chinese exports to all developing countries. This measure of past exposure is interacted with the exogenous growth of Chinese imports to all developing countries. Moreover, to mitigate further the endogeneity issue and add variation, the Chinese imports of country  $k$  will be subtracted from the total value of Chinese imports across all developing countries. In mathematical terms, the key measure of import competition  $IMP_{kt}^{CH}$  is instrumented by  $IMP_{k1999}^{CH} * (\Delta M_t^{CH} - \Delta M_{kt}^{CH})$ .  $IMP_{k1999}^{CH}$  is simply the value of imports originating from China in 1999 ( $M_{k1999}^{China}$ ) as a share of total Chinese imports for all developing countries in 1999 ( $M_{dev1999}^{China}$ ), where  $IMP_{k1999}^{CH} = (M_{k1999}^{China} / M_{dev1999}^{China})$ . The sum of all the shares to each developing country add up to unity. The shift-share instrumental variable approach has gained much credibility and popularity in recent years in the economic literature (Card, 2001; Furtado and Hock, 2010; Amuedo-Dorantes and Sevilla, 2014). Lastly, an advantage of this particular approach is that the threat of Chinese import competition is better reflected by this predicted measure of Chinese imports (Nicholas Bloom, Draca, and Van Reenen, 2016).

Table 1.2: Impact of China Shock on Patent Applications

Variables	(1) $\Delta\text{Total}$	(2) $\Delta\text{Local}$	(3) $\Delta\text{Resident}$	(4) $\Delta\text{Non-Resident}$	(5) $\Delta\text{Abroad}$
Chinese Imports $\Delta\text{IMP}_{it}^{CH}$	0.305* (0.172)	0.0931 (0.205)	0.173 (0.177)	0.421** (0.194)	0.129 (0.181)
Population	0.486 (1.875)	2.704** (1.287)	2.893* (1.641)	-0.837 (2.489)	2.972** (1.368)
Tertiary Grad.	-0.305 (0.389)	0.233 (0.337)	-0.130 (0.244)	-0.170 (0.449)	0.421 (0.307)
GDP	-0.110 (0.301)	0.140 (0.393)	-0.285 (0.324)	-0.145 (0.420)	0.286 (0.390)
Employment	2.728 (2.433)	1.558 (1.865)	4.079* (2.219)	2.751 (3.112)	1.395 (1.830)
$N$	753	831	696	736	767
R-squared	0.075	0.070	0.118	0.062	0.317
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent application measures in log 5-year differences. The following control variables are also in log: population, tertiary graduates and GDP.

### 1.5.3 Results

This section discusses the results obtained from the empirical strategy mentioned above. The estimation process is divided into three stages. First, the results of the impact of import competition on patent applications and grants are reported. Second, the effect of this Chinese import competition on patents in-force. Third, the results of the instrumental variable estimations undertaken to deal with endogeneity issues. Lastly, it is followed by a discussion of the potential mechanisms.

#### Patent Applications & Grants

Table 1.2 below presents the OLS estimation results on patenting application indicators. It is clear that there is only an impact of the trade induced import competition measure on two of the patent application variables; total and non-resident applications. The result for both is a positive and significant effect of Chinese import competition. A 1 percent increase in the China shock leads to a 0.30 and 0.42 increase in total and non-resident patent applications respectively. Despite having positive coefficients, there is no significant effect of import competition on local, resident and abroad patent applications.

The results in Table 1.3 show the impact of Chinese import competition on the different patenting grant indicators using OLS estimations. Once again, there seems to be no significant affect on any of the grant variables, except for patent grants abroad. The effect of the China shock is strong and positive on patenting grants abroad. Meanwhile, the impact on total patent grants, national grants, resident grants and non-resident grants, is insignificant. Only local patent grants has a negative sign but as it is insignificant as well, it is hard to extract any information from it.

The results in OLS for the impact of import competition on patents in-force are represented in Table

Table 1.3: Impact of China Shock on Patent Grants

Variables	(1) $\Delta$ Total	(2) $\Delta$ Local	(3) $\Delta$ Resident	(4) $\Delta$ Non-Resident	(5) $\Delta$ Abroad
Chinese Imports $\Delta \text{IMP}_{it}^{CH}$	0.290 (0.183)	-0.0704 (0.215)	0.141 (0.115)	0.304 (0.229)	0.409** (0.162)
Population	0.612 (1.662)	2.920** (1.388)	1.864 (1.208)	-1.646 (2.494)	0.195 (1.563)
Tertiary Grad.	-0.00704 (0.329)	-0.161 (0.344)	-0.168 (0.244)	0.268 (0.324)	0.479* (0.264)
GDP	0.262 (0.298)	-0.0990 (0.438)	-0.165 (0.283)	0.260 (0.299)	-0.361 (0.443)
Employment	-1.024 (2.585)	-5.516** (2.675)	-1.223 (2.286)	-2.550 (3.598)	-1.640 (2.759)
<i>N</i>	725	770	649	686	580
R-squared	0.095	0.047	0.081	0.081	0.137
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent grant measures in log 5-year differences. The following control variables are also in log; population, tertiary graduates and GDP.

1.4. On the one hand, a positive and significant effect is found for locals. A 1 percentage increase of Chinese imports is accompanied by almost a 0.27 percent increase in the patents in-force of locals. On the other hand, there were no other significant effects found of Chinese import competition on patents in-force at the total, resident, non-resident or abroad level. This sheds light on the reaction of locals to increased foreign import competition.

### Instrumental Variable Estimations

After presenting the OLS results, the same estimations are then conducted with the instrumental variable. The China shock is now instrumented by past exposure to Chinese imports, prior to China joining the WTO. In each table, the basic OLS results are re-presented alongside the first stage instrumental variable regressions and the second stage.

Tables 1.5 to 1.9 show the results for each instrumental variable estimation for patent application and grant indicators. Similarly, the basic OLS results are shown alongside the first stage instrumental variable regressions and the second stage results. As shown in the tables, none of the instrumental variable regressions for patent applications or grants indicate any significance of Chinese import competition. There is no particular effect at the aggregate or local level or for residents and non-residents. The increase in import competition does not seem to significantly impact patenting activity in developing countries. In similar fashion, tables 1.10 and 1.11 show the results for patents in-force instrumental variable estimations. Once again, there appears to be no significant effect of Chinese import competition on innovation on total patents in-force. Despite a positive effect on local patents in-force in OLS estimations, the effect disappears in the IV results. The effect of import competition is insignificant for resident and non-resident patents in-force as

Table 1.4: Impact of China Shock on Patents In-Force

Variables	(1) Total	(2) Locals	(3) Residents	(4) Non-Residents	(5) Abroad
Chinese Imports $IMP_{it}^{CH}$	-0.299 (0.185)	0.266* (0.143)	0.204 (0.209)	-0.199 (0.243)	0.0268 (0.125)
Population	-1.746 (2.553)	3.576*** (0.857)	4.441* (2.598)	-4.843 (3.019)	3.178*** (0.695)
Tertiary Grad.	-0.0304 (0.243)	0.513* (0.262)	-0.0163 (0.370)	0.0315 (0.265)	0.185 (0.164)
GDP	0.442 (0.576)	0.117 (0.428)	-0.0154 (0.392)	0.465 (0.652)	-0.360 (0.289)
Employment	-1.320 (1.386)	-0.808 (2.051)	-1.897 (1.919)	-2.203 (1.644)	1.825 (1.197)
$N$	449	670	376	385	666
R-squared	0.127	0.372	0.113	0.124	0.592
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. The dependent variables are patent in-force measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

well.

## Discussion

The results presented above may provide some potentially useful insights regarding innovation dynamics in developing countries. On the one hand, there appears to be no significant impact of trade induced import competition on patenting activity. The estimations illustrated that Chinese import competition was not significantly correlated with patent applications, grants or those in-force. In other words, this competition from trade did not trigger a particular innovation response in increased R&D spending or new inventions. Nor did it affect the number of patent grants which represent the quality of invention and innovation being produced. In terms of patenting innovation, such results infer that import competition does not have much of an effect.

The main takeaway from this empirical exercise suggests that import competition does not have a significant impact on patenting in developing countries. I find no evidence of Chinese import competition impacting patent applications, grants or those in-force. The non-significant results are the same whether at the national, abroad, local, resident or non-resident level. According to Bronwyn H Hall (2020), this should not be such a surprising finding since patents are not too relied upon in low and middle income countries. Moreover, the patent system is of relative unimportance specifically to domestic entities, even if a well-administered IP system is in place (ibid.). In fact, only a very small share of firms in those countries use the patent system at all (Bronwyn H. Hall and Helmers, 2019). Furthermore, the empirical literature shows that patents have a beneficial effect on innovation in specific sectors which mainly pharmaceutical, biotechnology,

medical instruments and chemicals. In other words, outside of those industries, patents are not amongst the main ways to appropriate returns to innovation (Cohen, R. R. Nelson, and Walsh, 2000). Those industries are also generally high-tech sectors which are less of a focus in low and middle-income countries (OECD, 2012). These results align with the existing literature regarding patenting and development. Hence, it should be unsurprising that import competition does not yield any significant impact on patenting in developing countries since they are already extremely uncommon while being pertinent for specific industries.

## 1.6 Conclusion

The main goal of this paper is to add to the existing body of economic literature discussing the impact of trade innovation. Thus, the contribution of this paper is done in four main ways. First, a deep dive on innovation indicators is conducted with a specific focus on patents and trademarks. Second, the theory behind the impact of import competition on innovation is summarized. Third, a collection and review of the most recent empirical economic analyses of import competition and innovation is discussed. Lastly, an empirical study is conducted analyzing the impact of Chinese import competition on innovation, measured by patenting activity.

On the one hand, patents have been the most commonly used innovation indicator in economic studies. Patents embody an exclusive right and aim to protect technological advancement. Timeliness and ability to proxy product invention allows patents to illustrate important parts of innovation dynamics. Patents tend to be most common in technological industries such as chemicals and pharmaceuticals. They are also more likely to be utilized by larger firms due to the associated financial costs.

On the other hand, trademarks have been an underutilized innovation indicator despite their ability to capture important aspects of the innovation process (Mendonça, Tiago Santos Pereira, and M. Godinho, 2004; Allegrezza and Guarda-Rauchs, 1999; Crass, 2014; Hugo, Ferreira, and M. M. Godinho, 2011). Trademarks protect a firm's marketing assets and signal new product development. They are also seen as particularly valuable in representing service innovation (Milot, 2009). Moreover, they refer to product or service innovation later in the innovation process as they are closer to commercialization. In contrast to patents, trademarks are also pertinent for all sectors of the economy. Moreover, trademarks are also the intellectual property tool of choice for SMEs while also being important for large firms as well. Both patents and trademarks capture different aspects of the innovation process making them both insightful and necessary for studying innovation dynamics.

A summary of the theories behind the impact of import competition is also discussed. A Schumpeterian effect leads due to decreased innovation as firms realize less profit margins. However, an escape-competition effect or firm preferences effect would lead to an increase in innovation activity. The former leads firms to reap the profits of their competitors while the latter being a reaction to private benefits being threatened. The initial productivity level of a firm also plays a role into which effect is materialized with less technologically advanced firms being more at risk.

Furthermore, the literature review summarizes the existing literature on trade liberalization and innovation. A particular focus is taken on import competition and highlights the different responses at the country level. The early empirical literature covers Latin American economies with most of the evidence pointing towards positive effects of trade on innovation. However, the majority of these studies used various measures of productivity as measures of innovation which has document weaknesses. This has changed in the more recent literature with studies using patents or R&D activity as the indicator of choice. These studies cover developed economies with rather ambiguous results with some finding a positive effects of trade on innovation, others finding a negative effect. A review of this existing literature emphasizes a need to revisit the study of import competition on innovation-related outcomes, especially in developing economies.

Lastly, an empirical analysis is conducted to analyze the impact Chinese import competition on patenting activities in developing countries. The results show no significant impact of import competition on patent applications, grants or those in-force. The existing literature can help us deduce that this effect is unsurprising as the patent system is used by very few firms in developing countries, especially for domestic entities (Bronwyn H Hall, 2020). Moreover, patents are more important for innovations in specific industries such as pharmaceuticals, biotechnology, medical instruments or chemicals which are less common in developing countries.

Finally, this paper identifies gaps in the literature which need more work. Firstly, more studies should be conducted on the impact of trade-induced competition on innovation as there is plenty of room for enrichment, particularly in developing countries. Studies which can employ the use of different innovation indicators and not only total factor productivity measures, can deepen our understanding. Moreover, with data becoming increasingly available, empirical analyses which can use firm level data can potentially illustrate deeper dynamics within an economy. Certainly, this topic of innovation and trade is of great importance and there is a lot left to learn.

## **1.7 Appendix**

### **1.7.1 Results**



Table 1.5: Impact of Import Competition on Total &amp; Local Applications

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Applications				Local Applications	
Dependent Variable	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.305* (0.172)		-1.600 (1.715)	0.0931 (0.205)		-0.853 (0.795)
Past Exposure		-15.70*** (3.803)			-16.03*** (3.963)	
Population	0.486 (1.875)	1.754*** (0.569)	3.734 (3.062)	2.704** (1.287)	1.010 (0.633)	3.600** (1.751)
Tertiary Grad.	-0.305 (0.389)	-0.365** (0.145)	-0.897 (0.646)	0.233 (0.337)	-0.230 (0.160)	0.0666 (0.348)
GDP	-0.110 (0.301)	0.397** (0.187)	0.903 (1.053)	0.140 (0.393)	0.328 (0.212)	0.578 (0.553)
Employment	2.728 (2.433)	1.268 (1.084)	4.705 (4.070)	1.558 (1.865)	1.712 (1.104)	2.946 (2.530)
$N$	753	740	740	831	819	819
F-Stat		19.70			17.50	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent application measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log; population, tertiary graduates and GDP.

Table 1.6: Impact of Import Competition on Applications of Residents

	(1)	(2)	(3)	(4)	(5)	(6)
	Residents				Non-residents	
Dependent Variable	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.173 (0.177)		-1.533 (1.387)	0.421** (0.194)		-1.628 (1.707)
Past Exposure		-16.31*** (3.701)			-15.75*** (3.969)	
Population	2.893* (1.641)	1.643*** (0.610)	5.580** (2.647)	-0.837 (2.489)	1.856*** (0.597)	2.861 (3.369)
Tertiary Grad.	-0.130 (0.244)	-0.395** (0.173)	-0.691 (0.528)	-0.170 (0.449)	-0.382** (0.149)	-0.839 (0.738)
GDP	-0.285 (0.324)	0.386* (0.199)	0.625 (0.910)	-0.145 (0.420)	0.378* (0.193)	0.914 (1.082)
Employment	4.079* (2.219)	1.184 (1.231)	6.037 (3.711)	2.751 (3.112)	1.276 (1.107)	4.944 (4.579)
$N$	696	681	681	736	723	723
F-Stat		20.87			19.48	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent application measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log; population, tertiary graduates and GDP.

Table 1.7: Impact of Import Competition on Total &amp; Local Grants

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Grants		Local Grants			
Dependent Variable	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.290 (0.183)		-1.801 (1.839)	-0.0704 (0.215)		-0.391 (0.770)
Past Exposure		-16.83*** (4.287)			-15.99*** (3.856)	
Population	0.612 (1.662)	1.612** (0.714)	3.709 (2.950)	2.920** (1.388)	1.031 (0.850)	3.233* (1.689)
Tertiary Grad.	-0.00704 (0.329)	-0.224 (0.156)	-0.359 (0.518)	-0.161 (0.344)	-0.232 (0.183)	-0.217 (0.352)
GDP	0.262 (0.298)	0.487*** (0.178)	1.570 (1.300)	-0.0990 (0.438)	0.321 (0.226)	0.0516 (0.524)
Employment	-1.024 (2.585)	1.141 (1.225)	1.887 (4.749)	-5.516** (2.675)	1.736 (1.279)	-5.381* (3.188)
$N$	725	713	713	770	759	759
F-Stat		22.29			16.83	
country FE	Yes	Yes	Yes	Yes	Yes	Yes
time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent grant measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log: population, tertiary graduates and GDP.

Table 1.8: Impact of Import Competition on Grants of Residents

	(1)	(2)	(3)	(4)	(5)	(6)
	Residents		Non-residents			
Dependent Variable	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.141 (0.115)		-0.179 (0.505)	0.304 (0.229)		-1.573 (1.736)
Past Exposure		-22.12*** (5.929)			-17.38*** (4.723)	
Population	1.864 (1.208)	1.872** (0.875)	2.344 (1.498)	-1.646 (2.494)	1.890** (0.733)	1.581 (3.254)
Tertiary Grad.	-0.168 (0.244)	-0.232 (0.188)	-0.210 (0.255)	0.268 (0.324)	-0.223 (0.175)	-0.0403 (0.498)
GDP	-0.165 (0.283)	0.411* (0.230)	0.0335 (0.430)	0.260 (0.299)	0.414** (0.189)	1.311 (1.115)
Employment	-1.223 (2.286)	0.424 (1.422)	-1.232 (2.458)	-2.550 (3.598)	1.053 (1.349)	0.791 (5.203)
$N$	649	636	636	686	675	675
F-Stat		24.60			23.09	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent grant measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log: population, tertiary graduates and GDP.

Table 1.9: Impact of Import Competition on Applications &amp; Grants Abroad

	(1)	(2)	(3)	(4)	(5)	(6)
	Applications Abroad			Grants Abroad		
Dependent Variable	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total	$\Delta$ Total	$\Delta$ China Imports	$\Delta$ Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.129 (0.181)		-1.466 (0.971)	0.409** (0.162)		0.270 (0.574)
Past Exposure		-18.81*** (3.202)			-18.12*** (3.851)	
Population	2.972** (1.368)	1.256*** (0.429)	4.914** (2.020)	0.195 (1.563)	2.206*** (0.533)	0.579 (2.182)
Tertiary Grad.	0.421 (0.307)	-0.237* (0.132)	0.132 (0.401)	0.479* (0.264)	-0.127 (0.153)	0.461* (0.264)
GDP	0.286 (0.390)	0.348** (0.172)	1.159* (0.615)	-0.361 (0.443)	0.341** (0.161)	-0.288 (0.490)
Employment	1.395 (1.830)	0.570 (1.132)	2.788 (2.855)	-1.640 (2.759)	1.407 (1.226)	-1.626 (2.790)
$N$	767	755	755	580	570	570
F-Stat		34.54			42.33	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent application & grant measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log; population, tertiary graduates and GDP.

Table 1.10: Impact of Import Competition on Patents In-Force of Locals

	(1)	(2)	(3)	(4)	(5)	(6)
	Total		Local			
Dependent Variable	Total	China Imports	Total	Total	China Imports	Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	-0.299 (0.185)		-1.044 (0.922)	0.266* (0.143)		1.379 (1.059)
Past Exposure		-12.12* (6.747)			-17.40*** (6.547)	
Population	-1.746 (2.553)	-0.801 (1.181)	-2.254 (3.451)	3.576*** (0.857)	-0.172 (0.392)	3.938*** (1.062)
Tertiary Grad.	-0.0304 (0.243)	0.0714 (0.114)	0.0260 (0.269)	0.513* (0.262)	0.00811 (0.0909)	0.437* (0.264)
GDP	0.442 (0.576)	0.480** (0.222)	0.934 (1.181)	0.117 (0.428)	0.314* (0.184)	-0.466 (0.618)
Employment	-1.320 (1.386)	-0.423 (0.866)	-2.283 (1.552)	-0.808 (2.051)	-0.203 (0.742)	-0.803 (2.517)
$N$	449	431	431	670	648	648
F-Stat		10.59			31.67	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent in-force measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log; population, tertiary graduates and GDP.

Table 1.11: Impact of Import Competition on Patents In-Force of Residents

	(1)	(2)	(3)	(4)	(5)	(6)
	Resident Grants		Non-Resident Grants			
Dependent Variable	Total	China Imports	Total	Total	China Imports	Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
Chinese Imports	0.204 (0.209)		-0.0125 (0.828)	-0.199 (0.243)		-1.186 (1.477)
Past Exposure		-9.269 (6.559)			-8.723 (6.511)	
Population	4.441* (2.598)	-0.758 (1.271)	4.423 (2.875)	-4.843 (3.019)	-0.706 (1.252)	-5.352 (4.034)
Tertiary Grad.	-0.0163 (0.370)	0.0659 (0.118)	-0.0151 (0.370)	0.0315 (0.265)	0.0557 (0.119)	0.0763 (0.344)
GDP	-0.0154 (0.392)	0.455* (0.272)	0.128 (0.737)	0.465 (0.652)	0.508** (0.251)	1.120 (1.549)
Employment	-1.897 (1.919)	0.160 (0.943)	-2.618 (2.150)	-2.203 (1.644)	-0.0758 (0.902)	-3.069 (1.941)
<i>N</i>	376	357	357	385	367	367
F-Stat		5.18			4.71	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. All changes are in 5-year differences, eg.  $\Delta(\text{IMP})_{it}^{CH}$  represents the 5-year difference in Chinese imports as a fraction of total imports. The dependent variables are patent in-force measures in log 5-year differences. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The following control variables are also in log; population, tertiary graduates and GDP.

Table 1.12: Pre-Trends Test of Patent Grant Variables

	(1)	(2)	(3)	(4)	
	Instrumental Variable: Past Exposure				
Total * Pre-WTO	0.0249 (0.0507)				
Local * Pre-WTO		0.0377 (0.0296)			
Resident * Pre-WTO			-0.00126 (0.0538)		
Non-Resident * Pre-WTO				0.0164 (0.0535)	
Abroad * Pre-WTO					-0.0711 (0.0452)
<i>N</i>	1533	1688	1216	1418	1073
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations are in OLS with cluster robust standard errors by country. The dependent variable is the constructed instrumental variable which is the past exposure to the China shock (pre-2000). The patent grant variables are in log form. "Pre WTO" is a dummy equal to unity before 2000 (and zero after).

Table 1.13: Country List

Countries included in the estimations
<p>Albania, Algeria, Antigua and Barbuda, Armenia, Azerbaijan, Bosnia and Herzegovina, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belize, Bhutan, Bolivia, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cabo Verde, Cambodia, Chile, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Gambia, Georgia, Ghana, Guatemala, Guyana Honduras, Hungary, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Madagascar, Malawi, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Nigeria, North Macedonia, Oman, Panama, Paraguay Peru, Phillippines, Poland, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Serbia, South Africa, Sri Lanka, Sudan, Syria, Tajikistan, Tanzania, Thailand, Trinidad &amp; Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Venezuela, Vietnam, Zambia, Zimbabwe</p>

## Chapter 2

# Import Competition and Innovation in Developing Countries: Evidence from Trademarks

### 2.1 Introduction

An important political debate is currently in progress regarding the impact of globalization on the economy, especially in the developing world. The question of how innovation in particular is affected by increased competition due to globalization is a central one in economics. After all, theory has well documented the notion that innovation is the fundamental and primary driver of economic growth (P. M. Romer, 1990; Aghion and Durlauf, 2005). Therefore, this question is critical to the economic progress of developing countries. The answer to this question carries various implications at the policy level concerning the liberalization of trade, deregulation of industries, resource allocation and others. Moreover, China's emergence as a significant economic power in world trade since joining the WTO in 2001, has given renewed importance to this question. China has shifted patterns of global trade and economies around the world are facing rising import competition. Despite an early literature which tackled the question of the impact of import competition on innovation in developing countries, the focus was heavily on Latin America due to multiple trade liberalization episodes and used measures of productivity which are now considered rather indirect measures of innovation. This paper explores how import competition from China affects innovation, measured by trademarking activity, in developing countries. More importantly, the effect on local and resident innovation is also analyzed.

