ESSAYS ON THE ECONOMICS OF REMITTANCES AND MIGRATION

by

THOMAS LEBESMUEHLBACHER
(Under the Direction of Santanu Chatterjee)

Abstract

International migration is a growing phenomenon both in scope and complexity. Today, almost 3.5% of the world's population, or 250 million people, live outside their country of birth. Yet, the macroeconomic consequences of migration are not well understood. On the one hand, migration drains the home country of its human capital, thus reducing its productivity and tax base. In terms of host country effects, migration is often associated with negative labor market outcomes, including unfavorable effects on wages and employment. On the other hand, migrants tend to stay connected with their home country by sending back remittances, re-migrating after receiving an education abroad, or sharing information through networks. In host countries, migrants can both stimulate demand, and increase productivity.

This dissertation contributes to the understanding of the macroeconomic consequences of migration for home and host economies. In particular, Chapter 2 establishes a link between migration and technology diffusion using a panel data set of 30 developed and 88 developing countries for the period 1980 - 2000. Then, Chapter 3 utilizes an open economy DSGE model with heterogeneous households to examine two important channels which influence the dynamic absorption of remittances: (i) the presence of borrowing constraints, and (ii) the distribution of remittances across recipient households. Finally, in Chapter 4, I study the design and impact of optimal government policies on growth and welfare when (i) refugees are sub-optimally distributed across countries and (ii) the presence of refugees causes congestion externalities for public services. The analysis contained in Chapters 2-4 gives new insights in several migration related spillovers, namely technology diffusion, remittances, and public goods congestion, yet emphasizes the complexity between migration and economic growth and development.

INDEX WORDS: Migration, Technology diffusion, DSGE model, Remittances, Credit constraints, Labor supply, Output, Investment, Consumption, Welfare, Public capital, Congestion

ESSAYS ON THE ECONOMICS OF REMITTANCES AND MIGRATION

by

THOMAS LEBESMUEHLBACHER
B.A., University of Bamberg, GERMANY, 2008
M.Sc., Goethe University of Frankfurt, GERMANY, 2010

A Dissertation Submitted to the Graduate Faculty
of the University of Georgia in Partial Fulfillment
of the
Requirements for the Degree

DOCTOR OF PHILOSOPHY

Athens, Georgia

2016

©2016

Thomas Lebesmuehlbacher

All Rights Reserved

ESSAYS ON THE ECONOMICS OF REMITTANCES AND MIGRATION

by

THOMAS LEBESMUEHLBACHER

Approved:

Major Professor: Santanu Chatterjee

Committee: William D. Lastrapes
David B. Mustard
Julio Garin

Electronic Version Approved:

Suzanne Barbour
Dean of the Graduate School
The University of Georgia
May 2016

Acknowledgments

First and foremost, I want to thank my advisor, Dr. Santanu Chatterjee, for his advice and support throughout my time at the University of Georgia. Dr. Chatterjee's dedication to his students far exceeded my expectations. He has been a great mentor in teaching and research, and I will always be grateful for his many contributions to the start of my career.

I am also indebted to the numerous contributions of the remaining members of my dissertation committee: Drs. William Lastrapes, Julio Garin, and David Mustard. I benefited tremendously from their expertise and encouragement, and highly appreciate that they always had an open ear for any of my questions. Similarly, I would like to thank the rest of the department, as well as Dr Berrak Bahadir, for their impact on my career. The entire faculty was always available to provide guidance in whatever I needed.

Finally, this dissertation would not have been possible without the support of my friends and family. I would like to thank my parents, Hubert and Martina Lebesmuehlbacher, for their support, encouragement, and sacrifice throughout my life, but especially over the past five years. They always encouraged me, motivated me, and provided me with the safe environment I needed to make it through this odyssey. The same can be said about my brothers Philipp and Patrick, whose brotherly rivalry has always pushed me to accomplish more than I thought was possible. Last but not least, I would like to thank my friends who always supported me and gave me the mental strength to cope with the challenges over the past 5 years. In particular, I would like to thank Raymond Edwards Jr., without whom I could not have made it through the first 2 years of my degree.