In fact, while there is a growing empirical literature studying the effect of import competition on innovation, no clear consensus has emerged. In recent empirical studies, overwhelmingly negative effects were found for the impact on innovation. Using more direct measures of innovation, studies in the US have found a negative impact of Chinese import competition on patenting, R&D expenditure, investment as well as employment (Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020; Pierce and Schott, 2018; Xu and Gong, 2017). A study of Canada found similar effects with a negative impact on innovation which was stronger for process innovations (M.-J. Yang, N. Li, and Lorenz, 2021). Recent studies which accounted for firm

heterogeneity found mixed effects, with an overall negative effect but positive for technology leaders. On the other hand, some empirical evidence from Europe has found a positive effect of import competition. Nicholas Bloom, Draca, and Van Reenen (2016) find a positive effect of Chinese import competition on patenting and R&D expenditures for 12 European countries. C. Chen and Steinwender (2021) find a positive effect of trade liberalization on Spain for initially unproductive family firms. Similar effects were also found in China where Bombardini, B. Li, and R. Wang (2017) document a positive effect of trade liberalization on patenting and R&D expenditure.

Furthermore, the recent empirical evidence for developing countries is quite sparse. An earlier body of literature focused on Latin America and trade liberalization episodes predating China joining the WTO. The majority of these studies used different measures of productivity as their primary indicator of innovation which are now less preferred than other more direct measures. Some studies have shown mixed effects of import competition on total factor productivity. When able to consider firm heterogeneity, evidence from Mexico and Colombia has shown a negative effect of import competition on less productive firms and a positive effect on more productive firms in less competitive industries (Iacovone, Keller, and Rauch, 2011; Fernandes, 2007). On the other hand, different studies in Latin America document a positive effect of trade liberalization on productivity measures in Brazil, Chile and Mexico (Muendler, 2004a; Pavcnik, 2002; Teshima, 2008). In Asia, research on India and Indonesia has also found a positive effect on TFP (Topalova and A. Khandelwal, 2011; Amiti and Konings, 2007). This brief summary of the literature indicates that indeed a revisit to the question of the impact of import competition on globalization is in order. It is important to account for China's rapid rise as a trade partner and use a more direct measure for innovation.

Trademarks can indeed capture important aspects of the innovation phenomena making it essential to better understanding growth. In fact, Bronwyn H Hall (2020) argues that trademarks are a more important form of IP, especially for domestic entities, in the course of development. While theory suggests that trademarks can play a critical role in the innovation process, the existing empirical literature using trademarks is sparse. In fact, there are multiple ways in which trademarks reflect innovation. Firstly, trademarks can enable firms to recoup past investments in innovation while also encouraging similar R&D investments in the future (Gangjee, 2020). Second, trademarks can also serve as indirect and complementary indicators of innovation, while helping to identify overall patterns of innovation. Multiple studies have found trademarks to be correlated with firm innovation activity (Brahem, El Harbi, and Grolleau, 2013; Mendonça, Tiago Santos Pereira, and M. Godinho, 2004; Schmoch, 2003; M. J. Flikkema, Man, Wolters, et al., 2010; Christine Greenhalgh and Longland, 2005; Malmberg, 2005; Michalisin, 2001). An underlying idea of this research is that trademark data can capture the value of the innovation output of firms which are not covered by patents. This would include innovations in retail, services, customer relations and other knowledge intensive products. Moreover, trademarks are correlated with technological advancements (M. M. Godinho, Mendonca, and Tiago SANTOS Pereira, 2003; Gotsch and Hipp, 2012). Trademarks can also behave as complements or substitutes for patents (Milot and Llerena, 2012; Jensen and Webster, 2009). Lastly, trademarks can reflect innovation activity not accounted for by other indicators such as service and marketing innovations, while

also best measure late-stage innovations (Dinlersoz, Goldschlag, Fila, and Zolas, 2018; M. J. Flikkema, Man, Wolters, et al., 2010; Gangjee, 2020). Trademarks can also account for organizational innovations which have a high degree of complementarity with the digital revolution built on information and communication technology (Mohnen, Polder, and Van Leeuwen, 2018). This is increasingly vital as the service sector has increased in economic importance across the majority of industrial economies. Hence, it would be insightful to use trademarks as a measure to understand the impact on innovation dynamics.

This paper studies how import competition affects innovation in developing countries by estimating the impact of greater exposure to trade on trademarking. Innovation is measured by both trademark applications and trademark registrations. As in recent literature studying competition and innovation, trade exposure is measured by the import penetration from China in developing countries. The database is constructed using country-level data on trademarks from the World Intellectual Property Office (WIPO), trade measures from the UN COMTRADE and MIT Observatory of Economic Complexity and other control variables from the World Bank. The empirical model used analyzes the within country margin of innovative activity as a result of import competition using a panel fixed effects data model with clustered standard errors. The estimations control for GDP, population, tertiary education and employment growth. The empirical strategy chosen deals with potential endogeneity issues of unobservable technology shocks correlated with the growth of Chinese imports using the identification strategy in Autor, Dorn, and Gordon H. Hanson (2016). A shift-share instrumental variable approach is taken whereby import penetration from China in a specific developing country is instrumented by import penetration in other developing countries. The results show that import competition has a weakly significant negative effect on local trademarking applications. However, the effect is positive for total applications which appears to be led by non-resident activity. The study's outcomes suggest that Chinese import competition increases overall trademarking but negatively affects local non-technological innovation activity.

This paper is related to three strands of the economic literature. Firstly, this paper contributes to the literature on import competition and innovation, particularly in developing countries (eg. Topalova and A. Khandelwal, 2011; Fernandes, 2007). This adds to the body of work using trademarking as the measure of innovation. Second, this paper contributes to the literature on the impact of import competition from China on innovation-related outcomes (eg. Dorn, Gordon H Hanson, G. Pisano, Shu, et al., 2020; Nicholas Bloom, Draca, and Van Reenen, 2016; Iacovone, Keller, and Rauch, 2011). The presented results corroborate with the negative effects found in the recent literature. Third, this study is connected to the growing body of empirical literature using trademarking as a measure of innovation.

The rest of the paper is organized as follows. Section 2 provides an overall background on trademarking and their suitability as an indicator of innovation. Section 3 presents the data. Section 4 presents the theoretical and empirical framework. Section 5 discusses the results and potential mechanisms with Section 6 providing concluding remarks.



## 2.2 Trademark Background

The economic literature on innovation tends to focus on patents and much less attention has been paid to trademarks. While theory suggests trademarks can play a critical role in the innovation process, the existing empirical research has been relatively sparse, especially in comparison with other innovation measures. In fact, economists have only recently begun to study whether indeed trademarking is a suitable measure of innovation. Is this intangible asset, commonly referred to as a branding investment, a true indicator of innovation? In this section, I will provide a brief background on the nature of trademarks and discuss the suitability of trademarking as an important measure of innovation.

### 2.2.1 What is a Trademark?

In the Agreement on Trade-Related Aspects of Intellectual Property (TRIPS), a trademark is defined as “any sign, or any combination of signs, capable of distinguishing the goods or services of one undertaking from those of other undertakings, shall be capable of constituting a trademark”.

The term “trademark” and “brand” are often used interchangeably in daily conversation, as well as amongst researchers. The American Marketing Association defines a brand as “a name, term, sign, symbol or a combination of them, intended to identify the goods and services of one seller or a group of sellers and to differentiate them from their competitors”, which highlights the commonality. Scholars of law have come to describe trademarks as the legal anchor for the use of the commercial functions of brands (J. Phillips, 2003). Economists have also identified trademarks as the legal instrument and the brand as a business tool. In fact, when discussing trademark economics, Landes and Posner (1987) called them “rough synonyms”.

Once a trademark is registered, it can be extended for an unlimited time period meaning it does not have an expiration date. As the trademark protects a firm’s marketing assets by providing an exclusion right, consumers in turn benefit from saved search costs by not being forced to navigate the product market on their own. The unlimited time span on trademarks prevents confusion from being created in the marketplace and prevent an unnecessary increase in search costs. This is in contrast to other forms of IP, such as patents which can last up to 20 years in order to properly incentivize innovative activities.

### 2.2.2 Trademarks as a Measure of Innovation

There are many ways in which trademarking can reflect innovative activity. Firstly, trademarks can enable firms to recoup past investments in innovation while also encouraging similar R&D investments in the future (Gangjee, 2020). Firms with strong brands that have a value advantage could benefit more from their innovation which allows for a positive feedback cycle for reinvestment in innovation (Castaldi and Dosso, 2018). A business with more loyal customers can have a greater return on R&D since the cost is spread out over a larger customer base. Moreover, strong goodwill provides market power so firms with trademarks are more willing to invest in exploratory R&D. These factors would suggest that firms may engage in R&D or patenting more actively after securing the registration of a trademark. This would make trademark filings

leading indicators of innovative activity (Dinlersoz, Goldschlag, Fila, and Zolas, 2018).

Second, trademarks can also serve as indirect and complementary indicators of innovation, while helping to identify overall patterns of innovation. More precisely, trademark use has been shown to be correlated with innovation activities. A study by Helmers and Rogers (2010) of 1600 large UK firms correlates trademarking with firm performance. Trademarking firms had a substantial difference in market value and productivity compared to non-trademarking firms. They also found higher trademarking levels in firm rivals to increase growth and share-market value, but at a lower productivity advantage over said rivals. Such findings reinforce the idea of Schumpeterian competition suggesting that trademarks do serve as a proxy of innovative activity. An underlying idea of this study is that trademark data can capture the value of the innovation output of firms which are not covered by patents. This would include innovations in retail, services, customer relations and other knowledge intensive products. Hence, trademarks can serve as partial or complementary innovation activity indicators. They can help paint the complete picture as regards to innovation dynamics which is necessary due to its multidimensional nature.

Further evidence of this has been found in the literature. One such study by Brahem, El Harbi, and Grolleau (2013) demonstrates this in the context of low-tech firms in a developing country. A survey of 116 Tunisian SMEs in the clothing industry showed that trademarking activity in the textile sector was associated with a high degree of product innovation, geographical market diversification, investment in quality improvement and the willingness to take financial risk. This aligns with other findings in the literature such as Mendonça, Tiago Santos Pereira, and M. Godinho (2004) who emphasize that trademarks provide a measure of the innovative output of firms. Their evidence from Portugal suggests that high-technology sectors and service industries make more intensive use of trademarks. In other words, they serve as an indicator of product innovation in competitive markets. The Schmoch (2003) analysis of German enterprises finds that trademarks are suitable as an indicator of innovation, illustrating a highly significant correlation with innovation in the service sector and even more so in the manufacturing sector. M. J. Flikkema, Man, Wolters, et al. (2010) studied the Benelux office finding a correlation between trademarking and a broad range of innovative activities, primarily the introduction of new products and services. A study by Malmberg (2005) on trademarking in Swedish firms points out that there is a strong correlation between new trademarks and new-to-the-firm innovation or new products, especially for industries which have a frequent use of trademarks and products targeting consumers. Moreover, Michalisin (2001) notes that indeed trademarking provides information on the level of product newness. We can thus understand that trademarks reflect innovation in the product markets.

There are several other reasons advanced for using trademarking as a proxy for innovation activity. Most notably, they are most widely-used form of IP protection across all industries, types of economic activity and firm size. They also identify the precise point when an innovation is commercialized. This is in contrast to some patents which may never be used. Moreover, trademarks include a broader range of innovative activity which include marketing and service innovations. Thus, they can complement the innovation picture in areas where patents are less common such as in the software industry.

Furthermore, trademarks are often related to technological advancements. The technology intensity of the industry was found to contribute to trademarking differences in a sharp and statistically significant way (M. M. Godinho, Mendonca, and Tiago SANTOS Pereira, 2003). High technology intensive industries were found to be statistically significant for heavy usage of trademarks. Regarding services, high information-intensive services sectors also demonstrated a greater association with trademarks than low information-intensive sectors. Similar findings were stated in a study of German firm-level data conducted by Gotsch and Hipp (2012) who showed that trademarks were positively and significantly correlated with innovation in high-tech manufacturing as well as in knowledge-intensive services, but not in low tech-manufacturing nor in other service sectors. Hence, trademarks reveal innovation information for technologies and knowledge-intensive sectors.

Moreover, trademarks can often behave as complements or substitutes for patents, another significant innovation indicator. In a study conducted by Millot and Llerena (2012) of publicly traded French firms, they find that the relationship between patents and trademarks differs by sector. A complementary dynamic is found in the chemical and pharmaceutical sector, while a substitute relationship is found in high-tech business sectors such as computer products and electrical equipment. Similarly, in a study of Australian firms by Jensen and Webster (2009), statistically significant correlations were found between innovation activities, patents and trademarks. They also report high correlations between R&D and patents and trademarks.

The literature also suggests that trademarks can capture some innovation aspects that are missed by other intellectual property tools, such as service and marketing innovation (Gangjee, 2020). This is an important component of innovation as the service sector has increased in economic importance across the majority of industrial economies. Dinlersoz, Goldschlag, Fila, and Zolas (2018) claim that trademarks can broaden the definition of the innovation segment in the economy as they reflect innovative activity not accounted for by patents. Trademarks can account for organizational innovations which have a high degree of complementarity with the digital revolution built on information and communication technology (Mohnen, Polder, and Van Leeuwen, 2018). In contrast to other forms of IP, trademarks are considered reliable indicators of service innovation or soft innovation (Stoneman, 2010). This is composed of artistic or aesthetic features used for product differentiation. M. J. Flikkema, Man, Wolters, et al. (2010) also argue that innovations in their late stages of development are best measured by trademarks as it is not captured by R&D expenditure nor patents which occur earlier in time. The combination of the above factors makes trademarks an interesting and important part of the innovation process which must be seriously taken into account.

### **Trademark Anecdotes**

The economic literature has shown that a public trademark filing effectively serves as a product announcement (Fink, Fosfuri, Helmers, Myers, et al., 2018). This reveals the product development plan of a firm to the market and its competitors. The name of the product alone can indicate a new addition or activity to a company's portfolio, such as the case of the Apple Watch. Many consumer product companies will file a trademark indicating the launch of a new product. These companies include Google in the tech sector,

Zynga in the video game development sector, LG Electronics in consumer electronics and Mattel in the manufacturing sector.

Furthermore, there are various types of service innovation that have emerged. Some have adopted the manufacturing mindset and others which have made use of rapidly improving information technology. Evidence shows this is greatly apparent in the transformations being witnessed in the retail and delivery industries in particular (Miles, 2016). These innovations deserve as much attention as the technological ones as they reveal innovative activity. Les Mills is an illustrative example of service innovation as it is a company which developed a new concept of group gym classes (Parviainen, 2011). This was an innovative and successful new business model and service. While the fitness industry is traditionally low tech and low skill, they developed new categories of gym classes such as BodyPump and Zumba which became extremely popular. Such an innovation is not patentable but trademarks allowed the company to lay claim on their innovations and protect them from imitation. Another example of service innovation would include the “pay to customize” feature of the popular video game Fornite. In contrast to the classic freemium model, the game does not charge for playing and progressing in the game. Instead, players pay to purchase “skins” or “emotes”, uniforms or dance moves respectively, to personalize their game characters (Moritz, Schöber, and Stadtmann, 2020). Another well known example of service innovation would be Amazon Web Services. The service allows Amazon customers to use its cloud computing services and artificial intelligence algorithms. With such innovations not being patentable, the service sector has historically presented issues due to a lack of appropriate statistical indicators (Schmoch, 2003). Trademark filings can prove to be useful in capturing such innovations.

Another aspect of trademarks is that they can facilitate and reflect marketing innovation. This generally revolves around brand identity, especially with the emergence of new marketing tools and methods. An example of marketing innovation through the adoption of new technologies is the “one click” online ordering process from Amazon (Y. Chen, 2006). One example of this marketing innovation is related to fluid trademarks, which change over time around a recognizable core. The well known Google Doodle is a good example of this and the internet has increased the popularity of such trademarks. The Covid-19 pandemic has inspired many leading brands to modify their logos to emphasize the importance of social distancing. Such trademark variants directly reflect new marketing techniques and strategies. The combination of service and marketing innovations allows us to better understand the complete picture with regards to innovative activity.

Moreover, Fink, Fosfuri, Helmers, Myers, et al. (2018) show that there is anecdotal evidence of intensifying use of trademark online databases for market intelligence. Trademark filings are leveraged across all sectors to speculate on new product offerings. These has been used on tech companies, video game developers, automobile manufacturers, sports franchises and even celebrities. This market intelligence is not solely gathered for US trademarks but also globally, including the online databases of key markets in Europe and Asia. This adds to the notion that trademarks provide real signals of product and marketing innovation.

Lastly, trademarks can certainly reflect different non-technological innovations in developing countries

as well. A brief zooming in on trademarks from Egypt can provide us with a few examples. In 2021, Own Snacks applied for a trademark for the launching of its brand. This company introduced healthy snacks such as protein bars to the market which would reflect product innovation. Another company, SWVL also applied for a trademark when launching its bus ride-sharing application which reflects service innovation. A new startup called Elmenus which is a food discovery and online ordering app, also applied for a trademark when launching their service. While certainly not all trademarks will reflect a new innovation, there are many trademarks which will and thus capture a different component of innovation dynamics.

### **2.2.3 Innovation Measures are Imperfect**

In the recent literature regarding import competition and innovation, different measures of innovation are used with patents and R&D as the most common one. Patents are a preferred choice of indicator due to its precise nature as a measurement and their data availability. However, patents as an innovation indicator are also imperfect. The patenting process is known to be highly uncertain. Davies, Kogler, and Hynes (2020) report that only 54 percent of applications were granted in the European Patent Office over the period from 1978-2017. The results are similar for the US where Carley, Hedge, and Marco (2015) report a 56 percent rate from 1996-2013. Moreover, patents are incredibly costly as a patent application includes a filing fee and fees paid to lawyers who prepare the patent application. The average cost of a patent application estimated by Davies, Kogler, and Hynes (2020) can easily exceed 100,000 euros when accounting for registration fees, translation fees and subsequent maintenance costs. Therefore, a firm will only go down in the patent route if the expected return outweighs the heavy upfront costs. Moreover, such heavy upfront costs skew the entire patent system towards large firms. This occurs because the innovation and application costs must be paid before any patent is granted, if it ever is granted. Thus, larger firms with deeper cash reserves, superior access to bank finance and better borrowing terms will be better able to invest in patents whilst benefiting from a reduced application cost (Egger, Von Ehrlich, and D. R. Nelson, 2012). One last point is that patents are known for having a weakness in measuring inventions rather than innovations (Gorodnichenko, Svejnar, and Terrell, 2010).

Considering R&D expenditures as an indicator of innovation may also be inaccurate as not all innovations are generated by R&D expenditures since they are measuring the input rather than the output. Moreover, previous studies have shown that the measure of R&D expenditures is biased against small firms (Michie, 1998; Archibugi, Sirilli, et al., 2001). However, most notable is the fact that this measure is not suitable for emerging economies where this aspect of innovation is likely to be observed (Gorodnichenko, Svejnar, and Terrell, 2010). Firms are expected to spend less on R&D, to be less engaged in invention-related activities and more into reformulation and adaptation of existing innovations.

## 2.2.4 Trademarks are More Suitable for Developing Countries

Amongst all the existing intellectual property rights indicators, trademarks are arguably the most pertinent measure of innovation in developing countries. There has been a rapid growth in the usage of trademarks by middle income countries across the world. These countries have shown a higher intensity use of trademarks than most high income countries (WIPO, 2013). The WIPO reports that the number of trademarks filed abroad were doubled from 1995 to 2011, reaching 872,000. Moreover, the volume of trademarks from middle and low-income countries applied at home and abroad has greatly increased for the past decade. In a study conducted by Abud, Fink, B. Hall, Helmers, et al. (2013) on the use different intellectual property rights in Chile, more than 90 percent of applicants only apply for trademarks compared to only 5 percent of applicants who apply for patents. Only 2 percent of applicants reported filing for more than one IP right which indicates that trademarking captures part of the innovation process unaccounted for by patents or other rights. This also indicates that developing countries have a higher intensity of trademarking than they do of patenting, which it makes important to account for.

Furthermore, trademarks are much cheaper and easier to obtain than patents, and can be up to 10 times less costly (Davies, 2009). They also have a wider applicability to businesses, products and services (WIPO, 2013). Most trademark activity is now stemming from lower income countries meaning it is no longer confined to rich countries. The WIPO international registration fees for trademarking are significantly less than the international phase fees for patenting. A trademark application requires a basic fee of 653 Swiss francs while a patent application will require an international filing fee of at least 1,330 Swiss francs, as well as a search fee and a transmittal fee which varies by country. Both patent and trademarks require further fees depending on the countries in which they seek protection. Trademark applicants are subjected to standard fees according to the number of classes seeking protection. Patent applicants will also be subjected to fees according to the number of claims they wish to protect as well as numerous other fees. In order to complete patent registration, this would include a fee for: filing, additional claims, priority claims, grant, publication and annual renewal. This does not include other potential payments regarding appeals and legal services. This makes patenting a much more costly endeavor than trademarking.

Moreover, previous research has found trademarking to be more prevalent among SMEs. In the Seip, Castaldi, M. Flikkema, and Man (2019) study of firm-level intellectual property use in the Netherlands, trademarks were the predominant type of IPR used. Compared to patents, the number of applicants was 5.6 times higher. Christiane Greenhalgh, Longland, and David Bosworth (2003) study medium to large manufacturing firms in the UK and find that smaller firms, measured by employment or sales, exhibit higher trademark filing intensity. Christine Greenhalgh and Rogers (2007) also confirm such findings for small to medium sized firms. They show that smaller firms tend to have higher volumes of both patent and trademark applications relative to their assets, meaning they are more intellectual property intensive than larger firms. In other words, the propensity to trademark amongst SMEs is higher relative to their size. This aligns with Mendonça, Tiago Santos Pereira, and M. Godinho (2004) finding that trademarks are used across more

sectors and by more firms than other forms of intellectual property rights. Also, a strand of literature exists which states that smaller firms can be more innovative than larger ones (Acs and Audretsch, 1990; Baldwin, Gellatly, Johnson, and Peters, 1999). The combination of the above would suggest that trademarks would be a more suitable measure of innovation in developing countries.

Lastly, trademarks are not limited to sectors witnessing rapid technological progress nor are they made only for firms at the technology frontier. Trademarks are used by firms from every sector of the economy to protect their innovations (Christine Greenhalgh and Rogers, 2007). This includes the service sector which observes modest use of other forms of IP and accounts for a large of GDP in most countries. Thus, trademarking can serve as a competent indicator of innovation, especially for the purpose of this study in a context involving the developing economies of the world.

## **2.3 Data**

The main purpose of this study is to empirically assess the impact of import competition on innovation in developing countries, with trademarking activity as the indicator. The result is a database combining trademarking data from the WIPO, trade data from the UN COMTRADE and further control variables from the World Bank open database.

### **2.3.1 Trademarks**

The data for trademarks is collected from the World Intellectual Property Office (WIPO) for 132 developing countries across the time period from 1995 to 2018. The level of the data is aggregated at the country level. While this does create a database of over 3200 observations, unfortunately it suffers from many missing values. The issue lies in the fact that the WIPO does not record such data firsthand, but rather collects the data from intellectual property offices of each individual country. The result is many missing values leading to an unbalanced panel due to the lack of data collection across the developing countries. In order to ensure this does not hinder the study, the patent is extrapolated to ensure no missing values. The estimations presented are with this data since it more efficient and does not suffer the same bias, especially when using cluster robust standard errors.<sup>1</sup> The primary measures of trademarking provided by the WIPO are applications and registrations. An trademark application is filled in order to file for trademark protection. However, this application is not automatically granted, only novel trademarks will then be registered. Hence, trademark applications and registration reflect two different stages in the process. Furthermore, the trademark classification system (called the NICE classification) divides the different typologies of trademarks of goods and services into 45 classes. Hence, while there is much missing, the database also includes data regarding trademark classification. Lastly, due to the varying standards of intellectual property offices across the world when it comes to trademark registration, a class count indicator is also used. This is because some countries

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<sup>1</sup>There is no significant difference found in the estimations between the extrapolated and non-extrapolated data. Results confirm the direction and significance of the coefficients.

require a separate trademark application for each class being filed. Hence, this measure is used to allow for robustness checks in estimations.

### 2.3.2 Import Competition

The trade information used is sourced from the UN Comtrade data system and the MIT Observatory of Economic Complexity. This is an international database of information at the product (denoted HS6) on all bilateral imports and exports between any given pairs of countries. The data is aggregated to sum all the exports and imports at the country level to match the trademark data panel. The value of imports originating from China ( $M^{China}$ ) as a share of total world imports ( $M^{World}$ ) in a country is used as the key measure of exposure to Chinese trade, following the “value share” approach outlined by Bernard, Jensen and Schott (2002, 2006). In other words  $IMP^{CH} = (M^{China}/M^{World})$ .

### 2.3.3 Control Variables

We use a series of control variables across all estimations. These include GDP, population, and education. Each of these is collected from the World Bank Open database. Regarding education, the control variable chosen was the number of tertiary education graduates per year to consider the education status of a country.

## 2.4 Methodology

### 2.4.1 Theoretical Framework

There are numerous theories regarding how import competition can impact innovation or technical change in a country. I will outline here below the Aghion Escape-Competition framework which predicts a negative effect of such trade liberalization on low-tech firms but a positive effect for firms on the tech frontier. Alternative theories will also be mentioned including the Schumpeterian model and the preferences-effect framework. I will also briefly mention the idea for foreign input competition.

#### Escape Competition Effect

This escape-competition effect builds on the original Arrow model which argues that one of the main benefits of innovation is that it allows for firms to overtake the profits of their competitors. Hence, with increased competition will come an increased incentive to innovate. Aghion’s escape-competition model takes this framework one step further to include the specific conditions which encourage innovation. Firms on the technological frontier respond positively to more intense competition.

On the other hand, firms below such frontier have a negative reaction to increased competition. Given that they believe they cannot beat out a potential new entrant, these firms undergo the opposite which is a discouragement effect. As the entry rate increases from such policies as trade liberalization, the more discouraged these firms become and the less they invest in innovation productivity. Moreover, the farther



a country is from the world leading technological frontier, the higher the fraction of firms far from such a frontier and the more innovation-reducing is increased market competition.

This model suggests increased trade liberalization for leading technological countries and decreased trade liberalization for those far from the global frontier. For developing countries far from the frontier, this will decrease the profitability and feasibility of innovation.

### **Schumpeterian Effect**

Schumpeter's original theories were the first to argue that a reduction in market share due to increased competition, would lower potential rents that a firm could capture from innovation. Dasgupta and Stiglitz (1980) followed this argument to illustrate more competition would lower profit margins and decrease a firm's incentive to allocate resources to R&D. This would imply that import-competition would have a negative effect on innovation activity.

### **Preferences Effect**

In 1983, Hart challenged the firm profit maximizing assumption by showing that firm managers may have preferences related to private gain alongside the firm's financial profits. If the existence of the firm is threatened by import competition, the manager may be fearful of losing the private benefits extracted only while the firm is alive. To combat this threat, a manager may begin to innovate. This effect would lead to import competition having a negative effect on innovation.

### **Access to Foreign Inputs Effect**

This effect could impact innovative activity both positively and negatively. It could increase innovation by improving production process efficiencies and increased access to inputs could increase profit margins. Firms could also learn by importing about new processes, methods and technologies. However, it could also have a negative effect by eliminating some of the domestic firms in the market and their need to invest in certain technologies. This outsourcing of production could hurt innovative prowess by isolating production R&D. These interactions are seen as critical for the innovation process (G. P. Pisano and Shih, 2012). Furthermore, cutting edge technologies may not be cost-effective in countries with cheap labor and limited technical skills (Fuchs and Kirchain, 2010).

## **2.4.2 Empirical Framework**

The empirical model used analyzes the within country margin of innovative activity in developing countries as a result of import competition. I use the measure of trademark counts as the indicator of such innovative activity. Hence, the main innovation indicators are trademark applications and trademark registrations.

## Innovative Activity Within Countries

The strategy used is a panel data model with country and year fixed-effects and clustered standard errors.

The basic equation for trademarking growth in country  $i$  at time  $t$  is:

$$\ln(\text{TRADEMARKS})_{i,t} = \alpha_i + \gamma_t + \beta_1^{TRA} \ln(IMP)_{it}^{CH} + \beta_2 GDP_{it} + \beta_3 \ln(\text{population})_{it} + \beta_4 \text{Tertiary education}_{it} + \epsilon_{it} \quad (2.1)$$

The measure  $IMP_{it}^{CH}$  is mainly the proportion of imports in country  $i$  that are originated from China ( $M_{it}^{CH}/M_{World}^{CH}$ ). The increase in the share of Chinese imports is hence used as a proxy for import competition. The trade induced innovation activity hypothesis is that  $\beta_1^{TRA} > 0$ . The specification in equation (1) controls for unobserved heterogeneity between countries using  $\alpha_i$  for country fixed effects and  $\gamma_t$  for year fixed effects. Since the Chinese import growth may still be induced by unobserved shocks, an instrumental variable strategy is also implemented. I construct a shift-share IV using past exposure to the China shock as a subsequent instrument for Chinese import growth.

This empirical strategy is implemented for both trademark measures: applications and registrations. Trademark applications are a good measure for the propensity to innovate while trademark registrations are a good measure of the quality of innovative activity. They are both critical to providing insight on the type of innovation occurring in these developing countries.

The set of control variables for all estimations include GDP, employment growth, population & tertiary education. Firstly, I include an employment variable in the estimations as it has been found in the literature to have an effect on innovation activities. In their paper, Nicholas Bloom, Draca, and Van Reenen (2016) show that employment growth has a positive and significant effect on patenting, IT intensity and R&D activity. Thus, it is included to prevent any omitted variable bias. Moreover, the economic literature has well documented the positive effect of education on innovation. This effect has been specifically pronounced with increased university level education. Studies by Andrews (2019), Hausman (2012) and Valero and Van Reenen (2019) have all shown that local invention increases with the establishment of universities. As a result, I included a tertiary education variable to account for this effect. Furthermore, it is important to remember that incentives matter for innovative activity. The patent system exists to reward innovators for their inventions. Research has shown that market size is a stimulant for economic activity. A greater market size provides a bigger incentive to innovators. Cerda (2003) shows that an increase in new drugs developed and introduced by pharmaceutical firms were largely due to an increased population or market size of the sector. Hence, a measure of population is included in the model. Lastly, a GDP is added as a control since the business cycle is likely to have effects on innovation (Aghion, Akcigit, Bergeaud, Blundell, and Hémous, 2019).

## Instrumental Variable Approach

A clear issue with estimating these regressions is the potential endogeneity of Chinese imports due to unobserved technology shocks which may be correlated with Chinese import growth. To address this issue, I consider an instrumental variable (IV) strategy based on China's initial conditions and using a shift-share design.

This approach draws on Nicholas Bloom, Draca, and Van Reenen (2016) which highlighted the fact that Chinese import growth is led by Chinese policy makers and their exogenous liberalization strategy. China's exports grew in industries where they had already enjoyed a specific comparative advantage. In the case of Europe during the early 2000s, China's exports increased significantly in the sectors of textile, furniture and toys. These were sectors which China had already established a comparative advantage prior to the 2000s. Similarly, China's export growth to developing countries is driven by the same exogenous liberalization strategy. Countries with the greater share of Chinese exports during the 2000s had relatively more exposure to Chinese exports before as well.

As a result, exposure to Chinese imports in 1999, prior to China's entry into the WTO, can be used as an instrument for China's subsequent growth in import share, hence the use of a shift-share IV. This measure of exposure will be interacted with the exogenous overall growth of Chinese imports across all developing countries. To add variation & mitigate potential endogeneity problems, the Chinese imports for country  $k$  will be subtracted from the total amount of Chinese imports across all developing countries. In other words, I use  $IMP_{k1999}^{CH} * (\Delta M_t^{CH} - \Delta M_{kt}^{CH})$  as an instrument for  $IMP_{kt}^{CH}$  which is our key measure of Chinese import exposure.  $IMP_{k1999}^{CH}$  reflects the value of imports originating from China in 1999 ( $M_{k1999}^{China}$ ) as a share of total Chinese imports for all developing countries in 1999 ( $M_{dev1999}^{China}$ ), where  $IMP_{k1999}^{CH} = (M_{k1999}^{China} / M_{dev1999}^{China})$ . The sum of Chinese import shares to each developing country add up to one.

This instrumental variable approach has already established some credibility. This identification strategy is similar to the use of "ethnic enclaves" by papers such as Card (2001) who use the proportion of current immigrants in an area as an instrument for future immigrants. Moreover, a potential advantage of this IV approach is that by using a predicted measure of Chinese imports rather than actual imports, this will better reflect the threat of Chinese import competition (Nicholas Bloom, Draca, and Van Reenen, 2016).

## First Stage Negative Effect

A perhaps puzzling finding is the negative effect found in the first stage results of the instrumental variable regressions. While these first stage coefficients are statistically significant which provides no technical issue, the negative sign goes against the grain of economic intuition. Indeed, one would expect a positive relationship between the instrument and potentially endogenous variable. I use binned scatter plots to graphically investigate this negative effect. This type of plot is a clear way of observing the relationship between two variables and visualizing OLS regressions. As figure 2.1 illustrates, the relationship between the instrument, the past exposure to Chinese imports, and the endogenous variable, the China shock, is positive when fixed

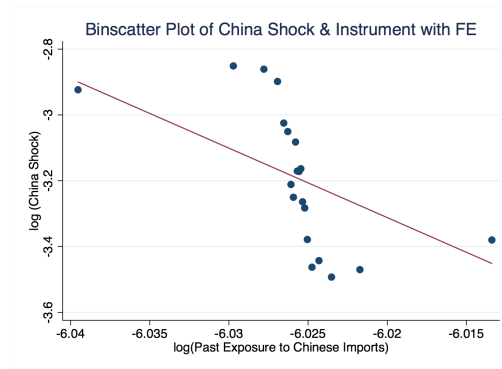
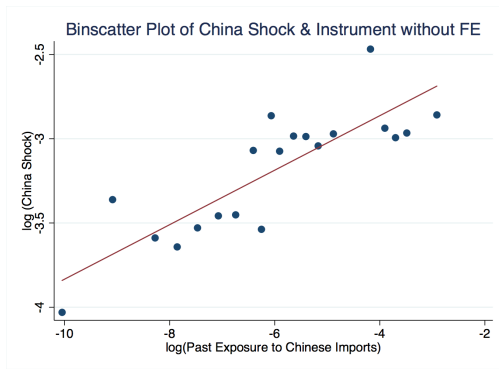


Figure 2.1: Binned Scatterplot Without Fixed Effects      Figure 2.2: Binned Scatterplot With Fixed Effects

effects are not included in the regression. However, once the fixed effects are added, the relationship becomes negative as seen in figure 2.2.

This evidence points to a trade diversion phenomenon occurring where trade flows away from some developing markets to others. The literature shows that potential mechanisms at play could be due to uncertainty. As De Sousa, Disdier, and Gaigné (2020) show, the first possible mechanism could be related to risk aversion as the uncertainty of future returns by firms causes them to prioritize certain markets over others. The second possible mechanism could be policy uncertainty whereby the changing trade policies in developing countries affect decisions of Chinese firms.

These are a convenient way of observing the relationship between two variables, or visualizing OLS regressions

## 2.5 Results

In this section, we discuss the results obtained from the empirical approach provided in the previous section. Our estimation process is divided into three stages. First the results for the impact of import competition at the trademark application level are reported. Then, results of the effect of Chinese import competition on trademark registrations are shown. Third, the results of the instrumental variable approach taken to deal with endogeneity issues are presented. The results are followed by a discussion of the potential underlying mechanisms at play.

### 2.5.1 Trademark Applications

Table 2.1 represents key results regarding the impact of the China shock on different trademark application measures. All columns control for country and year fixed effects as well as GDP, population, tertiary education graduates and employment growth. Cluster robust standard errors at the country level are also used across all estimations. Column (1) uses total trademark applications at the country level as the dependent variable and suggests a positively significant increase in total trademark applications.

In column (2), the level of trademark applications done by nationals in their home country is examined and a negative but insignificant coefficient on Chinese import share is found. In this case, a 1 percent

Table 2.1: Impact of China Shock on Trademark Applications

Variables	(1) Total	(2) Nationals	(3) Residents	(4) Non-Residents
China Shock $IMP_{it}^{CH}$	0.123** (0.0503)	-0.170 (0.116)	0.123** (0.0520)	0.185*** (0.0612)
Population	1.561*** (0.344)	3.060*** (0.738)	0.391 (0.609)	2.194*** (0.434)
Tertiary Grad.	0.116* (0.0661)	-0.0200 (0.165)	0.290** (0.127)	0.119 (0.0891)
GDP	0.304*** (0.0723)	0.407** (0.186)	0.498*** (0.156)	0.282*** (0.0830)
Employment	0.522 (0.507)	1.713 (1.331)	1.233** (0.607)	-0.638 (0.514)
<i>N</i>	880	954	870	868
R-squared	0.495	0.454	0.593	0.393
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. The dependent variables are trademark application measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

increase in Chinese import share is accompanied by a 0.17 percent drop in local trademark applications. This measure of trademarks is a good indicator of new commercial innovative activity conducted by the locals of a specific country.

Column (3) presents resident trademarking results showing a positive and significant effect of Chinese imports on trademark applications submitted by residents. Resident trademarks increases by 0.12 percent with a 1 percent increase in the China shock. Similarly, even stronger significant results are found for non-residents as shown in Column (4), where a 1 percent increase in the share of Chinese imports leads to an almost 0.20 percent increase in non-resident trademark applications. Thus, a significant impact of Chinese import competition is found on trademark applications at the total, resident and non-resident level in these baseline OLS estimations.

## 2.5.2 Trademark Registrations

Once a trademark application is submitted, it is then subject to review by the relevant IP office before being officially registered. Only applications fulfilling the proper criteria are approved making the number of trademark registrations a better measure of the quality of innovation activity.

The results presented in Table 2.2 demonstrate the effect of Chinese imports on the different trademark registration measures. Column (1) shows a small increase in total trademark registrations at the country level as that of applications when Chinese imports rise, but is insignificant.

The local trademark registration activity is presented in Column (2) showing a negative but insignificant effect on trademark registrations when Chinese import penetration increases. Local trademark registrations decrease by 0.20 percent when the level of China's import share goes up by 1 percent. Both measures of

Table 2.2: Impact of China Shock on Trademark Registrations

Variables	(1) Total	(2) Nationals	(3) Residents	(4) Non-Residents	(5) In-Force
China Shock $IMP_{it}^{CH}$	0.00812 (0.0616)	-0.200 (0.132)	0.0335 (0.0639)	0.115 (0.0746)	0.219 (0.176)
Population	1.966*** (0.626)	3.189*** (0.676)	1.135 (0.825)	2.788*** (0.632)	1.847 (1.297)
Tertiary Grad.	0.0543 (0.0861)	-0.252 (0.184)	-0.0344 (0.115)	0.0847 (0.111)	-0.114 (0.218)
GDP	0.376*** (0.0896)	0.300 (0.250)	0.594*** (0.173)	0.446*** (0.131)	-0.252 (0.238)
Employment	0.306 (0.689)	0.827 (1.549)	1.819* (0.943)	-0.469 (0.754)	-0.933 (1.105)
$N$	855	948	835	837	444
R-squared	0.265	0.461	0.471	0.270	0.241
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation is by OLS with cluster robust standard errors by country. The dependent variables are trademark registration measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

local non-technological innovation activity, in applications registrations, show a negative but insignificant decrease in the face of rising Chinese import competition.

In Column (3), the results for residents are presented and show a similar coefficient to that of resident applications, but with an insignificant coefficient on Chinese imports. The same insignificant effect is found for non-resident trademark registrations which are represented in Column (4). This is unlike the non-resident applications counterpart which was found to be significant. Moreover, an added dimension of trademarking is considered here which is the trademark registrations in-force. This represents the number of trademarks which are renewed to maintain their already existing exclusion rights. The results in Column (5) show that there appears to be no significant impact of Chinese import competition on trademarks in-force either.

### 2.5.3 Instrumental Variable Estimations

In Table 2.3, I re-present the basic OLS results for trademark applications alongside the first stage for the instrumental variable regressions and the second stage. Column 2 shows the first stage results and clearly indicates that the instrument, past exposure to Chinese imports pre-2000, is strongly correlated with the endogenous variable which is Chinese import share. Column (3) presents the second stage results with the coefficient on Chinese imports being 0.307 and remaining significant. The columns (4) through (6) replicate the same regressions for local trademark applications. Similarly, the coefficient for the first stage results indicates that the instrumental variable is strongly correlated with the instrumented variable. However, the coefficient on Chinese imports in column (6) is significant and negative. The magnitude of the IV estimate is much stronger than its OLS counterpart and shows a weak but significant negative effect of Chinese import competition on local non-technological innovation activity.

Table 2.3: Impact of Import Competition on Total &amp; Local Applications

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Applications			Local Applications		
Dependent Variable	Total	China Imports	Total	Total	China Imports	Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
China Shock	0.123** (0.0503)		0.307** (0.148)	-0.170 (0.116)		-0.756* (0.390)
Past Exposure		-15.40*** (4.222)			-15.73*** (4.282)	
Population	1.561*** (0.344)	-0.305 (0.705)	1.614*** (0.369)	3.060*** (0.738)	-0.837** (0.395)	2.528*** (0.867)
Tertiary Grad.	0.116* (0.0661)	-0.186** (0.0786)	0.146* (0.0757)	-0.0200 (0.165)	-0.0978 (0.0892)	-0.0635 (0.176)
GDP	0.304*** (0.0723)	0.475*** (0.148)	0.195* (0.108)	0.407** (0.186)	0.476*** (0.162)	0.745** (0.294)
Employment	0.522 (0.507)	0.107 (0.826)	0.494 (0.511)	1.713 (1.331)	-0.0217 (0.795)	1.870 (1.459)
<i>N</i>	880	862	862	954	935	935
F-Stat		42.76			44.78	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The dependent variables are trademark application measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

In Table 2.4, the same specifications are conducted for total & local registrations. The instrument remains highly correlated with the endogenous variable. Similar to total applications, the coefficient on Chinese imports is positive but still insignificant for total trademark registrations as well, as seen in Column (3). Columns (4) to (6) present the results for local registrations. The IV estimations tell a similar story to what was represented by OLS results. The OLS estimations showed that Chinese import competition had a negative but insignificant effect on local trademark registrations and this result was corroborated when using the instrumental variable. While coefficient on local registrations is negative, it remains insignificant. Hence, the instrumental variable estimations allow us to conclude that Chinese import competition does not have an impact on total or local trademark registrations.

A different side of the picture can also be painted when looking at resident & non-resident activity. Table 2.5 presents the estimates for resident & non-resident trademark applications. Similarly, columns (2) and (5) illustrate the significant correlation of the instrumental variable. The results of the IV estimation in Column (3) show that the China effect has no significant impact on resident activity, as with OLS. On the other hand, the coefficient of Chinese import competition on non-resident applications remains positive and significant. Table 2.6 presents the results for trademark registrations at the resident and non-resident level. Both the OLS and IV estimation results indicate no significant impact of Chinese import competition on non-technological innovation activity.

Moreover, Table 2.7 repeats the same estimations for trademark registrations in force. The OLS results

Table 2.4: Impact of Import Competition on Total &amp; Local Registrations

	(1)	(2)	(3)	(4)	(5)	(6)
	Total Registrations		Local Registrations			
Dependent Variable	Total	China Imports	Total	Total	China Imports	Total
Method	OLS	First Stage	IV	OLS	First Stage	IV
China Shock	0.00812 (0.0616)		0.203 (0.252)	-0.200 (0.132)		-0.587 (0.443)
Past Exposure		-15.96*** (4.336)			-16.45*** (4.209)	
Population	1.966*** (0.626)	-0.402 (0.750)	2.052*** (0.607)	3.189*** (0.676)	-0.775* (0.402)	2.854*** (0.767)
Tertiary Grad.	0.0543 (0.0861)	-0.167** (0.0817)	0.0805 (0.110)	-0.252 (0.184)	-0.146* (0.0754)	-0.296 (0.194)
GDP	0.376*** (0.0896)	0.425*** (0.161)	0.270* (0.151)	0.300 (0.250)	0.419** (0.165)	0.496 (0.361)
Employment	0.306 (0.689)	-0.0203 (0.856)	0.435 (0.711)	0.827 (1.549)	0.0772 (0.806)	1.165 (1.660)
<i>N</i>	855	837	837	948	929	929
F-Stat		43.22			49.93	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The dependent variables are trademark registration measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

in column (1) show a positive but insignificant effect of Chinese import competition, similar to the other trademark registration variables. However, the instrumental variable estimation in column (3) indicates a weakly significant and positive effect of import competition. This could potentially suggest that entities who registered trademarks value their own trademarks more in the face of increased foreign competition. As a result, these trademarks are renewed to preserve their rights in the face of new competition.

The main concern in interpreting the Chinese import competition correlation in Tables 2.1 and 2.2 as causal is that there are unobserved technology shocks. The instrumental variable estimations correct for this by controlling for such potential endogeneity concerns in a multitude of ways. This allows us to make better interpretations of the impact of import competition on trademarking activity. We find a strong and positive significant effect of Chinese import competition on total trademark applications. This appears to be driven primarily by non-resident trademarking activity, as the coefficients were significantly positive in both the OLS and IV estimations. On the other hand, a weakly significant negative effect is found for the impact of import competition on local trademarking applications. As for registrations, the instrumental variable results confirm baseline estimations that there is no significant impact of Chinese import competition on trademark registrations at any level. This suggests that the quality of non-technological innovation is not affected by Chinese import competition. Since a robust significant effect is found for trademark applications and not registrations, we may deduce that import competition decreases the number of new product or service innovations filed for but not necessarily the quality. This negative impact on applications may be perceived



as a discouragement effect. Overall, the evidence points towards import competition being detrimental to local non-technological innovation activity.

## **2.5.4 Potential Policy Implications**

While further research effort in this direction is required, the suggestive evidence of this paper may allow us to make some potential policy implications. The negative, although not very strong, impact of Chinese import competition on local trademark activity should be a cause for concern in developing countries. Indeed, with the lack of technological innovation in those countries, they should not want to hinder non-technological innovation. The local or resident innovation activity also has some growth implications which are important. As Bronwyn H Hall (2020) states, trademarking in developing countries is a critical measure of activity in the course of development.

Unfortunately, without finer data regarding the different trademarking sectors of activity, it is hard to make precise conclusions. However, if Chinese import competition is leading to a discouragement effect, where firms do not engage in any innovative activity and simply exit the market, then governments should step in to shield local firms from such competition. As famously stated in the Aghion, Nick Bloom, Blundell, Griffith, and Howitt (2005) inverted-U model, too much competition may have an adverse effect on innovation outcomes. With a better viewpoint of trademark activity disaggregated by sector, countries could then identify precisely where competition is oversaturated. Governments could then use policy tools to manage competition in different sectors accordingly. They could provide support for important sectors where a discouragement effect is taking place. This could include different policies such as tax breaks, subsidies or other incentives to boost activity within that area. Governments could also implement more capacity building mechanisms to improve the quality of output in those specific sectors.

On the other hand, if import competition is discouraging only the non-innovative players from trademarking, then it could be welfare improving. This could declutter local intellectual property rights offices and prevent unnecessary backlogs which would make them more efficient. Markets would also reflect this efficiency in turn. Future studies should dive deeper into this issue to potentially untangle these effects.