Thank you

To my parents

Contents

Acknowledgments **iv**

List of Figures **viii**

List of Tables **ix**

1 Introduction **1**

2 Understanding Technology Diffusion: The Role of International Trade and Factor Movements **4**

2.1 Introduction 4
2.2 Channels of Technology Diffusion 8
2.3 Data 11
2.4 Estimation 15
2.5 Results 16
2.6 Conclusion 21
Appendix 1 24

3 The Macroeconomic Consequences of Remittances **29**

3.1 Introduction 29
3.2 Analytical Framework 34
3.3 Calibration 37
3.4 Exogenous Remittance Shock 40
3.5 Countercyclical Remittance Shock 47
3.6 Model Fit 48
3.7 Discussion 52
3.8 Conclusions 54

Appendix 2 56

4 Public Capital and Refugee Distribution Across Countries 57

4.1 Introduction 57

4.2 Analytical Framework 62

4.3 A Centrally Planned Economy 64

4.4 A Decentralized Economy 68

4.5 Government Policy and Transitional Dynamics: A Numerical Analysis 71

4.6 General Discussion 84

4.7 Conclusion 85

List of Figures

3.1 Exogenous Remittance Shock (Cobb-Douglas Utility) 42

3.2 Exogenous Remittance Shock (GHH Utility) 43

3.3 Exogenous Shock to Remittances, v=1 (Wage Earners, CD Utility) 46

3.4 Exogenous Shock to Remittances, v=0 (Entrepreneurs, CD Utility) 47

3.5 Transitional Welfare Paths 48

3.6 Countercyclical Remittances 49

3.7 Share of Total Remittances from US and EU for Philippines, 1993-2011 50

3.8 Growth Rate of Real GDP, 1993-2014 53

3.9 Growth Rate of Real Private Investment, 1993-2014 54

4.1 Asylum Application per 100,000 Capita: 2015 58

4.2 EU-Relocation Scheme 59

4.3 Decrease in Northern Government Spending ($g_n - 0.05$) 76

4.4 Increase in Southern Government Spending ($g_s + 0.06$) 77

4.5 Increase in Southern Income Tax Rate ($\tau_y + 0.158$) 78

4.6 Decrease in Northern Refugee Income ($T_n - 0.0003$) 80

4.7 Optimal Policy Combination 83

List of Tables

2.1 Growth Decomposition by Source Country . . . 5

2.2 Indicators of Technology Diffusion . . . 6

2.3 Descriptives: Technology Usage Intensities . . . 13

2.4 Summary Statistics . . . 14

2.5 Estimation Results . . . 19

A.2.1 List of Variables . . . 24

A.2.2 List of Technologies . . . 25

A.2.3 List of countries . . . 25

A.2.4 Extreme Bound Analysis . . . 26

A.2.5 Robustness: Re-classification . . . 27

A.2.6 Robustness:BRIC . . . 28

3.1 Remittances and Private-Sector Credit (% of GDP), 1995-2014 . . . 30

3.2 Baseline Calibration . . . 39

3.3 Model Fit: Standard Deviations and Correlations (CD Utility) . . . 51

3.4 Model Fit: Sensitivity to Preferences . . . 52

4.1 First Arrivals of Refugees in 2015: By Frontline State . . . 57

4.2 Calibration of the Centrally Planned Economy . . . 72

4.3 Steady State Equilibrium in the Centrally Planned Economy . . . 73

4.4 Sensitivity of Benchmark Results to variations in σ . . . 74

4.5 Policy Parameters of the Decentralized Economy . . . 74

4.6 Steady State Equilibrium in the Decentralized Economy . . . 75

4.7 Equilibrium in a Decentralized Economy: Long-run Effects of Policy Shocks . . . 79

4.8 Welfare Analysis of Policy Shocks and Sensitivity to Congestion Parameter (in $\%\Delta$) . . . 82

4.9 Optimal Policy Combination . . . 84

Chapter 1

Introduction

Today, approximately 250 million individuals, or 3.5% of the world's population, live outside their country of birth. As such, migration bears a lot of potential, as well as challenges for home and host economies. In the host country, migrants contribute to productivity and the economy's tax base, but also add to congestion of the domestic health care and infrastructure system, including education. In contrast, the home country suffers from a reduction of its human capital and a diminishing tax base, yet benefits from migrants sending back remittances, sharing information through networks, or remigrating after obtaining an education abroad. As a result, migration and growth are complex, interdependent processes. It is the goal of this dissertation to contribute to the understanding of migration and its consequences for home and host economies. Thereby, I focus particularly on three spillovers from migration: technology diffusion, remittances, and public services congestion.