## **2.6 Conclusion**

Motivated by the recent emergence of China as a major player in global trade, this paper analyzes the implications of this shock on innovation in developing countries. An empirical study is conducted on this impact of Chinese import competition on innovation, measured by trademarking activity. Using data from the WIPO covering trademark activity for more than 80 developing countries, baseline estimations show that there is a positive significant effect of import competition on trademark application variables, except for those at the local level. However, no significant effect was found on registrations. Moreover, a shift-share instrumental variable approach is taken to relieve endogeneity issues. The instrumental variable estimations show a weakly significant negative impact of import competition on local trademarking applications, but

not local trademarking registrations. In other words, Chinese import competition is found to negatively affect domestic non-technological innovation. Hence, results show that import competition negatively affects non-technological innovation activity by locals in developing countries.

This paper's findings add to the debate regarding the effect of import competition on innovation. These empirical results add a more nuanced understanding of the impact of foreign competition on innovation in developing countries. In the case of developing countries, it may be detrimental to late-stage local non-technological innovation activity. Given the importance of this question for policy implications, further research using firm level data would be fruitful.

## **2.7 Appendix**

### **2.7.1 Results**

Table 2.5: Impact of Import Competition on Applications of Residents &amp; Non-Residents

Dependent Variable Method	(1)	(2)	(3)	(4)	(5)	(6)
	Resident Applications			Non-Resident Applications		
	Total OLS	China Imports First Stage	Total IV	Total OLS	China Imports First Stage	Total IV
China Shock	0.123** (0.0520)		-0.0369 (0.218)	0.185*** (0.0612)		0.363** (0.156)
Past Exposure		-15.36*** (4.236)			-15.36*** (4.237)	
Population	0.391 (0.609)	-0.336 (0.735)	0.309 (0.623)	2.194*** (0.434)	-0.334 (0.735)	2.267*** (0.403)
Tertiary Grad.	0.290** (0.127)	-0.185** (0.0794)	0.267** (0.124)	0.119 (0.0891)	-0.186** (0.0794)	0.146 (0.0900)
GDP	0.498*** (0.156)	0.467*** (0.147)	0.584** (0.232)	0.282*** (0.0830)	0.466*** (0.147)	0.183 (0.113)
Employment	1.233** (0.607)	0.0000933 (0.809)	1.246* (0.662)	-0.638 (0.514)	-0.00343 (0.810)	-0.750 (0.533)
N	870	852	852	868	850	850
F-Stat		42.5			42.47	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The dependent variables are trademark application measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.6: Impact of Import Competition on Registrations of Residents &amp; Non-Residents

Dependent Variable Method	(1)	(2)	(3)	(4)	(5)	(6)
	Resident Registrations			Non-Resident Registrations		
	Total OLS	China Imports First Stage	Total IV	Total OLS	China Imports First Stage	Total IV
China Shock	0.0335 (0.0639)		-0.156 (0.273)	0.115 (0.0746)		0.177 (0.239)
Past Exposure		-15.91*** (4.372)			-15.91*** (4.372)	
Population	1.135 (0.825)	-0.473 (0.783)	1.039 (0.791)	2.788*** (0.632)	-0.473 (0.782)	2.841*** (0.595)
Tertiary Grad.	-0.0344 (0.115)	-0.165** (0.0827)	-0.0600 (0.129)	0.0847 (0.111)	-0.165** (0.0827)	0.0911 (0.117)
GDP	0.594*** (0.173)	0.429*** (0.163)	0.695*** (0.240)	0.446*** (0.131)	0.429*** (0.163)	0.418** (0.190)
Employment	1.819* (0.943)	0.0258 (0.857)	1.974* (1.029)	-0.469 (0.754)	0.0269 (0.857)	-0.494 (0.801)
N	835	816	816	837	818	818
F-Stat		41.83			41.88	
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The dependent variables are trademark registration measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.7: Impact of Import Competition on Registrations In-Force

Dependent Variable Method	(1)	(2)	(3)
	Total OLS	Registrations In-Force China Imports First Stage	Total IV
China Shock	0.219 (0.176)		1.294* (0.705)
Past Exposure		-10.98 (7.023)	
Population	1.847 (1.297)	-1.076 (1.204)	3.259 (2.174)
Tertiary Grad.	-0.114 (0.218)	0.0408 (0.116)	-0.201 (0.231)
GDP	-0.252 (0.238)	0.547** (0.226)	-0.973 (0.649)
Employment	-0.933 (1.105)	-0.429 (0.899)	-0.537 (1.154)
<i>N</i>	444	425	425
F-Stat		9.17	
Country FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations in Column (1) and (4) are OLS with cluster robust standard errors by country. Column (2) and (5) show first stage regression results. Column (3) and (6) represent second stage regression results. The IV is a shift-share instrument interacting value of Chinese imports in 1999 with the growth of Chinese imports across all developing countries. The dependent variables are trademark registration measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.8: Impact of China Shock on Trademark Applications

Variables	(1)	(2)	(3)	(4)
	Total	Nationals	Residents	Non-Residents
China Shock	0.0146*** (0.00535)	-0.0214 (0.0193)	0.0206*** (0.00692)	0.0229*** (0.00732)
Population	0.179*** (0.0389)	0.605*** (0.134)	0.0470 (0.0955)	0.269*** (0.0530)
Tertiary Grad.	0.0142* (0.00759)	0.00326 (0.0325)	0.0466** (0.0222)	0.0149 (0.0107)
GDP	0.0354*** (0.00752)	0.0729** (0.0291)	0.0718*** (0.0263)	0.0344*** (0.00956)
Employment	0.0562 (0.0530)	0.248 (0.188)	0.150* (0.0839)	-0.0767 (0.0590)
<i>N</i>	873	946	863	861
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations are poisson panel regressions with cluster robust standard errors by country. The dependent variables are trademark application measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.9: Impact of Import Competition on Trademark Registrations

Variables	(1) Total	(2) Nationals	(3) Residents	(4) Non-Residents	(5) In-Force
China Shock	0.000962 (0.00702)	-0.0286 (0.0232)	0.00953 (0.00976)	0.0142 (0.00910)	0.0192 (0.0153)
Population	0.239*** (0.0725)	0.746*** (0.171)	0.203 (0.126)	0.353*** (0.0773)	0.171 (0.121)
Tertiary Grad.	0.00926 (0.00983)	-0.0239 (0.0409)	0.00329 (0.0171)	0.0135 (0.0139)	-0.0105 (0.0192)
GDP	0.0431*** (0.0101)	0.0640 (0.0450)	0.0910*** (0.0305)	0.0540*** (0.0160)	-0.0202 (0.0210)
Employment	0.0393 (0.0743)	0.165 (0.250)	0.258* (0.133)	-0.0503 (0.0872)	-0.0817 (0.0990)
<i>N</i>	848	940	827	829	436
Country FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation are poisson panel regressions with cluster robust standard errors by country. The dependent variables are trademark registration measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.10: Trademark Applications Class Counts by Goods &amp; Services

	Dependent Variable: Trademark Application Variables			
	(1) Total Goods	(2) Local Goods	(3) Total Services	(4) Local Services
China Shock	0.723*** (0.198)	0.259 (0.753)	0.621*** (0.204)	0.180 (0.869)
Controls	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes
Observations	357	630	357	609

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimation are panel fixed effect regressions with cluster robust standard errors by country. The dependent variables are trademark class count application measures in log form. The following control variables are also in log; population, tertiary graduates and GDP.

Table 2.11: Pre-Trends Test of Trademark Application Variables

	(1)	(2)	(3)	(4)
	Instrumental Variable: Past Exposure			
Total * Pre-WTO	0.000979 (0.000616)			
Local * Pre-WTO		0.000425 (0.000347)		
Resident * Pre-WTO			0.000723 (0.000501)	
Non-Resident * Pre-WTO				0.00113 (0.000799)
<i>N</i>	2229	2667	2123	2119
Country FE	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations are in OLS with cluster robust standard errors by country. The dependent variable is the constructed instrumental variable which is the past exposure to the China shock (pre-2000). The trademark application variables are in log form. "Pre WTO" is a dummy equal to unity before 2000 (and zero after).

Table 2.12: Country List

Countries included in the estimations
Albania, Algeria, Angola, Argentina, Armenia, Azerbaijan, Bahrain, Bangladesh, Barbados, Belarus, Belize, Bhutan, Bosnia and Herzegovina, Brazil, Brunei, Bulgaria, Burkina Faso, Burundi, Cabo Verde, Cambodia, Chile, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Ghana, Guatemala, Honduras, Hungary, India, Indonesia, Iran, Jamaica, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Lao People's Democratic Republic, Madagascar, Malawi, Malaysia, Mexico, Moldova, Mongolia, Montenegro, Morocco, Mozambique, Nepal, Nicaragua, Nigeria, North Macedonia, Oman, Panama, Peru, Philippines, Poland, Qatar, Romania, Russia, Rwanda, Saudi Arabia, Serbia, Sierra Leone, South Africa, Sri Lanka, Sudan, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, Uruguay, Uzbekistan, Venezuela, Vietnam, Zimbabwe

Table 2.13: First Stage Regressions with Different Instruments

	Dependent Variable: China Shock						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Past Exposure * All Dev Countries	-15.40*** (4.222)						
Past Exposure * Outside Continent		-1.144** (0.495)					
Past Exposure * to EU			-2.564*** (0.562)				
Past Exposure * to NA				-0.0712* (0.0374)			
Past Exposure * to Africa					-0.147* (0.0878)		
Past Exposure * to Asia						-4.134*** (1.132)	
Past Exposure * to LA							-0.472*** (0.116)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	889	889	889	678	853	889	889

Notes: \*\*\* denotes 1% significance; \*\* denotes 5% significance; \* denotes 10% significance. Estimations are in OLS with cluster robust standard errors by country. The dependent variable is the China shock. "Past exposure" corresponds to the Chinese import share to developing countries in 1999, prior to China joining the WTO. This is interacted with a variable representing Chinese exports to a specific geographic location.

## 2.7.2 First Stage Negative Effect

In order to investigate the first stage negative effect further, I build different instruments to test. Each instrument interacts past exposure to the China shock with exports from China to developing countries in different geographic regions. The results show a consistent negative effect for all regions. This aligns with the idea of a trade diversion phenomenon going on between developing countries.



## Chapter 3

# Importing Gender Equality: A Technological Revolution Effect

*Written with Alexis Noir-Luhalwe*

### 3.1 Introduction

In many countries, women have on average less high-paid jobs, full-time jobs, labour force participation, experience or educational attainment than men. Such gender differences entail large economic worldwide costs reaching 160.2 trillion USD as it prevents women from developing their full potential as productive workers (Wodon and De La Briere, 2018). As global integration continues, there has been increasing interest in the impact of globalization on gender issues. Existing studies examine the effect of a trade shock on gender inequalities, e.g. a trade liberalization episode. However and to the best of our knowledge, none of them document if gender inequalities are affected by trade actors.

This paper addresses that issue by examining if gender inequalities from a country are influenced by its trading partners. We adjust a spatial model normally used for identifying a spatial effect between geographically close units, and adapt it to trade by considering the economic notion of distance. Our approach consists of disaggregating trade into 3 levels from bilateral and import-export to technology-level products in order to identify a technology channel in line with Juhn, Ujhelyi, and Villegas-Sanchez (2014). However, the technology-level products allow a more detailed analysis of the impact of technology traded on gender inequality. We then have constructed for each country spatial trade variables of gender inequalities by trade level which are weighted according to the importance of its trading partners, i.e. a major trading partner has a bigger influence than a minor one. Using a panel of country level data from 1997-2013 across 123 countries, results indicate that the import of medium-tech products, high-tech and mineral-fuel products play a significant role in the diffusion of gender standards.

The literature reports mixed evidence on the effect of a trade shock on gender inequalities. On the one hand, trade can have negative effects on gender inequalities through a decline of female productivity, a reduction of female labor market opportunities and a decrease of female labor force participation. From 1990 to 2007, Sauré and Zoabi (2014) document that the gender wage gap increases and female labor force

participation falls in the US when trade with Mexico expands in female-intensive sectors, i.e. sectors that use female labor intensively. More recently, Keller and Utar (2018) argue that Chinese import competition leads to an increase in gender inequality in Denmark over the period from 1999-2009 by reducing labor market opportunities. Hakobyan and McLaren (2018) also examine the North American Free Trade Agreement (NAFTA) in 1999-2000 and show evidence of the relationship between tariff reductions and the reduced wage growth of married blue-collar women in the US. On the other hand, trade can positively affect gender inequalities through an increase in competition and technological upgrading. During the period from 1977-1994, Black and Brainerd (2004) show that increased competition resulting from international trade in US manufacturing industries led to a reduction in gender inequalities, i.e. the gender wage gap decreases and the female labor force participation increases. Ederington, Minier, and Troske (2009) who examine Colombian plant-level data from 1977 to 1991, provide similar evidence about competition since women are more employed following a trade liberalization episode. For their part, Juhn, Ujhelyi, and Villegas-Sanchez (2014) argue that in the 1990's, NAFTA increased employment of Mexican women in blue-collar tasks following a technological upgrading within new exporting firms.

Our study falls within the Juhn, Ujhelyi, and Villegas-Sanchez (ibid.) approach by considering gender inequality spillovers through technology. We provide evidence that the technological upgrading within firms is at hand when a country trades with a more gender-equal partner. The relative female productivity increases as jobs become less physically demanding with access to imported office/industry machines and agricultural machines Pieters (2015). However, the range of products included in technology-level categories allow us to consider a larger technology effect. First, importation of advanced technology products modifies the female opportunity cost of time for having children. On the one hand, access to surgical/medical equipment, medicine and contraceptive methods allows women to control their fertility in order to study or work (Goldin and L. F. Katz, 2000). On the other hand the rise of household appliances such as vacuum cleaners, washing machines, dryers and refrigerators save time on household tasks (Greenwood, Seshadri, and Yorukoglu, 2005). Women who remain the first providers of such tasks can therefore reallocate their time to study or work. Second, governments spend money on military technology imports by acquiring electronic systems, holographic sights and laser rangefinders among others which require high investments in public R&D with spillover effects on private R&D. That, in turn, encourages technology upgrading in the private sector (Moretti, Steinwender, and Van Reenen, 2019).

All these technological mechanisms depend directly on the development level of the country. In advanced economies, these effects should be less pronounced because there is less scope for firms, households and governments to improve their technology level. However, the period under observation reveals an abundance of technological progress, e.g. creation of computers. Then, gender inequality is affected by technology imports from more gender-equal countries. We present this phenomenon as the technological revolution.

The rest of the paper is organized as follows. Section 2 describes the trade mechanisms on gender inequality from the literature. Section 3 presents data. Section 4 provides empirical evidence of the cross-country transmission channel with explanations about the potential mechanisms at hand. Finally, section 5

presents some concluding remarks.

## 3.2 Trade Mechanisms on Gender Inequality

The literature identifies several main channels by which trade liberalization can affect gender inequalities: discrimination, comparative advantage, capital intensity and technological revolution (Pieters, 2015).

The effect of discrimination on gender inequality was developed by Becker (2010) and then adapted to the international trade framework. Becker first defined discrimination as a difference in treatment between two individuals with identical observable productive characteristics. Discrimination is related to employers' taste on observable non-productive characteristics such as gender. His model shows that discrimination disappears in presence of competition since it is costly for employers. In the case of gender disparities, some employers prefer to hire men over women despite equal productivity between both. Women will then accept lower wages and employers who apply discrimination against women deprive themselves of lower costs. Considering that international trade increases competition between firms, non-discriminating firms have a competitive advantage in terms of costs over discriminating ones. As a result, discriminating firms being less competitive will exit the market. Black and Brainerd (2004) test this mechanism developed by Becker in the US by examining the effect of increased competition on discrimination. Considering globalization in the 1980s, authors compare the unexplained part of the gender wage gap computed on full-time workers from concentrated manufacturing industries in 1976 and 1993. With competitive industries used as control, results show that the gender wage gap narrows faster in concentrated manufacturing industries than in competitive ones. Ederington, Minier, and Troske (2009) also examine the Becker theory using trade liberalization which affects firms in Colombia between 1984 and 1991. They provide evidence of less female discrimination on the labor market following an increase in competition. On the contrary to Becker, results show that the effect is more explained by discriminating plants hiring more women rather than driving them out of the market. Firms that faced less cut-throat competition in 1984 will be more inclined to reduce discrimination. Bøler, Javorcik, and Ulltveit-Moe (2015) explore the relationship between exporting firms and gender discrimination on the labor market. For this purpose, they use wage data between 1996 and 2009 from Norwegian manufacturing employees working full-time. They find that the gender wage gap is smaller within exporting firms which have a higher share of women in the total labor force. These trends are observed before exporting firms enter into foreign markets, meaning that less discriminating firms are more competitive.

More recently, the impact of trade on gender inequalities has been explained through well-known trade theories. In international trade, the Ricardian theory advances that each country has a comparative advantage over others in producing a good at a lower relative opportunity cost. Accordingly, countries are able to engage in profitable trade with its trading partners. Even if advanced economies could produce goods more efficiently, they would benefit from importing from those lagging behind. On the contrary, laggards would benefit from exporting goods in which opportunity costs are lower. In their article, Do, Levchenko,

and Raddatz (2016) applied the comparative advantage principle on fertility, advancing that differences in technologies and endowments reflect differences in gender labor force use. First, they developed a theory stating that countries with a comparative advantage in female-intensive goods reveal lower fertility since it is affected by women's opportunity cost of time. Second, they test their model on 79 sectors in 146 countries between the 1960s and the 2000s. Results show evidence that countries exporting goods that are female-intensive in labor exhibit lower fertility.

In addition, sector reallocation of production factors is also an interesting issue when examining international trade. A trade liberalization episode implies an expansion of the sector in which countries have a comparative advantage. Surprisingly, Sauré and Zoabi (2014) argue that female labor force participation declines and the gender wage gap widens when international trade expands capital-abundant sectors. They developed a model based on Heckscher-Ohlin theory with two production factors associated with a gender, i.e. capital intensive sectors as female-intensive sectors and labor-intensive sectors as male-intensive ones. Female labor and male labor are thus assumed to be distinct production factors. The underlying mechanism for explaining the result is as follows: the price of female labour rises in a capital-intensive country trading with others because of an increasing demand. The production expands in capital-intensive sectors and contracts in other sectors. A reallocation of factors occurs toward the expanding sector with male labor moving to capital-intensive sectors. The male labor being only composed by labor, its entry into capital-abundant sectors dilutes the capital intensity, resulting in a female productivity decline. Accordingly, the gender wage gap increases while the female labor force participation falls. Authors test their theory using bilateral data between the US and Mexico for over the period 1990-2007. They provide evidence of their theory on the female labor force participation rate. Gaddis and Janneke Pieters (2017) also examine the effect of trade liberalization on gender reallocation between sectors. Using data from Brazil between 1991 and 2000, they find that tariff cuts reduce labor force participation and employment rate of men and women. Micro regions more affected by the trade shock show a faster reduction of gender differences driven by the declining labor force participation and employment rate of men. The sectors of goods and services traded internationally, composed by low-skilled workers, are mainly exposed to these reductions. In fact, men are more represented in these sectors which require physical strength. Such a finding aligns with the imperfect substitutability of male and female labor developed in Sauré and Zoabi, 2014.

Furthermore, the literature on trade provides much more evidence on a skill-upgrading phenomenon rather than a factors reallocation one. In their article, Juhn, Ujhelyi, and Villegas-Sanchez (2014) develop a model where firms choose between using routine physical tasks or computers. A trade shock represented by a liberalization episode decreases the cost of entering the foreign market. More productive firms are then encouraged to modernize their technologies to be competitive. Then technology replacement affects mainly low-skilled workers for their physical skills are less required. This improves the relative wage and employment of women in blue-collar tasks. Authors test their model on firm-level data from Mexico with the North American Free Trade Agreement (NAFTA) between 1992 and 2001. Results show firstly that tariff cuts increase the number of exporting firms, secondly that the upgrading-technology within exporting firms

is driven by newly exporting ones. Lastly, female labor outcomes are improving through the growing share of female labor in blue-collar tasks and the increase of female wages.

In this paper, we adopt the approach of Juhn, Ujhelyi, and Villegas-Sanchez (ibid.) based on technology in order to identify a channel through which gender inequality may be affected. The data at hand in the following section allow us to isolate the technology-level of traded products.

## **3.3 Data**

We combine a number of rich data sources together to build the database for this study. Our base dataset is the CEPII (Centre d'Études Prospectives et d'Informations Internationales) BACI database for trade. Our indicator for gender equality standards is the Gender Inequality Index (GII) from the IMF. We also source our control variables from the World Bank. Our sample is composed by 123 countries (see Table 3.2 in appendix)

### **3.3.1 Trade Flows**

Our trade flow data comes from the BACI dataset which is an international trade database at the product level. The database covers more than 200 countries and provides disaggregated data on bilateral trade flows for more than 5000 products. The dataset is built directly from the data reported to the UN Comtrade by each country. One of the main advantages of the BACI dataset is that it uses a procedure to reconcile the declarations of the exporter and importer and harmonizes information which may have been different in the original data. This approach resolves discrepancies and makes the data more reliable. The procedure involves estimating and removing CIF (cost, insurance and freight) from import values to compute FOB (free on board) import values. The BACI also takes into account the reliability of a country in its reporting of trade data. Countries which tend to report data that is very different than that of its trade partners, are considered less reliable and granted a lower weight in the calculation of the reconciled trade flow value. Furthermore, products are classified according to the HS (Harmonized System) nomenclature, at the 6-digit level. This is the finest level of disaggregation available which is similar across all countries. Given that our data runs from 1997 to 2013, we use the HS07 revision as it is the most pertinent for that period. Consequently, we convert the HS96 data, which was pre-2007, to HS07 to harmonize the classification across time.

### **3.3.2 Gender Inequality Index**

In order to measure gender inequalities, we use the Gender Inequality Index (GII, 2010) developed by the UNDP. The index groups three dimensions capturing women's disadvantage, i.e. reproductive health, empowerment and labour market. First, reproductive health is based on two indicators which are the maternal mortality ratio and the adolescent fertility ratio. The first one is an indicator of women's status

in society by reflecting women conditions during childbirth. The other measures the fertility rate for 15-19 year olds girls for shedding light on their future opportunities, i.e. child rearing when being young may prevent access to higher educational attainment which reduces the scope of professional possibilities. Second, empowerment captures educational attainment from secondary education as well as the share of female and male seats in parliament. Such a measure reflects women's visibility and leadership in a society via political positions and high educational attainment leading to better positions. Third, labour market measures economic activity through the labor force participation rate. Even if the female labor force participation is not totally accurate because of women's unpaid work, i.e. home and family work, the rate reflects the degree of economic activity between men and women.

Since 2010, the formula for computing the GII has evolved. The latest version is based on five steps (See technical note of UNDP for GII). The first one is treating zeros and extreme values. While the use of the geometric mean is impossible with zero values, maternal mortality ratio is right truncated for simplicity, i.e. countries for which maternal mortality ratios exceed 1,000 report similar conditions and support for maternal health. The second one aggregates the three dimensions by gender using geometric means. Such a transformation makes the GII association-sensitive (Seth, 2009). Then the third one aggregates across gender with previous geometric means by the harmonic mean<sup>1</sup>. The fourth one calculates the geometric mean of all arithmetic means from indices with both gender. The result is used as a reference standard by aggregating female and male indices with equal weights. The final step compares the harmonic mean (step 3) with the reference standard (step 4) from 0 (no gender inequality across dimensions) to 1 (total gender inequality across dimensions). Finally, the GII score gives the country's situation in reference to normative ideals, i.e. gender equality (Gaye, Klugman, Kovacevic, Twigg, Zambrano, et al., 2010).

### 3.3.3 World Bank

The remaining variables used in our estimations are sourced from the World Bank open database. These are the selected control variables used, even if other ones may be relevant<sup>2</sup>. We include measures of trade openness, FDI openness and population. Trade openness here is defined as the sum of exports and imports divided by GDP. The value of exports and imports is provided by the BACI database while the GDP is taken from the World Bank. Similarly, FDI openness is defined as the FDI inflows divided by GDP. FDI inflows refers to direct investment equity flows, of 10 percent or more of the ordinary shares of voting stock, into the reporting economy. This data is also obtained from the World Bank database which is aggregated from the IMF. All data is annual.

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<sup>1</sup>A harmonic mean is one of the three Pythagorean means which is often used to compute the average of rate or ratio.

<sup>2</sup>The literature provide empirical evidence for immigration having a positive effect on trade (Egger, Von Ehrlich, and D. R. Nelson, 2012; (ibid.)). However, this link also appears to be stronger for trade in commodities with informational problems. Given that our results reflect a technological channel at play, we do not perceive an upward bias due to migration

### 3.3.4 Technology Classification

The literature documents that a technology upgrading channel exists for explaining the effect of trade on gender inequality. In their survey, Juhn, Ujhelyi, and Villegas-Sanchez, 2014 advance that import increases competition while export enhanced market opportunities. Firms are then encouraged to upgrade their technologies via trade for becoming more competitive. They show that this effect is mainly driven by exporting firms. This paper examines if a spillover effect of technology upgrading exist via trade. Henceforth, we use the UNCTAD Skill and Technology Classification of products in order to isolate the effect of each level of technology.

The UNCTAD classification is unique in that it accounts for the mix of skill, technology, capital and scale requirements at the final product stage (see Klotz, Kniahin, and Jansen, 2016). Products are grouped into six different categories; high-technology, medium-technology, and low-technology, resource-intensive, mineral-fuel and non-fuel commodities. The UNCTAD is especially useful as it allows for both differentiating between technology-intense products and non-tech products, as well as within technology-intense products. High-tech products include optical, measuring and medical instruments, chemical manufactures, plastics and rubber. Medium-tech products include machinery, mechanical appliances and electrical equipment. Low-tech products include based metals, vehicle, aircraft and vessels products as well as other transport equipment. Resource-intensive products include textiles, footwear, leather, wood and paper, stone and plaster, precious stone or metal, and miscellaneous manufactured articles. Non-fuel products include vegetable, animal and oil products, prepared foodstuffs, tobacco manufactures, and mineral products. Lastly mineral-fuel products include arms and ammunition and works of art. An exhaustive list of products by technology classification can be found in the appendix. We use the classification in Klotz, Kniahin, and Jansen (ibid.) to match HS sections to the corresponding UNCTAD technology product classification. We consider a section with a majority of products belonging to a specific classification to be entirely categorized under that classification. Table 3.3 in appendix details the HS sections under each technological category according to our final classification.

Furthermore, we use the OECD technological classification as well for the purpose of robustness (see Table 3.4 in appendix). The classification captures the extent to which an industry uses technology and takes into account the importance of direct and indirect R&D intensity. Direct intensity is measured by weighing each sector with its share in production or value added of all OECD countries. The indirect indicator is obtained from the R&D expenditure in intermediates and capital goods either imported or purchased in the domestic market. The result is a classification into the following: high-tech, medium-high tech, medium-low tech, low tech and other. High-tech products include optical and photographic instruments. Medium-high tech products include chemical manufactures, machinery, mechanical appliances, electrical equipment, vehicles, vessels, aircrafts, transport equipment and arms and ammunition. Medium-Low tech products include plastics, rubber, stone, cement, glass, ceramics, pearls and base metals. Low tech includes animal products, oils, beverages, tobacco, foodstuffs, wood, textiles, furniture and toys. Lastly, the other products

classification includes mineral products, footwear, works of art and antiques. In similar fashion, we follow Klotz, Kniahin, and Jansen (2016) to match HS sections to the respective OECD technology classification. Table 3.4 in the appendix presents the correlation matrix amongst the technology classification spatial lag variables. Table 3.6 in appendix, for its part, provides a basic summary of descriptive statistics. It should be noted that our panel is balanced, the difference in number of observations for spatial lag variables and all other variables is simply due to the one year lag.

## 3.4 Empirical Application

### 3.4.1 Spatial Econometrics

The majority of existing literature investigates the effect of trade on gender inequality by considering this effect to be endogenously determined within each country. However, trade induces a globalization process where all countries are connected via trade exchanges and trade agreements. Such a connection between trading partners may play a role in influencing the global trend observed, i.e. a decrease gender inequality. In this study, we examine if a spillover effect of trade mechanisms on gender inequalities exists between trading partners. We use technology-level product categories to deepen our analysis on the technology upgrading channel<sup>3</sup> by isolating the effects of each technology. Thus, we adopt a spatial econometrics approach in order to identify a spillover effect of technology upgrading channel between trading partners.

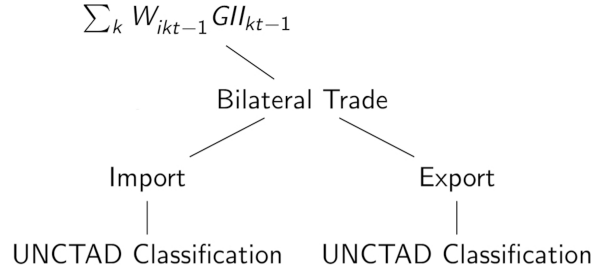
In a globalizing world, spatial frictions can play an important role in understanding the economics of cities and nations. Since the 1990's, the field of spatial economics, commonly known as new economic geography, has been growing. Such studies are critical in understanding the movement of goods, knowledge and factors of production. As a result, economists have developed different spatial approaches from regional economics through urban economics to transportation economics (see Proost and Thisse, 2019 for a survey). Most recently, notions of space are taken into account in other economic fields. The gravity law connecting bilateral trade to GDP and the distance between countries is considered as empirical evidence in the literature (Frankel and D. H. Romer, 1999; Head and Mayer, 2014). Moreover, the gravity law has been applied to many economic contexts including migration & capital flows. Indeed, similar approaches have been taken such as Candau and Dienesch (2015) who show that spatial integration plays a role in the spatial distribution of skills. Spatial analyses show the existence of spatial clusters which make cross sectional units dependent on one other. First Anselin (1988) and then LeSage (1999) have popularized spatial econometric methods for estimating spillover effects resulting from spatial correlations. The latter can take two forms. The first one is the spatial lag model where a spatial lag of the dependent variable is included as an explanatory variable. In this case, the dependent variable will be partially explained by all dependent variables with which it is connected. The second one is the spatial error model in which spatial correlation between residuals is considered.

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<sup>3</sup>See Pieters, 2015 for a review on the technology upgrading channel within the literature.



Figure 3.1: Three Stages of Spatial Estimations



Note : All three stages of spatial lagged variables estimations included in the regression. First the spatial lagged bilateral trade, second the bilateral trade decomposed into spatial lagged by imports and exports, then imports and exports decomposed into spatial lagged product technological classification.

While most spatial studies are based on geographic spatial correlations, we decide to adjust the spatial lag model to consider economic notions of space to identify a cross-country spillover effect of gender standards via trade linkages. We first investigate for spatial autocorrelation, i.e. the concept that objects "closer" to each other tend to be more similar, with respect to a specific attribute, than distant ones. The presence of spatial autocorrelation has also been taken to be a sign that further investigation is required to understand the reasons behind such spatial variation (Cliff and Ord, 1981). We use a global Moran's index which provides an "average" picture of the spatial distribution of the GII. Table 3.7 indicates positive spatial autocorrelation in bilateral, import and export trade meaning "nearby" regions tend to exhibit similar values of gender inequality. We then spatially lagged variables for trade exchanges which are included as main explanatory variables in our model. They are lagged by one year since we consider that they could not exert a contemporaneous effect. Even though trading partners are connected among them, we also consider that a major trading partner's influence is greater than a minor trading partner's one. Accordingly, the spatial lagged variable for trade is defined as  $\sum_k W_{ikt-1}^{TE} GII_{kt-1}$ . Where  $W$  is the spatial weighting matrix containing all trade weights associated with the share of each trading partner of the country $_i$ 's total trade under observation. In this respect, regional trade are taken into account since intensive trade between countries within a regional trade agreement is more weighted than other trade exchanges outside the agreement. The spatial lagged variable then captures the average effect of GII from country $_i$ 's trading partners', weighted by trade linkages in term of quantity, on the GII from country $_i$ . Even if the trade literature shows evidence that exporting encourages firms to upgrade their technologies, increased competition from imports can also be an incentive for firms to invest in technologies Pieters, 2015. Trade relationships are then disaggregated in order to identify a specific channel responsible for a spillover effect. Here, the estimation process is divided into three stages with only one spatial trade exchanges variable in order to avoid multicollinearity issues (see Table 3.4 for UNCTAD and Table 3.5 for OECD correlation matrices).

First we run a model with spatial bilateral trade. Then, we do this twice again with spatial imports and spatial exports instead of spatial bilateral trade. Finally we decompose imports and exports by each product category according to UNCTAD and repeat the operation for all spatial product categories (see 3.1).

Finally, the following spatial autoregressive model in equation (3.1) is estimated at each stage of the

estimation process.  $\sum_k W_{ikt-1}^{TE} GII_{kt-1}$  successively taking values of spatial lagged bilateral trade, spatial lagged exports, spatial lagged imports and the spatial lagged of each product technology category for exports and imports:

$$GII_{i,t} = \beta_1 GII_{it-1} + \beta_3 \sum_k W_{ikt-1}^{TE} GII_{kt-1} + \beta_4 FDI_{it} + \beta_5 Trade_{it} + \beta_6 \ln population_{it} + \gamma_t + \alpha_i + \epsilon_{it} \quad (3.1)$$

Where  $\sum_k W_{ikt-1}^{TE} GII_{kt-1}$  is the spatial lagged trade variable for trade exchanges (TE) as explained above,  $\gamma_t$  represents country fixed effects,  $\alpha_i$  time fixed effects and  $\epsilon_{it}$  as the error term.  $FDI_{it}$  and  $Trade_{it}$  are computed by dividing FDI inflows and Trade by the GDP of the country of observation.

### 3.4.2 Empirical Strategy

Econometric analysis of time and space simultaneously is scarce in the economics literature. The presence of a dynamic process combined with spatial effects can lead to endogeneity issues such as measurement errors, variable omission and simultaneity relationships. Regarding equation (3.1), spatial lagged variables are not strictly endogenous but predetermined which means that they are potentially correlated to lagged values of the residuals (Arellano, 2009). For its part, the autoregressive term is strictly endogenous. Accordingly, OLS estimation becomes inconsistent and biased. The literature suggests a limited number of estimators that can handle space and time in a panel. J Paul Elhorst (2003, 2005) developed the ML function by estimating the unconditional loglikelihood of the model in first-difference. Most recently, Yu, De Jong, and Lee (2008) propose the quasi-maximum likelihood estimators by maximisation of the concentrated likelihood function of the demeaned model. Then J. Elhorst (2008) suggested two mixed estimators; the mixed spatial MLE/Spatial Dynamic MLE and the mixed spatial MLE/GMM. Finally, Beenstock and Felsenstein (2007) developed a two-step procedure which consists of estimating least-squares dummy variable estimators without the spatial lagged variables and re-estimating the entire model with least-squares dummy variable estimators with estimated values of the dependent variables from the first estimation as instruments for the spatial lagged variables. We use system-GMM estimators (Manuel Arellano and Bover, 1995; Blundell and Bond, 1998) for the simplicity of their implementation and their suitability to the GII. The methodology of Ahn and Schmidt (1995) adds nonlinear moment conditions to basic linear moment conditions to improve the estimators' efficiency, in particular when the autoregressive coefficient is close to unity, i.e. this is our case with the GII (see *ibid.*). System-GMM procedure estimates a system of two equations: a first one is in levels and another is first-differenced to control for individual fixed effects, i.e. country fixed effects. While lagged first-differences from the first-differenced equation are used as instruments for the level equation, lagged levels from the levels equation are used as instruments for the first-differenced equation. Therefore, instruments of one equation are strongly correlated with explanatory variables from the other but not with its residuals. In the literature, articles estimating a dynamic spatial panel model with endogenous explanatory variables

apply system-GMM (see Foucault, Madies, and Paty, 2008; Heid, Langer, and Larch, 2012; Hong, 2008; Madariaga and Poncet, 2007). Our GII equation (3.1) is estimated with non-linear system-GMM estimators but we still used system-GMM with linear moment conditions to control for the required assumption of serially uncorrelated idiosyncratic errors. Panel fixed effects regressions are also used in order to provide robustness estimations. For linear and non-linear system-GMM estimations, we use 10 lagged values of variables as instruments<sup>4</sup> for the first difference equation which we collapse following Roodman (2009) and Kiviet and Kripfganz (2020). Restriction and collapsing of instruments allows to avoid the weak instrument bias since it is very unlikely that lagged values far in the past are strongly correlated with present value (Roodman, 2007). The equation in level used no lag as it is usually used in the literature: we estimate the level equation instrumented by first difference equation variables. As a common rule of thumb, our number of instruments is lower than our number of groups (country) for solving the problem of overidentification. All our regressions results indicate the absence of serially correlated idiosyncratic errors (AR2)<sup>5</sup> as well as the validity of instruments (HS1/HS2)<sup>6</sup>

## 3.5 Empirical Results

In this section, we discuss the results obtained from the empirical approach provided in the previous section. Our estimation process is divided into three stages. We start by reporting the spatial effect of trade linkages on gender standards at the bilateral trade level, followed by an analysis of the effect of the export and import channels. We then leverage our sample to study how the spatial effect of trade linkages differs at the product level according to technological classification. The interpretation of results is very important regarding the data context (see subsection 3.3.2). Basically, regression coefficients signs give the direction of the correlation between the explanatory variable and the explained one. However and apart from a few minor exceptions, the global trend of the gender inequality index over the period of observation is decreasing (see Stotsky, Shibuya, Kolovich, and Kebhaj, 2016). This stylized fact suggests that our results can be interpreted only in the sense of reducing gender inequality, i.e. higher gender equality abroad spills over via trade into higher domestic gender equality. In fact, we do not observe more than a half of trading partners of a country with increasing GII.

### 3.5.1 Trade as Transmission Channel for Gender Standards

For our initial estimations, Table 3.1 summarizes the spatial effects of trade, from a country's trading partners, on the gender standards of the domestic country for the third stages: at the bilateral trade level, at the import/export level and at the technology level (see in appendix Tables 3.8-3.10 for detailed results). All estimations control for country and year fixed effects, and standard errors are clustered by country

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<sup>4</sup>We use 6 instruments for mineral fuel in our main estimations and 4 instruments for medium-high in our robustness estimations since using 10 instruments indicate invalid instruments for these sections.

<sup>5</sup>Arellano-Bond test for second order serial correlation is based on residuals

<sup>6</sup>Sargan-Hansen difference test of overidentification restriction in one-step and two-step

throughout. Column (3) represents our main and most efficient estimation, nonlinear system-GMM. For their part, columns (1)-(2) report results for panel and linear system-GMM estimations respectively. First, we find no robust results for bilateral trade since only panel regression indicate a significant positive effect. In order to further analyse the GII spillover effect, we proceed to repeat this analysis at the second stage of the estimation process, i.e. the export and import level. Table 3.1 also uses the same identification strategy to study the spatial effect of exports in the diffusion of gender standards. On the contrary to the literature, we find no evidence of the exports' spatial effect across our estimations (See Juhn, Ujhelyi, and Villegas-Sanchez, 2014 for the effect of export firms). This suggests that a country's export partners do not have much influence on domestic gender standards. On the other hand, we also examine the spatial effect of the import channel. In column (3), we see the nonlinear system-GMM results and find a positive significant spatial effect of imports. Here, such findings show that an increase in the GII of import trade partners has a positive effect on the GII of the domestic country. The results demonstrate significance across all three specifications presented. The import channel appears to be the main driver of such spillover effects. The evidence suggests that countries' gender standards are influenced primarily by other countries they import from. Appendix 3.17 presents robustness checks with the OECD product classification which is consistent with our main estimations.

In addition, we control for lagged GII, trade openness, FDI openness and population in all specifications (see in appendix 3.7 for each table). Not surprisingly, the lagged GII being strongly correlated with GII indicates that past values of GII predict present trends of GII. In addition, we find no robust effect for trade openness across all specifications. Population has been shown to have a negative effect in the literature as an increased population size reduces the actual protection of the economic rights of women (Z. Wang, 2018). However, we do not find a robust effect in our estimations. Our results report no support for the significance of population in spilling over gender equality. Similarly, we find an effect of FDI openness on GII only in panel fixed effect regressions. The existing literature also does not report evidence of FDI openness exerting any substantial influence on gender equality (Neumayer and De Soysa, 2011; Z. Wang, 2018). We interpret that as a further indicator that relationships within a trade network matter more for the diffusion of gender standards than the degree of openness and population within a country.

Table 3.1: Spatial Effect Estimation of Trade

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
<b>1st level</b>			
Spat. bilateral trade $_{t-1}$	0.022* (0.011)	0.047** (0.020)	0.028 (0.018)
<b>2nd level</b>			
Spat. export $_{t-1}$	0.006 (0.012)	0.003 (0.016)	0.010 (0.022)
Spat. import $_{t-1}$	0.023* (0.012)	0.040** (0.017)	0.034** (0.014)
<b>3rd level</b>			
Spat. high-tech. products $_{t-1}$	0.029** (0.012)	0.046** (0.022)	0.037** (0.016)
Spat. medium-tech products $_{t-1}$	0.045** (0.018)	0.065** (0.027)	0.062** (0.031)
Spat. low-tech products $_{t-1}$	0.024 (0.020)	0.043 (0.040)	0.041 (0.027)
Spat. resource-intensive product $_{t-1}$	0.042*** (0.015)	0.024 (0.027)	0.018 (0.040)
Spat. non-fuel products $_{t-1}$	0.016 (0.016)	0.028 (0.020)	0.025 (0.016)
Spat. mineral-fuel products	0.014* (0.007)	0.020** (0.010)	0.019* (0.011)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

After illustrating the importance of imports in the technology upgrading channel, we seek to identify if a level of technology drives the results. According to the literature on globalization and gender, the majority of channels by which trade liberalization can reduce gender inequalities depend on particular industries (Pieters, 2015). The CEPII database provides bilateral trade flows at the product level which are identified using the Harmonized System (HS). By controlling for the product category, we can therefore distinguish transmission channels. We use the UNCTAD skill and technology intensity classification to create spatial trade exchange variables by product technology level. This allows us to study the spatial effect of each product technology category: high-tech, medium-tech, low-tech, resource-intensive, mineral fuel and non-fuel products. The following subsections shed light on specific transmission channels which may play a role in the cross-country transmission of gender standards. Such channels are consistent with the GII's composition. The technological upgrading mechanism is based on female labor force participation which is composed in the GII's dimension of economic activity. Moreover, the technology revolution mechanism is related to the economic activity dimension but also to the reproductive health dimension through the adolescent fertility ratio. It is also related to the women empowerment dimension through educational attainment. Accordingly, the GII reflects gender equality as a social norm depending on various gender measures.

### 3.5.2 Technological Upgrading

The technological upgrading channel operating in industries aligns with our results. The notion of trade stimulating technological upgrading has been previously documented in the literature. Increased import competition can induce firms to invest in technological upgrading in order to better their competitive standing which can improve gender standards (Pieters, 2015). By comparing the content of women's work to that of men in West Germany, Black and Brainerd (2004) examine the role of task changes on the gender wage gap. They find that task changes have been more important for women than men over the period 1979-1999. Such findings are mainly explained by the decline in routine tasks experienced by women. Authors show that task changes account for 41 percent of the closing gender wage gap. This phenomenon is observed more quickly in occupations in which computers have been increasingly used. In addition, Bamber and Hamrick (2019) provide insight on how increased technology intensity of products made in a country may affect gender distribution of employment. For this purpose, they analyze Costa Rica and the Dominican Republic in the medical devices manufacturing global value chain from 2004-2011 and 2006-2016 respectively. Results show that the medical devices manufacturing global value chain offers women opportunities to work in the high-tech sector in professional and technical positions.

In this respect, Table 3.1 reports a strong and positive spatial effect of medium tech product imports in each column. In our linear system-GMM estimation, we observe that a one point increase in the imports of medium-tech products from higher GII countries will spillover into an 0.065 increase in the GII for home countries. We find a very similar coefficient of 0.062 in the non-linear system-GMM estimation as well. This robust effect is validated across all three estimations. This technology level category is composed by machinery, mechanical and electrical equipment and data processing equipment (such as computers, phones, etc.). These results are consistent with the technological upgrading effect whereby access to electrical machines and computers increases the relative productivity of women. With better equipment, jobs become less physically demanding allowing for greater female inclusion. As said in Pieters (2015), the technology upgrading channel is more suitable to developing countries that import from developed ones. However, the period of observation indicates a global increasing trend in technological innovation. Amil, Giannoplidis, and Lipp-Lingua (2007) show that the trend for high-tech is clearly increasing since the mid-1990's with a peak around the year 2000 driven by office machinery, computers, TV, radio and communication equipment and a steady growth of pharmaceuticals<sup>7</sup>.

### 3.5.3 Technology Revolution Effects

Beyond the notion of technological upgrading in industries, our results point towards a deeper effect of technology on gender equality standards. While technological upgrading certainly has an impact on the sector and industry level, our findings suggest that technology may have an impact at the household and government level as well. Hence, a technology revolution channel based on firms, households and governments

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<sup>7</sup>Statistics based on the OECD technology classification. See subsection 3.3.4 for more details about the classification

behaviors may play a role in our results.

### **Female Opportunity Cost**

At the individual level, the literature documents that women face an opportunity cost for having children. Do, Levchenko, and Raddatz (2016) show that countries with a comparative advantage in female-intensive sectors report lower fertility rate. In fact, the opportunity cost for having children is related to the notion of time since they remain the main provider of child-rearing and household tasks. Women shoulder a much larger load of the house work: they conduct 76 percent of the total amount of care work, triple that of men (Bonnet, Vanek, and M. Chen, 2019). Furthermore, 25 percent of women in the EU state their care and personal responsibilities as the reason for not partaking in the job market, contrary to only 3 percent of men (Women, 2015). In advanced economies, working women demand for more job flexibility in order to ensure their caretaker functions (Bertrand, 2018). On the contrary, in laggards economies, the absence of contraceptive methods may force women and girls to stay home to take care of their children (Gaye, Klugman, Kovacevic, Twigg, Zambrano, et al., 2010). Accordingly, a technology revolution effect in advanced or laggard economies may explain a change in the opportunity cost for having children. On the one hand, availing contraceptive methods can allow young women to study and improve their job opportunities (Goldin and L. F. Katz, 2000). As a result, with increased access to high-tech products, improvements can be made in the reproductive health of women and indirectly in female educational attainment. On the other hand, the rise of household appliances<sup>8</sup> enable a great amount of time savings to be made by improving the efficiency of household tasks. The result is more time for household workers, traditionally women, to partake in other activities.

Our results align with these mechanisms since we find positive spatial effects of medium tech and high tech product imports for panel, linear and non-linear system-GMM regressions. The medium tech products category includes household equipment and the high tech products category includes medical/surgical instruments, medicament and contraceptive methods. Results for the medium tech products category are presented in subsection 3.5.2. Concerning high tech products, our linear system-GMM estimation shows that a one point increase in high tech product imports from countries with higher GIIs increase the GII by 0.046, a similar coefficient of 0.037 is found in the non-linear system-GMM estimation. Panel fixed effect regressions also reports a positive and significant effect of the spatial lag variable of high-tech product imports.