Understanding the factors of technology diffusion is critical as most of the world's innovations are generated in only a few developed countries. For instance, foreign sources of technology account for up to 90 percent of domestic productivity growth in many developing countries (Keller, 2004). Given the importance of foreign R&D in developing countries, technology diffusion has become a wide area of research. For example, Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997) study the effects of imports on technology diffusion, while Harrison and Aitken (1999) and Keller and Yeaple (2009) analyze the role played by FDI. In contrast, the relationship between migration and technology diffusion is less understood. Intuitively, migration can affect technology diffusion in one of two ways. On the one hand, migration deprives a country of its human capital, thus slowing down diffusion. On the other hand, migrants stay connected with their home country through receiving an education abroad and re-migrating, information sharing within networks, or through sending remittances.

In 2015, these remittance flows equaled approximately $601 billion, with developing countries receiving $441 billion.[1] As such, remittances are the second-largest flow of capital across the world (after FDI), accounting for almost a third of all international capital flows (Yang, 2011). Given the sheer magnitude of remittance flows to developing countries, their economic impact has naturally become an important area

[1] World Bank: Migration and Remittances Factbook 2016

of research. However, there is little consensus among economists on either the usage of remittances or the macroeconomic consequences for the receiving country. For example, while Durand et al. (1996) and Combes and Ebeke (2011) find that remittances primarily finance household consumption, Bansak and Chezum (2009) and Alcaraz, Chiquiar, and Salcedo (2012) find that remittances are used for financing investments. Moreover, Durdu and Sayan (2010) find that remittances dampen the business cycles in Mexico, but amplify the cycles in Turkey, whereas Acosta, Lartey, and Mandelman (2009) document potential negative effects of remittances in the form of a Dutch Disease.

The ambiguous effects of migration on the home country extends to host economies. Migration can add to the skill level of the domestic workforce, and thus increase productivity. However, there can be negative labor market effects such as shrinking wages for the domestic population and rising unemployment (e.g. Cohen-Goldner and Paserman (2011) and Ceritoglu et al. (2015)). Moreover, migration puts a burden on the host economies by increasing the demand for public services, which in turn leads to negative externalities in the form of congestion. For example, Gould, Lavy, and Paserman (2009) show that the presence of immigrants in the class room has significant negative spillovers on domestic students in Israel. In addition to negative spillovers on human capital, Baez (2011) finds that the presence of refugees has negative health consequences for local children in Tanzania.

This dissertation sheds some light on the complex relationship between migration and the macroeconomic consequences for home and host economies, particularly with respect to technology diffusion, remittances, and public services congestion. In Chapter 2, I analyze a panel data set of 30 developed and 88 developing countries for the period 1980 - 2000 to establish a link between migration and technology diffusion. The main finding of the chapter indicates that migration enhances technology diffusion only in developing countries. Since migration differs largely in terms of skill levels and choice of destination country, I further investigate the importance of skill and location effects on the overall importance of migration regarding technology diffusion. Separating migration into skill groups and migration to OECD countries suggests that the effect of migration on technology diffusion is entirely driven by a location effect. In other words, migration from developing countries to OECD countries accelerates within-country diffusion, while the skill level of migrants is irrelevant.

Chapter 3 continues by examining two important channels which influence the dynamic absorption of remittances at the macroeconomic level: (i) the presence of borrowing constraints, and (ii) the distribution of remittances across recipient households. Using an open economy DSGE model with heterogeneous households, Chapter 3 shows that remittances accruing to hand-to-mouth households (with no capital ownership or access to credit markets) generate a dynamic response that is inherently contractionary for the recipient economy. On the other hand, credit-constrained households with ownership of capital respond in a way that

is inherently expansionary, when they are the principal recipients. Further, the ability of countercyclical remittances to smooth business cycle shocks also depends critically on their distribution across households.

Finally, in Chapter 4, I study the design and impact of optimal government policies on growth and welfare when (i) refugees are sub-optimally distributed across countries and (ii) the presence of refugees causes additional congestion externalities for public services. I find that that (i) too many refugees choose to locate in the more advanced North relative to the "first-best" solution derived by the social planner, and (ii) the "first-best" distribution of refugees can be achieved by using public investment, income tax rates, and welfare payments to refugees as policy tools. Reducing public investment in the North gradually achieves a redistribution of refugees from the North to the South. While this policy option increases the welfare of Northern households it slows down steady state growth rates relative to the centralized solution. In contrast, an increase public investment in the South achieves the same gradual redistribution of refugees with increasing steady state growth rates in the South and declining welfare levels of Southern households. While consumption taxes in this framework are non-distortionary, and thus not suited to achieve the "first-best" allocation of refugees, an increase in the Southern income tax rate achieves the social planner's distribution in combination with Southern welfare gains and a drop in steady state growth rates. Finally, shocks to refugee transfer payments or movement costs achieve an instantaneous redistribution of refugees from the North to the South without significantly affecting welfare levels or steady state growth rates.