### **Governmental Actions**

At the country level, the literature documents that arms and ammunition may play a role on gender inequality. In fact, the defense expenditure of a country is divided into two components: arms/ammunition and military technology. Considered as high-technology, the latter often requires important investments in

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<sup>8</sup>Greenwood, Seshadri, and Yorukoglu, 2005 documents a consumer goods revolution we have witnessed over the past century which was enabled by massive investments in specific technological progress in the production of household capital. Household appliances are plentiful, for instance central heating, dryers, electric irons, frozen foods, refrigerators, sewing machines, washing machines and vacuum cleaners among others. Authors show that this household technological revolution has led to a decrease in the number of homemakers and an increase in the female labor-force participation rate over time.

R&D departments. Products such as electronic systems, night-vision devices, holographic sights and laser rangefinders are included in high and medium tech products, i.e. optical and photographic equipment, electrical machinery and data processing equipment. Hence, the import of arms and ammunition is correlated with that of military technology from high and medium tech products. In their article, Moretti, Steinwender, and Van Reenen (2019) examine the impact of public defense R&D spending on private R&D spending and productivity. They find that public defense spending leads to an increase in a country's total expenditures on innovation in a given country. Considering imports as being part of expenditure, the spillover effect can apply here. The indirect channel of arms and ammunition imports is also explained as the technology upgrading channel: the private technological change resulting from public defense spending steadily increases the relative productivity of women; i.e. high investments in R&D allows for more suitable technology upgrading throughout the entire economy over the long-term (Falk, 2007). As seen in Table 3.1, our system-GMM estimations show that imports of mineral products from countries with higher GIIs increase the domestic GII by 0.019 and 0.020 when increasing by one unit for non-linear and linear system-GMM estimations respectively. Similarly, we find a positive and significant effect for high-tech product imports in the panel-fixed effect estimation. Overall, by allocating resources to high-technology sectors, countries can improve their productivity levels and competitiveness. This helps reduce gender inequalities and improve the GII score across the different dimensions as well.

### 3.5.4 No Effect

One perhaps surprising result is the insignificant spatial effect of exports on the GII. The literature documents that export stimulates female employments through technology and competition (Juhn, Ujhelyi, and Villegas-Sanchez, 2014). However, employment in the export sector may be detrimental to gender equality if poor working conditions and low wages are part of a larger strategy to minimize costs. This is especially pertinent for workers in the informal sector who have no control over working conditions under their subcontracting agreements (Carr and M. Chen, 2004). Moreover, exporting generally increases the stability of skilled jobs but not of precarious unskilled ones (Bas, Bombarda, Jean, and Orefice, 2019). Despite such unfavorable conditions, women are often forced to accept their only possible paid employment due to family duties or social norms (Balakrishnan, 2002). Moreover, accelerating female employment through exports is not common in agricultural economies as women are crowded out of commercial crops (Wold, 1997). Women's care responsibilities also play a role in seizing new opportunities in the export sector. Exporting sectors show that female labor participation in trade related opportunities was dependent upon having another female household member to share the responsibilities with (E. G. Katz, 1995). Indeed informal work arrangements have increased in the race for more flexibility, disproportionately affecting women. Increased flexibility can also mean greater turnover and job insecurity for women (Barrientos, Kabeer, and Hossain, 2004).

Lastly, we find no significant robust effect for low-tech, resource-intensive and non-fuel product imports. Low-tech products include base metals and transport related equipment which is very male-intensive (Pieters,



2015). Similarly, the resource-intensive products are primarily manufacturing related products which are industries dominated by men, save for textiles. Meanwhile, non-fuel products are mainly agricultural related products which are also male-intensive industries and much less likely to benefit women (Wold, 1997). All detailed tables for results are presented in appendix (see in appendix Tables 3.11-3.16)

### 3.6 Concluding Remarks

An important political debate is in progress regarding the impact of globalization on gender inequality across the world. While the existing literature provides evidence that trade liberalization affects gender outcomes, this paper shows that trade actors may also play a role in reducing gender inequality.

Using panel data from 1997-2013 across 123 countries, we adopt a spatial model to identify gender norm spillovers between trading partners. Trade relationships are disaggregated by technology-level products since technological upgrading within firms is known to affect gender inequality (Juhn, Ujhelyi, and Villegas-Sanchez, 2014). Our results indicate that a spillover phenomenon of gender equality is observed from the imports of high tech, medium tech and mineral products from more gender-equal partners. Such findings are consistent with a technological upgrading phenomenon since imported office/industry and agricultural machines increase the relative productivity of women. However, results suggest that a larger phenomenon is at hand. A technological revolution occurs within households and governments. First, the importation of advanced technologies changes the female opportunity cost for having children. The access to contraceptive methods allows a fertility control in laggard economies while the increasing use of household appliances enables women to reallocate their time outside the home in advanced economies (Goldin and L. F. Katz, 2000; Greenwood, Seshadri, and Yorukoglu, 2005). Women are therefore encouraged to study or work. Second, government spending in military technology requires high investments in public R&D which spill over onto private R&D (Moretti, Steinwender, and Van Reenen, 2019).

Our results are intuitive and consistent with the observed declining trend of gender inequality around the world (Stotsky, Shibuya, Kolovich, and Kebhaj, 2016). This paper shows that the characteristics of trading partners matter for reducing gender inequality within a country. Even though our measure of gender inequality covers all possibilities of observed gender disparities, there is still a need for further research to isolate each component of gender disparity outcomes in order to identify more specific transmission channels at hand.

## 3.7 Appendix

### 3.7.1 Migration

In a spatial analysis setting, it is necessary to acknowledge the link between migration and trade. Networks of migrants can help overcome transaction costs in international trade. The social solidarity, trust and social capital built among co-ethnics can play an important role in trade networks (Granovetter, 2005). There is consistent empirical evidence for immigration having a positive effect on trade. Studies using the gravity-based model for the effect of migration on trade have found a greater effect of immigration on imports than on exports, when results for both exports and imports were reported (Egger et al., 2012). However, this link also appears to be stronger for trade in commodities with informational problems (Egger et al., 2012). Given that our results reflect a technological channel at play, we do not perceive an upward bias due to migration. Moreover, we leave this direction of the literature to be pursued in a future study.

Table 3.2: Countries Included in the Sample

Countries
Albania, Algeria, Argentina, Armenia, Australia, Austria, Bangladesh, Barbados, Belgium/Luxembourg, Belize, Benin, Bolivia, Botswana, Brazil, Bulgaria, Cambodia, Cameroon, Canada, Chile, China, Colombia, Congo, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, El Salvador, Estonia, Eswatini, Fiji, Finland, France, Gabon, Gambia, Germany, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Ivory Cost, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Kyrgyztan, Lao, Latvia, Lesotho, Lithuania, Malawi, Malaysia, Maldives, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Mongolia, Morocco, Mozambique, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Russian Federation, Rwanda, Senegal, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe
Notes: Sample of 123 countries from 1997 to 2013 for 2091 observations

Table 3.3: UNCTAD Technology Classification

Technology Intensity	HS Sections with products
<b>High-tech</b>	
HS Section 6	Products of the chemical or allied industries
HS Section 7	Plastics and articles thereof; Rubber and articles thereof
HS Section 18	Optical, photographic, cinematographic, measuring, checking, precision, medical or surgical instruments and apparatus; Clocks and watches; Musical instruments; Parts and accessories thereof
<b>Medium-tech</b>	
HS Section 16	Machinery and mechanical appliances; Electrical equipment; Parts thereof; Sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles
<b>Low-tech</b>	
HS Section 15	Base metals and articles of base metal
HS Section 17	Vehicles, aircraft, vessels and associated transport equipment

Table 4 (continued)

Technology Intensity	HS Sections with products
<b>Resource-intensive</b>	
HS Section 8	Raw hides and skins, leather, fur skins and articles thereof; Saddlery and harness; Travel goods, handbags and similar containers; Articles of animal gut (other than silk-worm gut)
HS Section 9	Wood and articles of wood; Wood charcoal; Cork and articles of cork; Manufactures of straw, of esparto or of other plaiting material; basket ware and wickerwork
HS Section 10	Pulp of wood or of other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard; Paper and paperboard and articles thereof
HS Section 11	Textiles and textile articles
HS Section 12	Footwear, headgear, umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, ridingcrops and parts thereof; Prepared feather and articles made therewith; Artificial flowers; Articles of human hair
HS Section 13	Articles of stone, plaster, cement, asbestos, mica or similar materials; Ceramic products; Glass and glassware
HS Section 14	Natural or cultured pearls, precious or semi-precious stones, precious metals, metals clad with precious metal and articles thereof; imitation jewelry; Coin
HS Section 20	Miscellaneous manufactured articles
<b>Non-fuel commodity</b>	
HS Section 1	Live animals; Animal products
HS Section 2	Vegetable products
HS Section 3	Animal or vegetable fats and oils and their cleavage products; Prepared edible fats; Animal or vegetable waxes
HS Section 4	Prepared foodstuffs; Beverages, spirits and vinegar; Tobacco and manufactured tobacco substitutes
HS Section 5	Mineral products
<b>Minerals</b>	
HS Section 19	Arms and ammunition; Parts and accessories thereof
HS Section 21	Works of art, collectors' pieces and antiques

Table 3.4: Summary Statistics of the Variables

	count	mean	sd	min	max
GII	2091	0.41	.1972482	.01	.83
population	2091	46.37	157.32	.096574	1357.38
Trade openness	2091	0.62	.3748148	0	2.853184
FDI openness	2091	0.06	.2022108	-.1602823	4.736793
<b>Trade Spatial Lag Variables</b>					
Bilateral	1968	0.29	.0997312	0	.6378459
Imports	1968	0.31	.0991237	0	.652642
Exports	1968	0.27	.1072709	0	.6370055
<b>UNCTAD Spatial Lag Variables</b>					
High tech	1968	0.27	.0963548	0	.6075583
Medium tech	1968	0.23	.07929	0	.6328286
Low tech	1968	0.27	.0976802	0	.6050551
Resource-intensive	1968	0.27	.0968863	0	.6704116
Non-fuel	1968	0.32	.1053287	0	.680954
Mineral-fuel	1968	0.25	.1085399	0	.6465686
<b>OECD Spatial Lag Variables</b>					
High-tech	1968	0.22	.0743313	0	.6411046
Medium-high tech	1968	0.25	.088067	0	.6061561
Medium-low tech	1968	0.28	.1007974	0	.5697177
Low tech	1968	0.29	.1013325	0	.6865805
Other	1968	0.32	.1074241	0	.6518381

Notes: Spatial variables are lagged by one year and lie between 0 and 1 because of the raw standardization.

Table 3.5: Spatial Autocorrelation of Bilateral Trade, Imports and Exports

Year	Bilateral Trade	Imports	Exports
1997	0.148***	0.100**	0.205***
1998	0.201***	0.166***	0.252***
1999	0.273***	0.216***	0.315***
2000	0.244***	0.224***	0.277***
2001	0.231***	0.226***	0.267***
2002	0.236***	0.215***	0.300***
2003	0.257***	0.233***	0.317***
2004	0.260***	0.257***	0.306***
2005	0.260***	0.240***	0.318***
2006	0.267***	0.240***	0.333***
2007	0.129***	0.116***	0.138***
2008	0.246***	0.221***	0.299***
2009	0.266***	0.232***	0.319***
2010	0.253***	0.210***	0.324***
2011	0.251***	0.215***	0.320***
2012	0.289***	0.256***	0.344***
2013	0.289***	0.252***	0.320***
Observations	123	123	123

Notes: \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Figure 3.2: Moran's Diagram of Bilateral Trade in 1997/1998

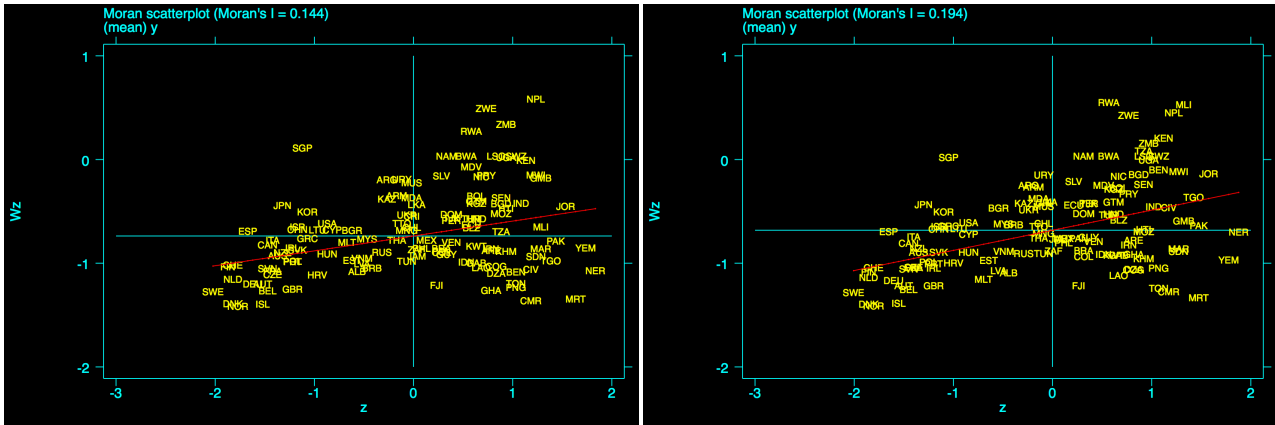


Figure 3.3: Moran's Diagram of Bilateral Trade in 1999/2000

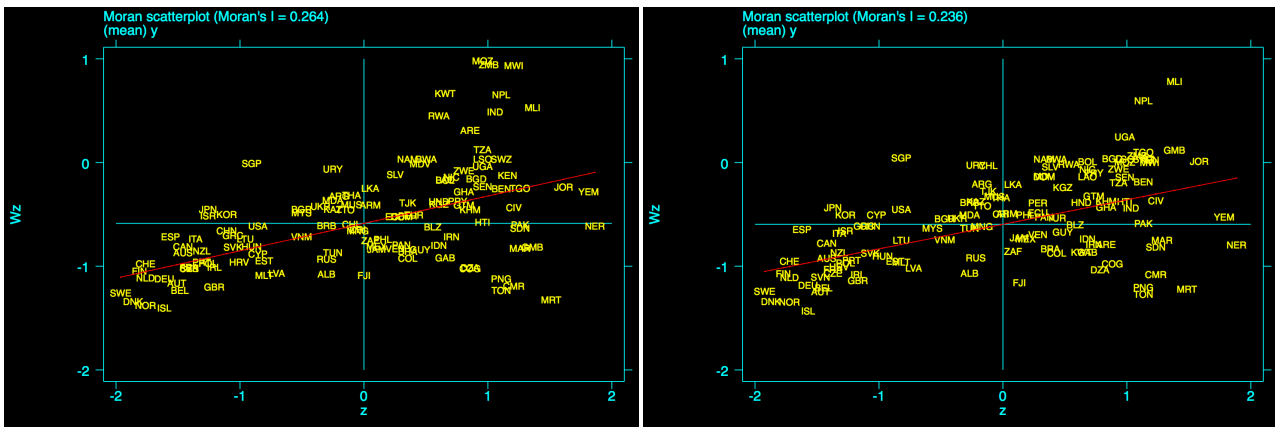


Figure 3.4: Moran's Diagram of Bilateral Trade in 2001/2002

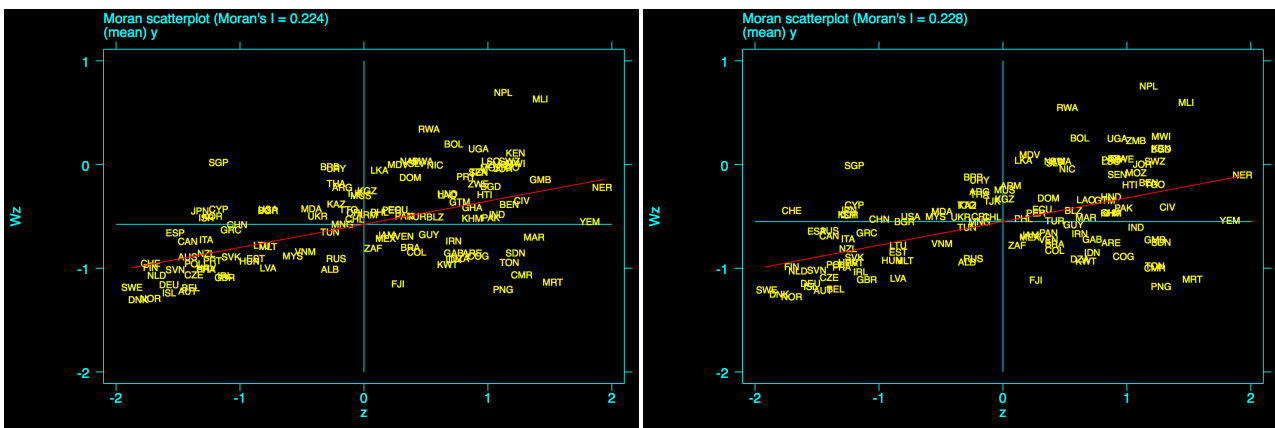


Figure 3.5: Moran's Diagram of Bilateral Trade in 2003/2004

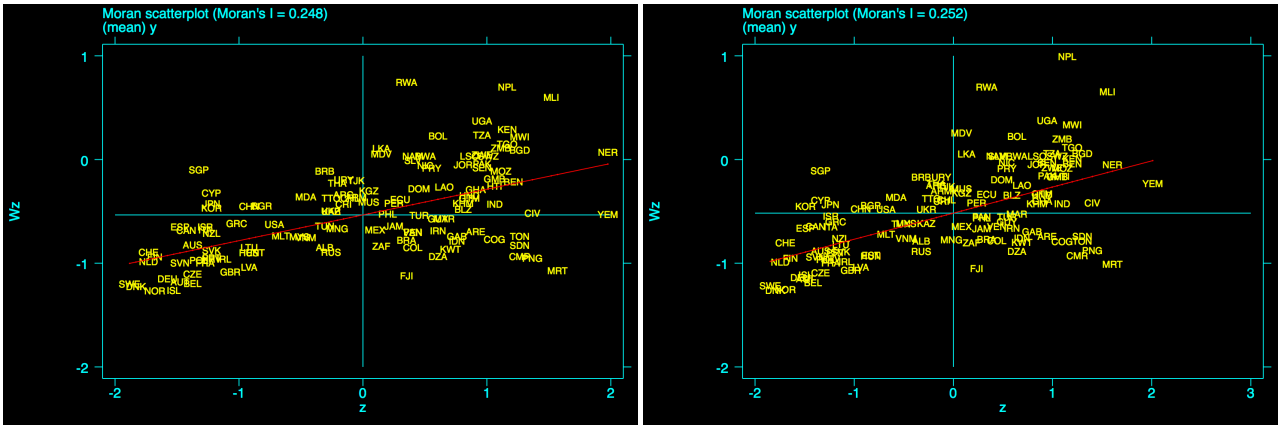


Figure 3.6: Moran's Diagram of Bilateral Trade in 2005/2006

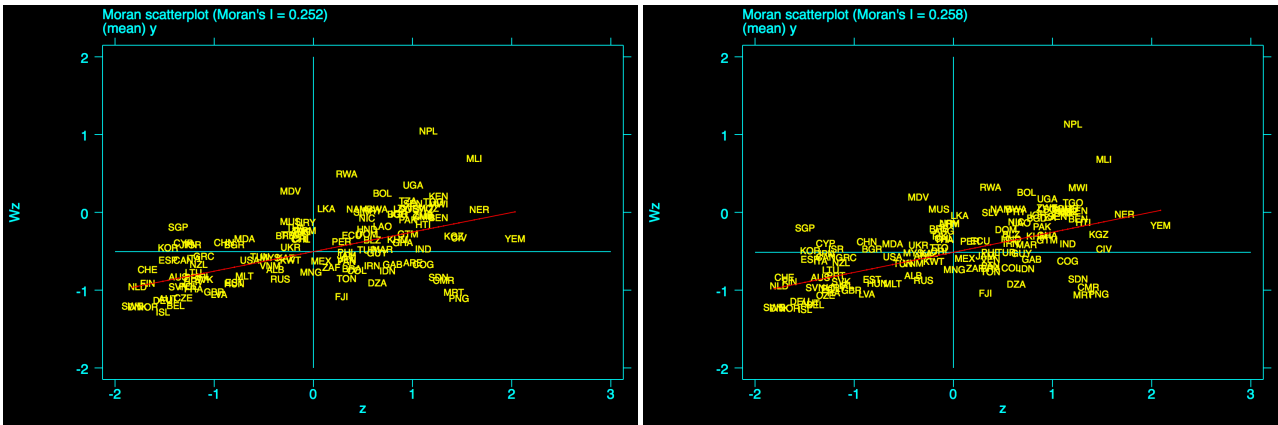


Figure 3.7: Moran's Diagram of Bilateral Trade in 2007/2008

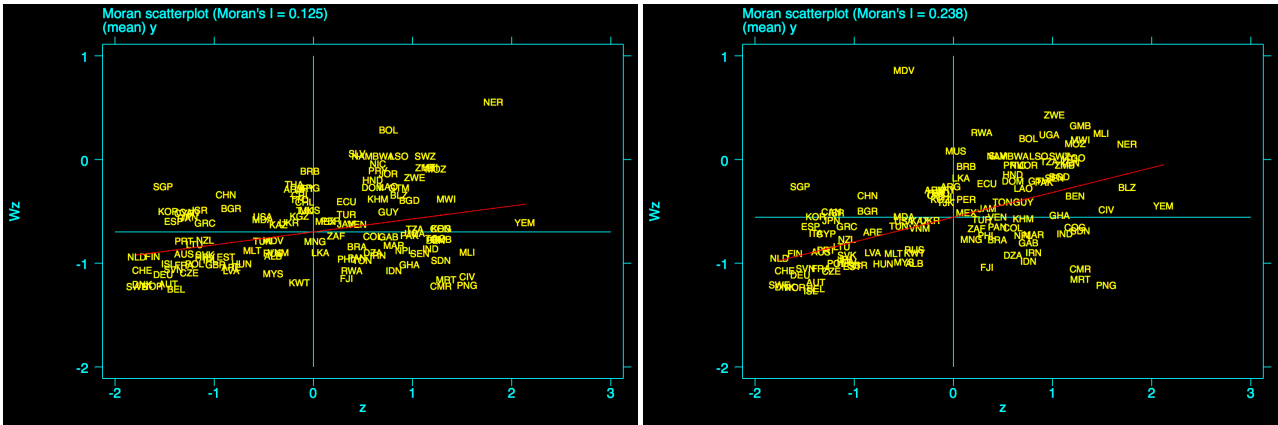


Figure 3.8: Moran's Diagram of Bilateral Trade in 2009/2010

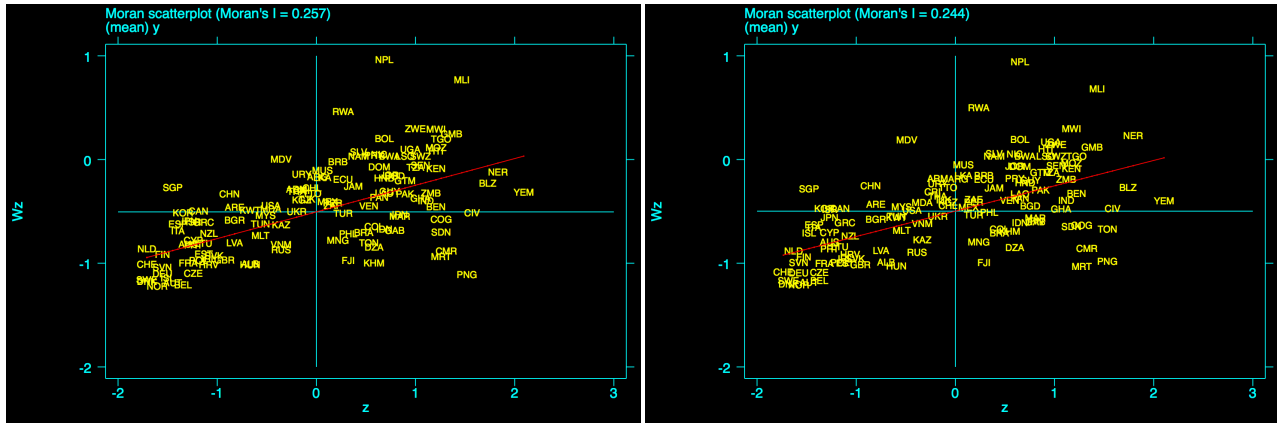


Figure 3.9: Moran's Diagram of Bilateral Trade in 2011/2012

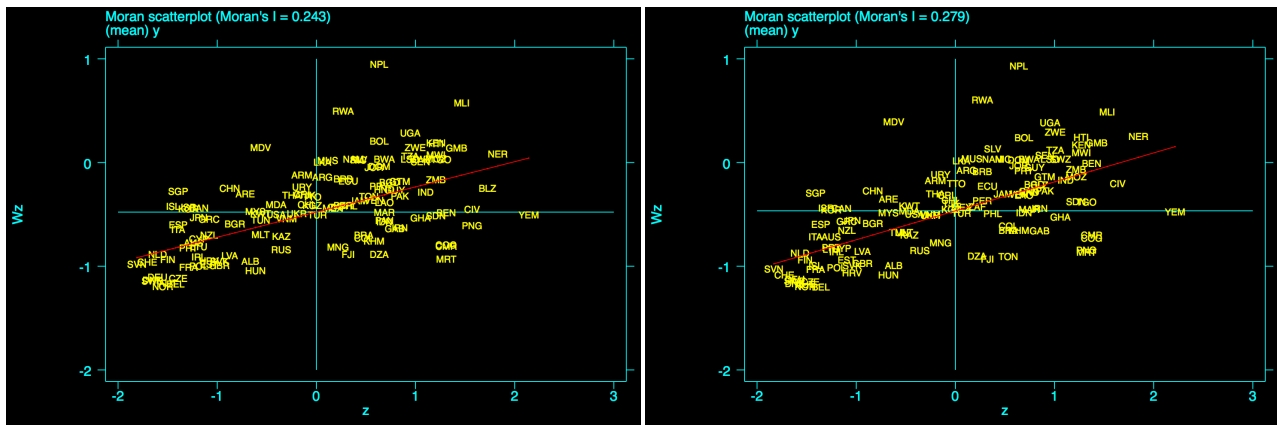


Figure 3.10: Moran's Diagram of Bilateral Trade in 2013

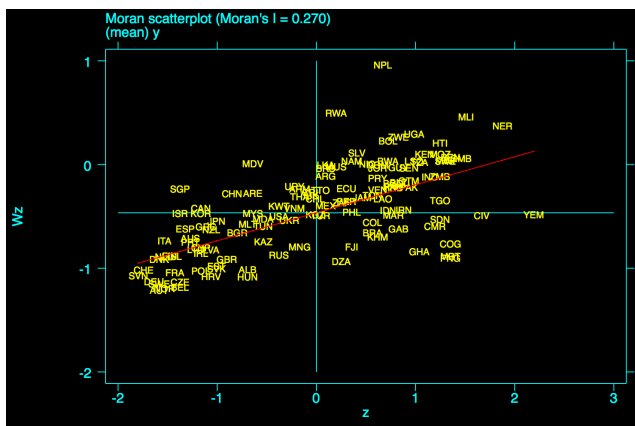




Figure 3.11: Moran's Diagram of Import Trade in 1997/1998

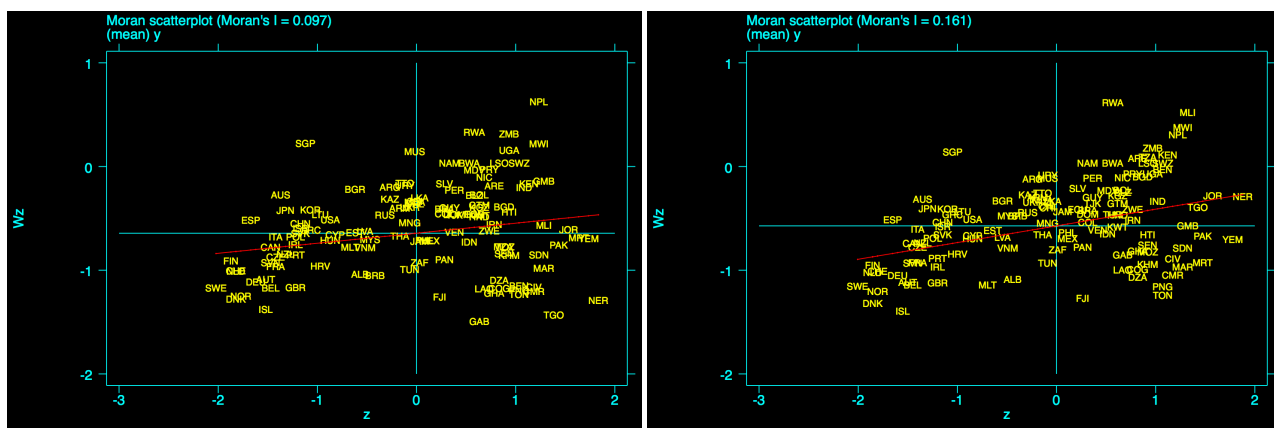


Figure 3.12: Moran's Diagram of Import Trade in 1999/2000

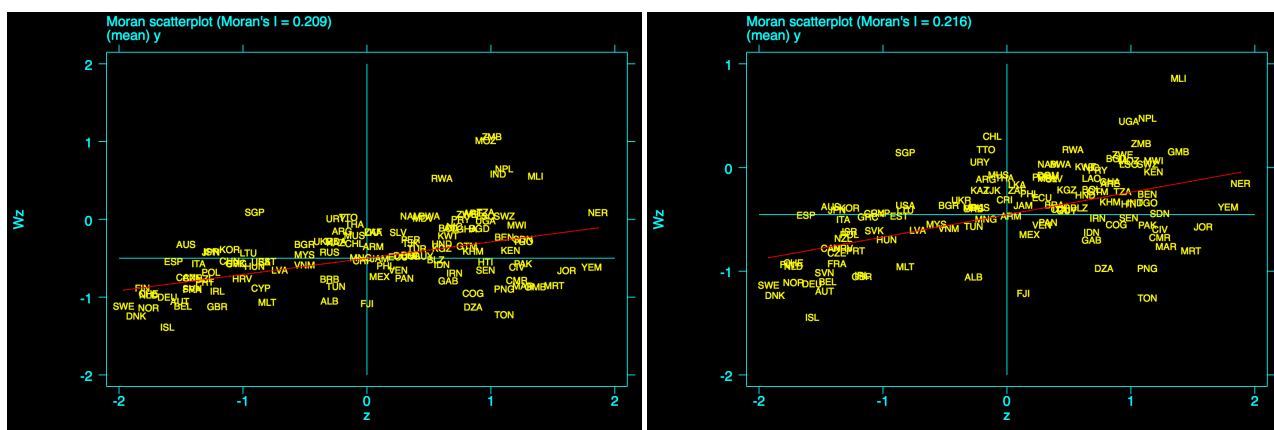


Figure 3.13: Moran's Diagram of Import Trade in 2001/2002

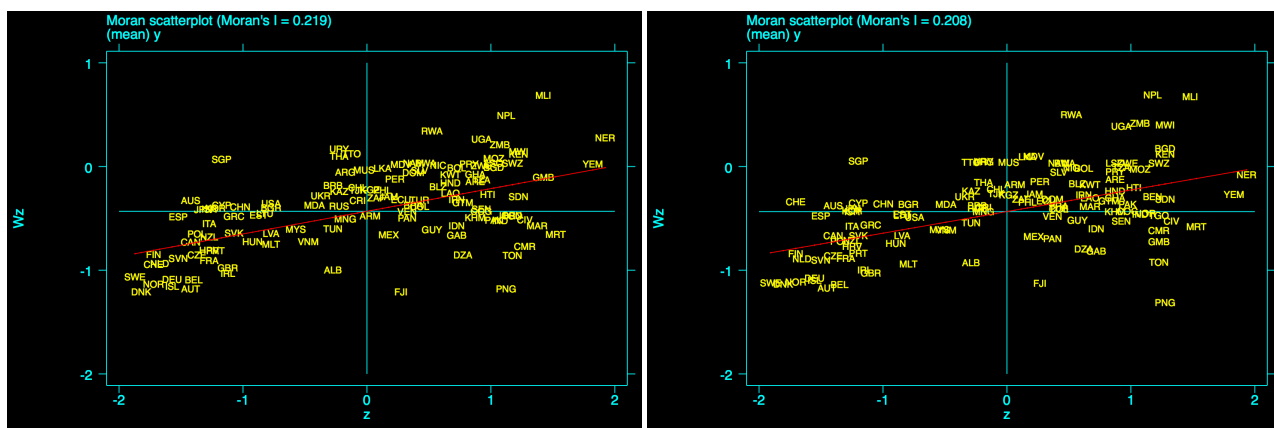


Figure 3.14: Moran's Diagram of Import Trade in 2003/2004

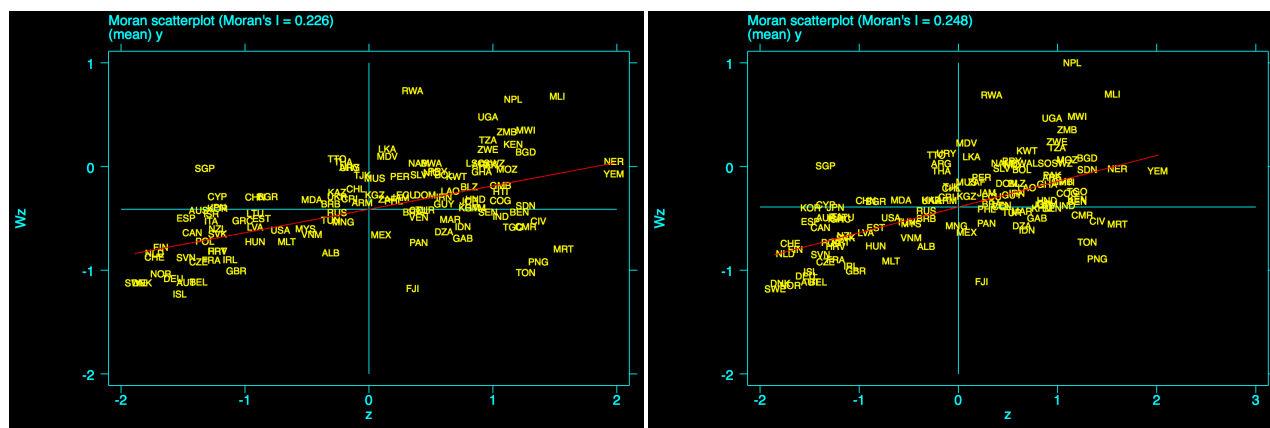


Figure 3.15: Moran's Diagram of Import Trade in 2005/2006

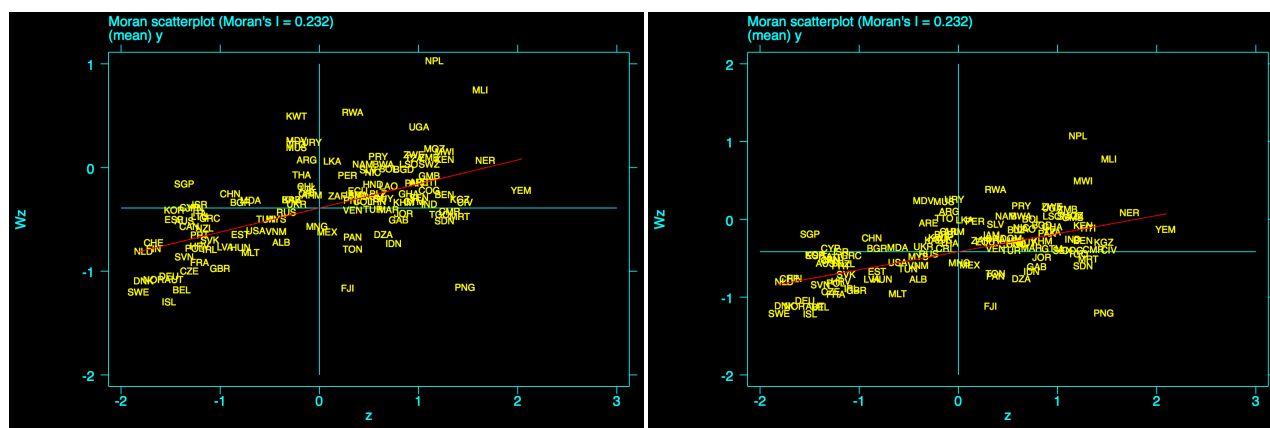


Figure 3.16: Moran's Diagram of Import Trade in 2007/2008

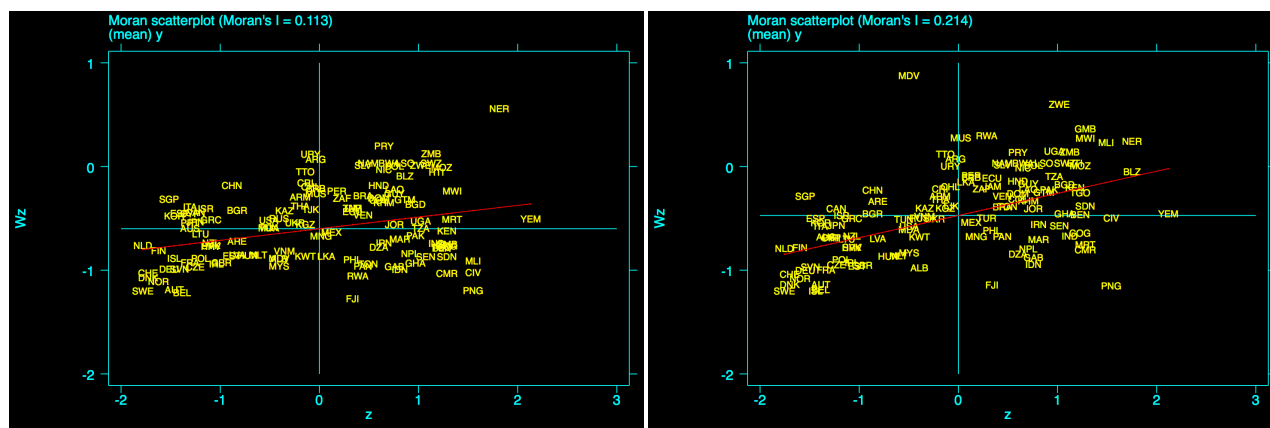


Figure 3.17: Moran's Diagram of Import Trade in 2009/2010

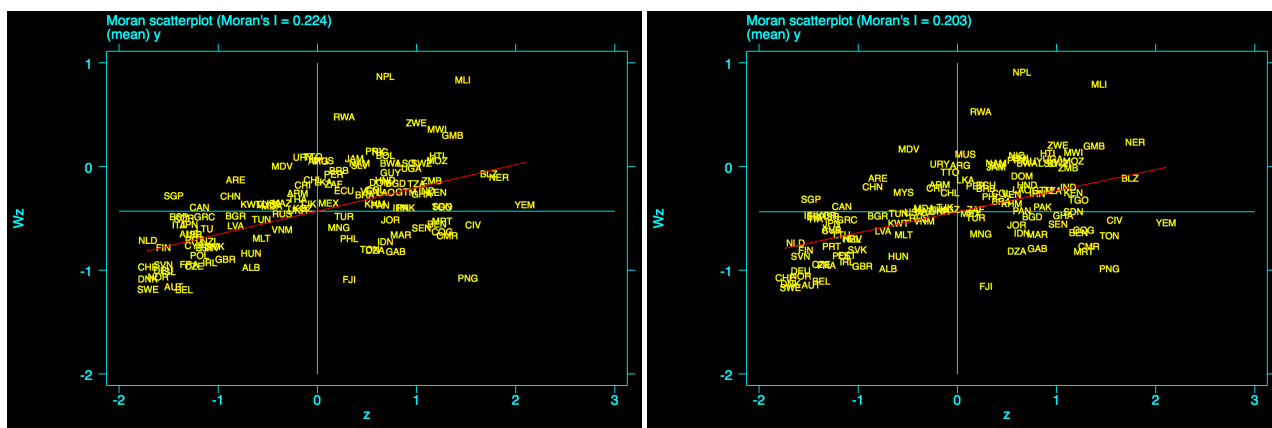


Figure 3.18: Moran's Diagram of Import Trade in 2011/2012

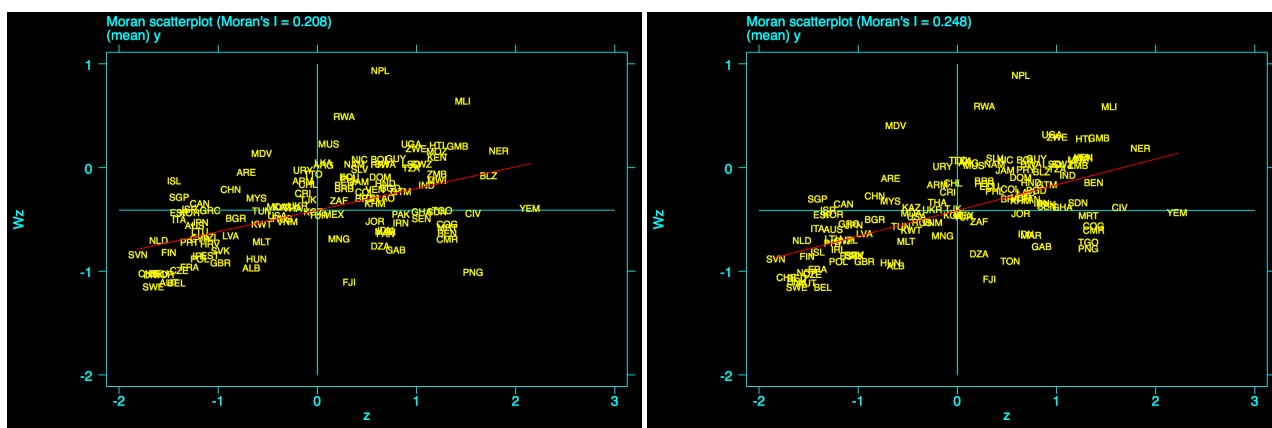


Figure 3.19: Moran's Diagram of Import Trade in 2013

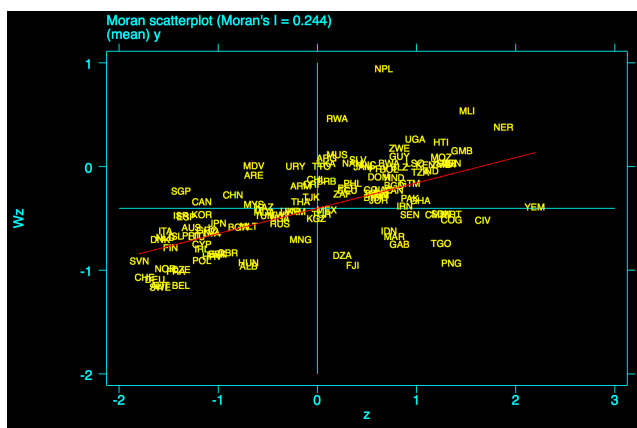


Figure 3.20: Moran's Diagram of Export Trade in 1997/1998

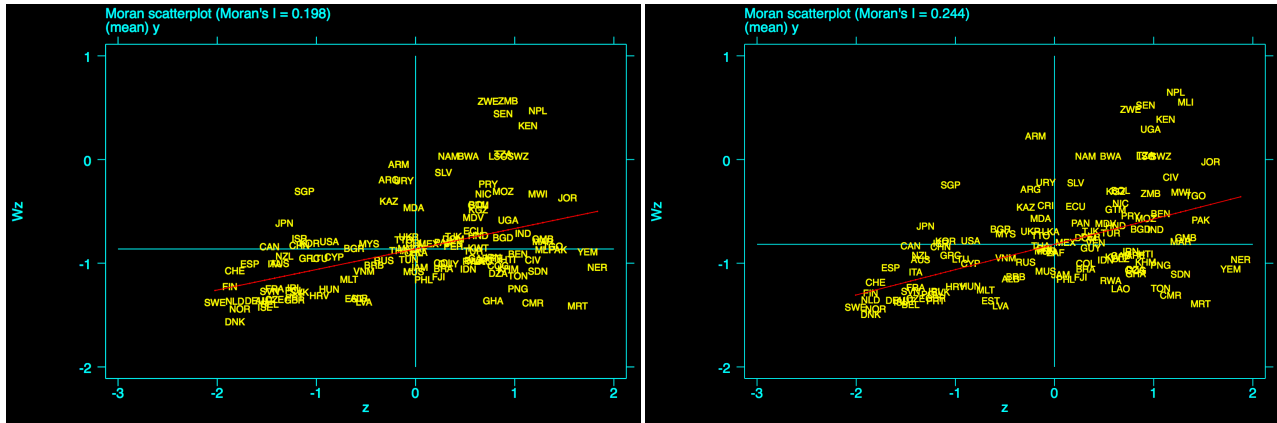


Figure 3.21: Moran's Diagram of Export Trade in 1999/2000

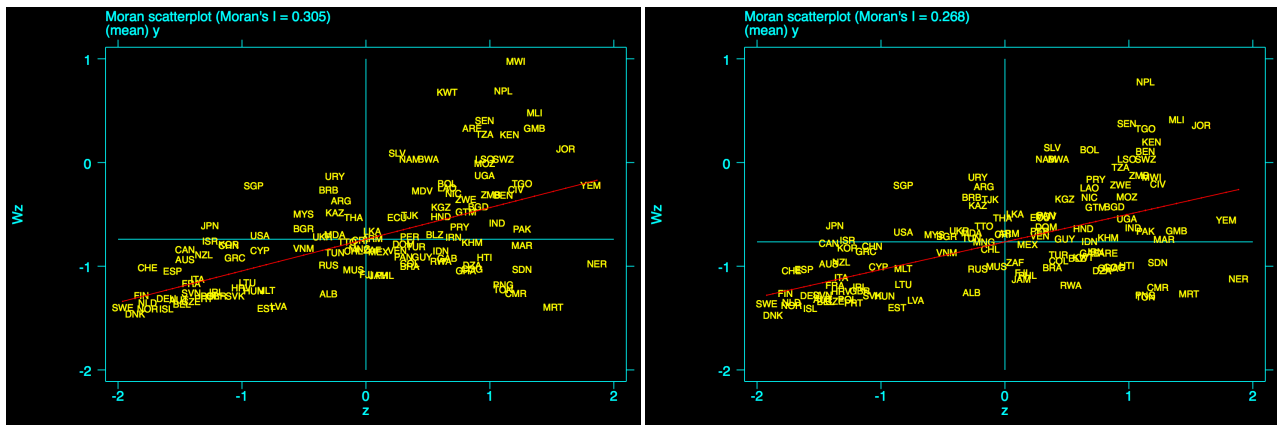


Figure 3.22: Moran's Diagram of Export Trade in 2001/2002

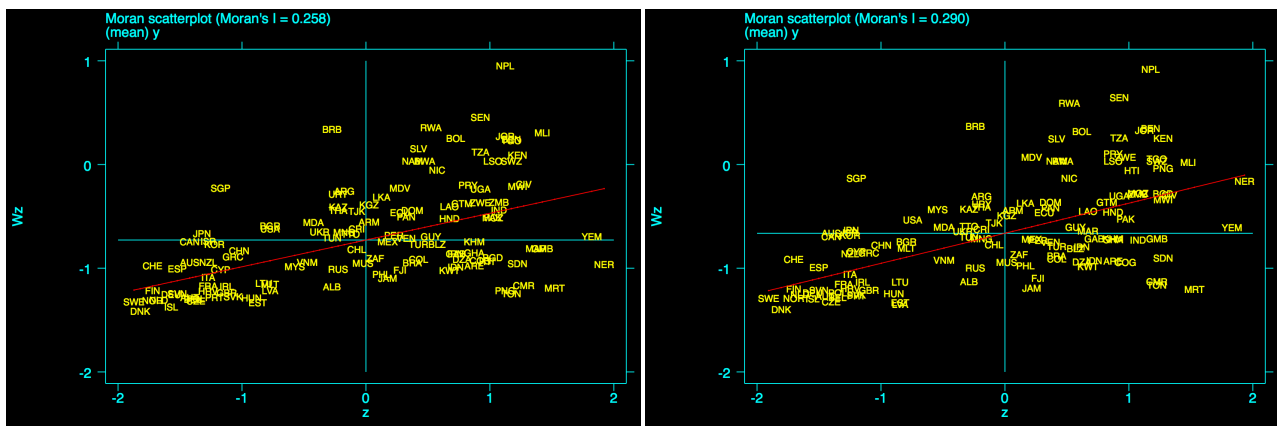


Figure 3.23: Moran's Diagram of Export Trade in 2003/2004

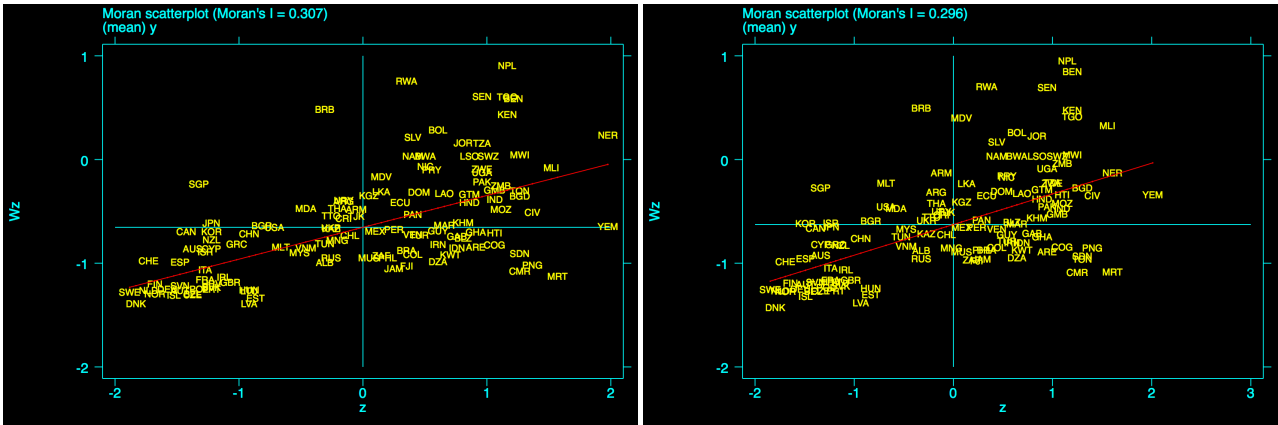


Figure 3.24: Moran's Diagram of Export Trade in 2005/2006

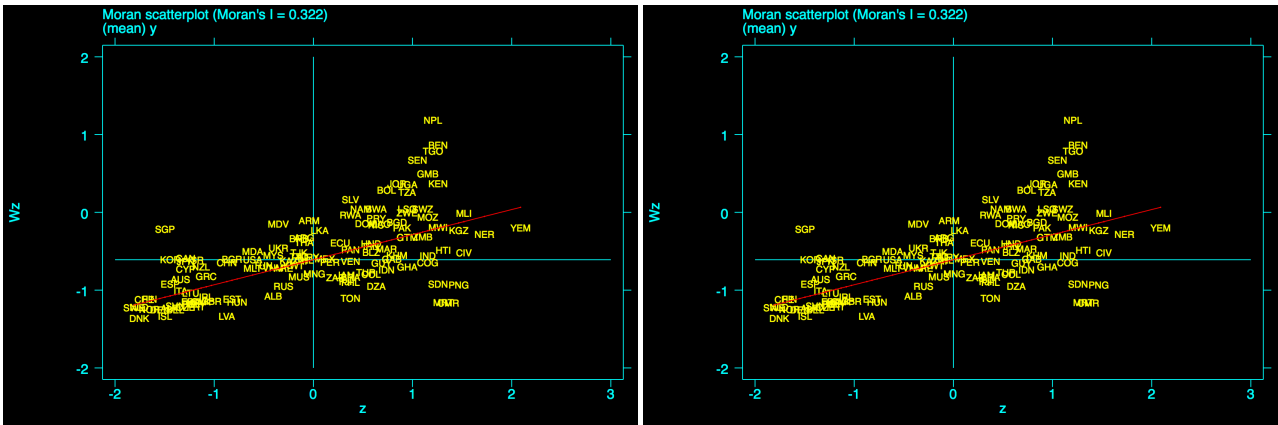


Figure 3.25: Moran's Diagram of Export Trade in 2007/2008

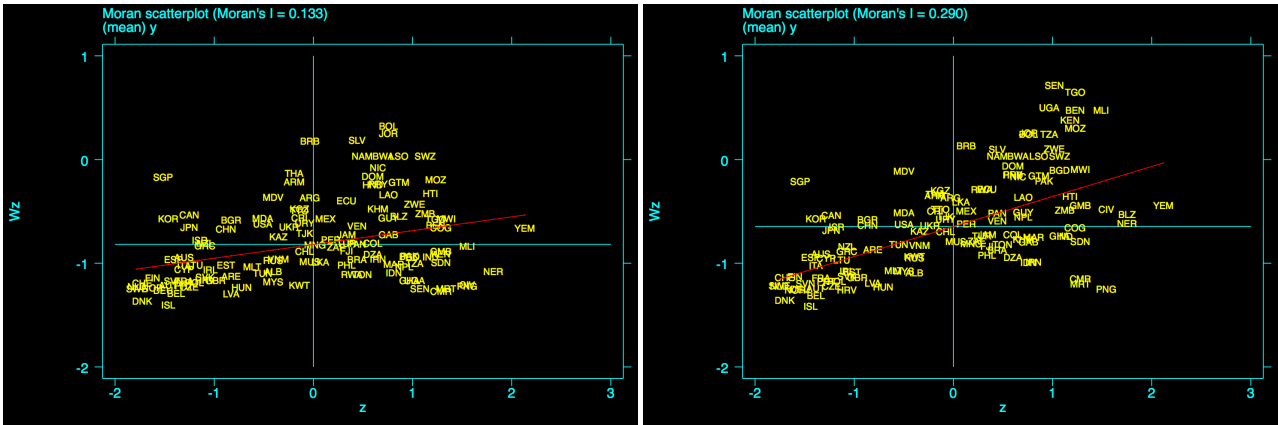


Figure 3.26: Moran's Diagram of Export Trade in 2009/2010

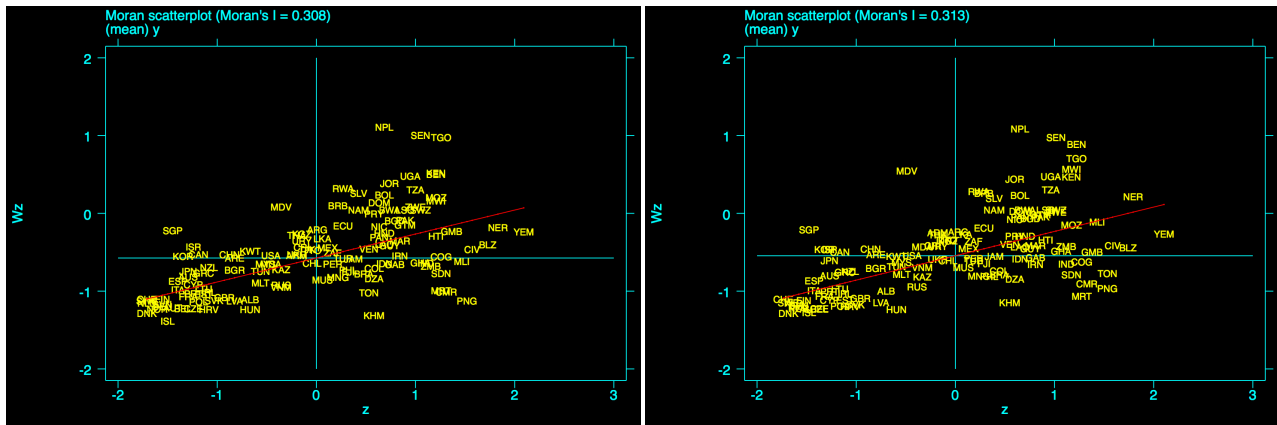


Figure 3.27: Moran's Diagram of Export Trade in 2011/2012

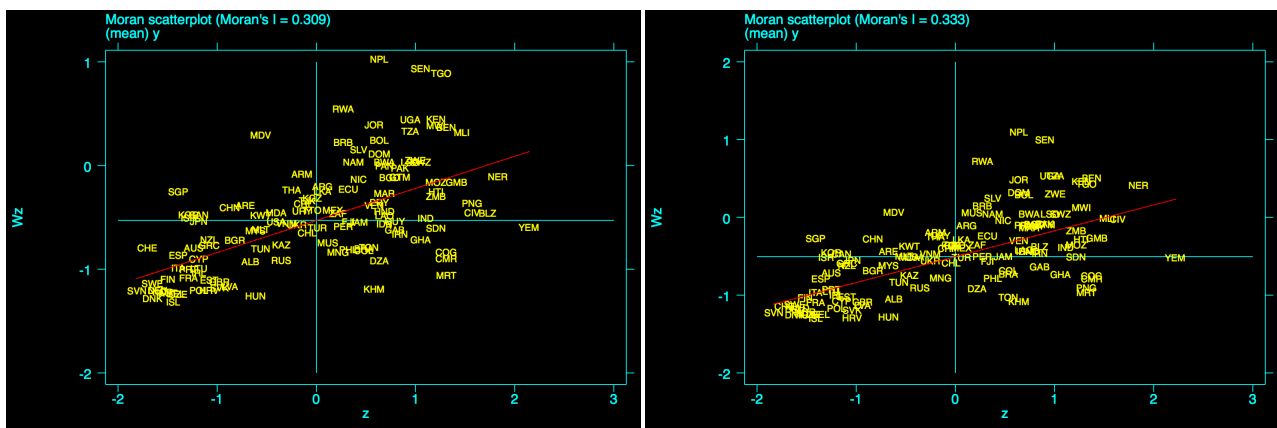


Figure 3.28: Moran's Diagram of Export Trade in 2013

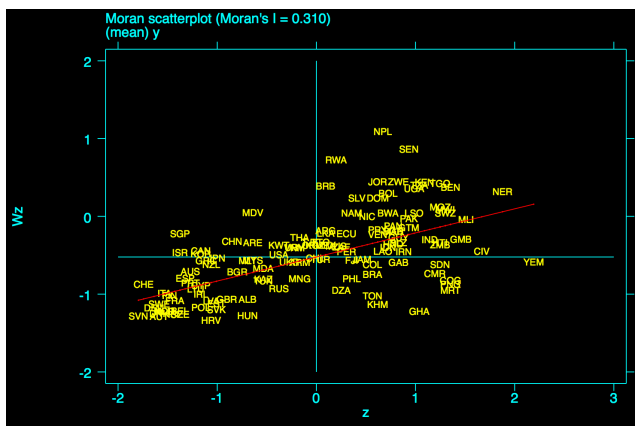


Table 3.6: UNCTAD Trade Variables Correlation Matrix

Variables	1	2	3	4	5	6	7	8	9
1:Bilateral	1.000								
2:Imports	0.935 (0.000)	1.000							
3:Exports	0.901 (0.000)	0.762 (0.000)	1.000						
4:High tech	0.856 (0.000)	0.868 (0.000)	0.765 (0.000)	1.000					
5:Medium tech	0.824 (0.000)	0.829 (0.000)	0.744 (0.000)	0.854 (0.000)	1.000				
6:Low tech	0.836 (0.000)	0.871 (0.000)	0.733 (0.000)	0.851 (0.000)	0.861 (0.000)	1.000			
7:Res.-Intense	0.862 (0.000)	0.877 (0.000)	0.772 (0.000)	0.896 (0.000)	0.884 (0.000)	0.863 (0.000)	1.000		
8:Non-fuel	0.906 (0.000)	0.982 (0.000)	0.732 (0.000)	0.804 (0.000)	0.774 (0.000)	0.806 (0.000)	0.822 (0.000)	1.000	
9:Min.-fuel	0.540 (0.000)	0.553 (0.000)	0.489 (0.000)	0.512 (0.000)	0.547 (0.000)	0.532 (0.000)	0.549 (0.000)	0.541 (0.000)	1.000
Observations	2091	2091	2091	2091	2091	2091	2091	2091	2091

Notes: The correlation matrix is computed before creating spatial variables with trade variables. Thus, trade variable included in the matrix are not lagged by one year.

Table 3.7: OECD Trade Variables Correlation Matrix

Variables	1	2	3	4	5	6	7	8
1:Bilateral	1.000							
2:Imports	0.935 (0.000)	1.000						
3:Exports	0.901 (0.000)	0.762 (0.000)	1.000					
4:High tech	0.748 (0.000)	0.741 (0.000)	0.692 (0.000)	1.000				
5:Medium-high tech	0.850 (0.000)	0.873 (0.000)	0.746 (0.000)	0.778 (0.000)	1.000			
6:Medium-low tech	0.866 (0.000)	0.893 (0.000)	0.769 (0.000)	0.785 (0.000)	0.895 (0.000)	1.000		
7:Low tech	0.854 (0.000)	0.880 (0.000)	0.762 (0.000)	0.786 (0.000)	0.863 (0.000)	0.890 (0.000)	1.000	
8:Other	0.888 (0.000)	0.967 (0.000)	0.711 (0.000)	0.665 (0.000)	0.769 (0.000)	0.806 (0.000)	0.784 (0.000)	1.000
Observations	2091	2091	2091	2091	2091	2091	2091	2091

Notes: The correlation matrix is computed before creating spatial variables with trade variables. Thus, trade variable included in the matrix are not lagged by one year.

Table 3.8: Spatial Effect Estimation of UNCTAD Bilateral Trade

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.795*** (0.043)	1.013*** (0.022)	1.013*** (0.020)
Spat. bilateral trade $_{t-1}$	0.022* (0.011)	0.047** (0.020)	0.028 (0.018)
Bilateral/GDP	-0.005 (0.005)	-0.004 (0.024)	0.013 (0.008)
FDI/GDP	0.002** (0.001)	0.073 (0.051)	0.030 (0.031)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.2472	/
H-S1	/	0.7669	0.7531
H-S2	/	0.7734	0.2940
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.9: Spatial Effect Estimation of UNCTAD Exports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.795*** (0.043)	1.006*** (0.019)	1.000*** (0.019)
Spat. export $_{t-1}$	0.006 (0.012)	0.003 (0.016)	0.010 (0.022)
Bilateral/GDP	-0.005 (0.005)	0.019 (0.017)	0.013 (0.017)
FDI/GDP	0.002** (0.001)	0.007 (0.030)	0.016 (0.028)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.3339	/
H-S1	/	0.6522	0.8900
H-S2	/	0.5672	0.4222
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.



Table 3.10: Spatial Effect Estimation of UNCTAD Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
GII <sub>t-1</sub>	0.793*** (0.042)	0.997*** (0.018)	1.026*** (0.026)
Spat. import <sub>t-1</sub>	0.023* (0.012)	0.040** (0.017)	0.034** (0.014)
Bilateral trade/GDP	-0.006 (0.005)	-0.016 (0.012)	0.015 (0.012)
FDI/GDP	0.002*** (0.001)	0.063 (0.040)	0.042 (0.026)
Lnpopulation	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.2773	/
H-S1	/	0.7854	0.7948
H-S2	/	0.3222	0.1386
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.11: Spatial Effect Estimations of UNCTAD High-Tech Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
GII <sub>t-1</sub>	0.794*** (0.043)	1.039*** (0.084)	0.997*** (0.047)
Spat. high-tech. products <sub>t-1</sub>	0.029** (0.012)	0.046** (0.022)	0.037** (0.016)
Bilateral trade/GDP	-0.006 (0.005)	0.009 (0.024)	0.012 (0.027)
FDI/GDP	0.002** (0.001)	0.032 (0.048)	0.008 (0.041)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.3197	/
H-S1	/	0.5805	0.8593
H-S2	/	0.4070	0.2233
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels

Table 3.12: Spatial Effect Estimation of UNCTAD Medium-Tech Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.793*** (0.043)	0.984*** (0.036)	0.979*** (0.030)
Spat. medium-tech products $_{t-1}$	0.045** (0.018)	0.065** (0.027)	0.062** (0.031)
Bilateral trade/GDP	-0.006 (0.005)	-0.026 (0.022)	-0.009 (0.010)
FDI/GDP	0.002** (0.001)	0.043 (0.036)	0.015 (0.021)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.3175	/
H-S1	/	0.4750	0.5810
H-S2	/	0.4922	0.4462
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.13: Spatial Effect Estimation of UNCTAD Low-Tech Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.793*** (0.043)	0.978*** (0.100)	0.951*** (0.077)
Spat. low-tech products $_{t-1}$	0.024 (0.020)	0.043 (0.040)	0.041 (0.027)
Bilateral trade/GDP	-0.006 (0.005)	0.017 (0.017)	0.011 (0.007)
FDI/GDP	0.002** (0.001)	0.011 (0.039)	0.008 (0.016)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.3312	/
H-S1	/	0.2063	0.5776
H-S2	/	0.1288	0.2067
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.14: Spatial Effect Estimation of UNCTAD Resource-Intensive Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.791*** (0.043)	1.034*** (0.046)	1.016*** (0.022)
Spat. resource-intensive product $_{t-1}$	0.042*** (0.015)	0.024 (0.027)	0.018 (0.040)
Bilateral trade/GDP	-0.006 (0.004)	-0.009 (0.020)	0.014 (0.013)
FDI/GDP	0.002** (0.001)	0.041* (0.024)	0.021 (0.023)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.3255	/
H-S1	/	0.3208	0.4358
H-S2	/	0.3358	0.2008
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.15: Spatial Effect Estimation of UNCTAD Non-Fuel Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.794*** (0.042)	1.029*** (0.026)	1.022*** (0.012)
Spat. non-fuel products $_{t-1}$	0.016 (0.016)	0.028 (0.020)	0.025 (0.016)
Bilateral trade/GDP	-0.006 (0.005)	-0.006 (0.024)	0.012 (0.009)
FDI/GDP	0.002** (0.001)	0.055 (0.041)	0.031 (0.029)
Lnpopulation	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.2982	/
H-S1	/	0.8304	0.8932
H-S2	/	0.8048	0.6428
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.16: Spatial Effect Estimations of UNCTAD Mineral-Fuel Product Imports

	(1) Panel	(2) Sys-GMM	(3) GMM-NL
$GII_{t-1}$	0.795*** (0.043)	0.836*** (0.084)	0.895*** (0.113)
Spat. mineral-fuel products	0.014* (0.007)	0.020** (0.010)	0.019* (0.011)
Bilateral trade/GDP	-0.006 (0.005)	-0.031 (0.027)	-0.024 (0.029)
FDI/GDP	0.002** (0.001)	-0.083 (0.076)	-0.006 (0.043)
$\ln population$	0.000 (0.000)	0.000 (0.000)	0.000 (0.001)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
AR2	/	0.2367	
H-S1	/	0.5283	0.8010
H-S2	/	0.5315	0.0383
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

Table 3.17: Spatial Effect Estimation of OECD Technological Product Imports

	(1) Panel	(2) Sys-GMM	(3) Sys-GMM-NL
Spat. high tech products $_{t-1}$	0.012 (0.011)	0.029* (0.015)	0.029** (0.014)
Spat. medium-high products $_{t-1}$	0.035** (0.014)	0.057*** (0.022)	0.059*** (0.020)
Spat. medium-low products $_{t-1}$	0.037** (0.018)	0.099** (0.046)	0.068* (0.036)
Spat. low tech products $_{t-1}$	0.015 (0.013)	0.016 (0.016)	0.009 (0.012)
Spat. other-trade products $_{t-1}$	0.020* (0.010)	0.029* (0.016)	0.029* (0.017)
Country FE	YES	YES	YES
Time FE	YES	YES	YES
Standard Errors	Cluster	Cluster	Cluster
Observations	1968	1968	1968

Notes: The dependent variable in all estimations is the Gender Inequality Index. Column (1) represents panel fixed effects estimation. Columns (2) and (3) show system-GMM estimations, linear and non-linear respectively. Time and country fixed effects are included, and standard errors are clustered at the country level in parentheses. \*, \*\* and \*\*\* indicate significance at the 10%, 5% and 1% levels respectively.

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**Titre:** L'  onomie du commerce, de l'innovation et de la r  volution technologique

**Mots cl  s:** economie internationale; innovation; competition; marques commerciales; brevets; economie du genre

**R  sum  :** Cette th  se   tudie principalement l'impact du commerce international sur l'innovation, avec un accent particulier sur les pays en d  veloppement. Elle couvre   galement l'effet du commerce sur les in  galit  s de genre. Le chapitre 1 est un aper  u de la litt  rature   conomique th  orique et empirique r  cente qui traite de l'effet du commerce sur les r  sultats li  s    l'innovation. Une analyse empirique est   galement men  e pour examiner l'impact du commerce sur l'innovation, mesur  e par l'activit   de d  p  t de brevet, dans les pays en d  veloppement. Le chapitre 2 est une   tude empirique qui examine l'impact du commerce sur l'innovation dans les pays en d  veloppement, en utilisant une nouvelle mesure qui est le d  p  t de brevet. Les r  sultats montrent un effet global d  croissant de la concurrence

des importations sur l'activit   de marquage. Cela fournit une preuve suggestive que la concurrence des importations affecte n  gativement les innovations locales de produits ou de services dans les pays en d  veloppement. Le chapitre 3   value l'impact du commerce international sur les normes d'  galit   de genre. Les r  sultats montrent que des normes d'  galit   de genre plus   lev  es    l'  tranger se r  percutent, via les importations de produits de moyenne, haute technologie et min  raux, sur des normes d'  galit   de genre plus   lev  es au niveau national. Nos r  sultats sugg  rent qu'une r  volution technologique a un impact sur les entreprises, les m  nages et les gouvernements en ce qui concerne l'autonomisation des femmes.

**Title:** The Economics of Trade, Innovation and the Technology Revolution

**Keywords:** International Trade; Innovation; Competition; Trademarks; Patents; Gender Economics

**Abstract:** This thesis primarily studies the topic of the impact of international trade on innovation, with a specific focus on developing countries. It also covers trade spillovers and gender inequality. Chapter 1 is a survey of the recent theoretical and empirical economic literature discussing the effect of trade on innovation-related outcomes. An empirical analysis is also conducted to examine the impact of trade on innovation, measured by patenting activity, in developing countries. Chapter 2 is an empirical study examining the impact of trade on innovation in developing countries, using a new measure which is trademarking. The results show an overall decreasing effect

of import competition on trademarking activity. This provides suggestive evidence that import competition negatively affects new local product or service innovations in developing countries. Chapter 3 assesses the impact of international trade on gender equality norms. Results show that higher gender equality standards abroad spill over via the imports of medium, high-tech and mineral products into higher domestic gender equality standards. Our results suggest that a technological revolution affects firms, households and governments in impacting female empowerment.