Chapter 2

Understanding Technology Diffusion: The Role of International Trade and Factor Movements

2.1 Introduction

Technological progress plays a critical role in economic growth across countries. However, with increasing globalization, a country's own R&D effort becomes relatively less important compared to R&D activity abroad. For example, innovations (as measured by total patent applications of residents in their home filing office) in upper-middle income countries are on average only about 10% relative to high income countries for the period 1980-2010, and less than 1% for all other income groups.[2] In other words, many of the world's innovations are generated in a few developed countries and then adopted globally. Panel A in Table 2.1 shows the importance of foreign technology adoption on domestic productivity growth of 5 highly innovative economies (Germany, France, United Kingdom, Japan and United States). On average, foreign R&D explains 55% of productivity growth in these economies. In emerging countries the dependency on foreign R&D is even higher (Panel B), and can account for up to 90 percent of domestic productivity growth in some countries (Keller, 2004). Globalization has greatly facilitated the exposure to foreign innovations by increasing international trade and factor movements.[3] Yet, the capacity to absorb new technologies throughout the economy remains low due to inefficient institutions, low infrastructure spending, and skill differences between rural and urban population in many countries. Therefore, this paper investigates the relationship between within-country technology diffusion and international trade and factor movements in developed and developing countries, with a particular focus on the role of migration.

In contrast to the previous literature on technology diffusion, I examine how technology usage increases within countries, rather than across, by analyzing the growth rate of a country's usage intensity of several technologies to be specified below. Particularly in developing countries, within-country diffusion is an important aspect in development. For instance, metropolitan areas, such as Shanghai or Bangalore, adopt new

[2]Source: WIPO; Total patent applications - Resident count by filing office, where resident refers to filings made by applicants at their home office.

[3]see for example Coe and Helpman (1995), Keller and Yeaple (2009) and Park (2004)

Table 2.1: Growth Decomposition by Source Country

Panel A)	Due to R&D performed in:				
Fraction of productivity growth in:	Germany	France	U.K.	Japan	U.S.
Germany	0.38	0.06	0.09	0.31	0.16
France	0.23	0.22	0.09	0.31	0.16
U.K.	0.24	0.05	0.30	0.28	0.12
Japan	0.16	0.03	0.06	0.65	0.09
U.S.	0.14	0.03	0.06	0.19	0.58

Panel B)	Due to R&D performed in:		
Fraction of productivity growth in:	Emerging	OECD (-)	OECD (+)
Emerging	0.36	0.20	0.44
OECD (-)	0.11	0.56	0.33
OECD (+)	0.07	0.09	0.84

Panel A is from Jovanovic (1995), Panel B is from Santacreu (2014). Emerging Countries include Argentina, Brazil China, Hong Kong, India, Indonesia, Malaysia and Philippines. OECD(-) includes less innovative OECD countries: Greece, Ireland, Italy Portugal and Spain. OECD(+) includes all other OECD countries.

technologies rather quickly, and thus do not lag far behind developed countries in terms of the extensive margin of technology adoption. However, slow diffusion within the country implies low overall usage intensities, and thus low efficiency gains. For example, da Silva and Zainudeen (2007), Aker and Mbiti (2010), and Aker and Fafchamps (2015) examine efficiency gains associated with increasing cell phone usage. Their results indicate that a reduction in communication costs associated with cell phones has economic benefits, such as improving agricultural and labor market efficiency, and increasing producer and consumer welfare. For these effects to set in, it is not only of relevance whether cellphones are being used (cross-country diffusion), but also how many are being used (within-country diffusion).

In examining the role of international trade and factor movements on technology diffusion I separate between developed and developing countries, as the latter are relatively less integrated in the world market.[4] Consequently, developing countries face higher barriers of information flow, which in turn limits their exposure to new technology.[5] At the same time, most developing countries invest less in R&D and infrastructure, have worse institutions, a less educated work force, and higher rural-urban inequality which limits their ability to absorb new technologies. Table 2.2 illustrates the lack of absorption in developing countries. Usage intensities of both older and more recent technologies are only a fraction compared to developed countries.

[4]Countries are categorized into 30 developed and 88 developing countries according to the definition of the IMF's World Economic Outlook 2012. The IMF's classification takes into account per capita income, export diversification, and the degree of integration into the global financial system.

[5]For example, Comin and Hobijn (2010) report that developing countries adopt new technologies, on average, 21 years after developed countries.

For example, landline-phone penetration in low-income countries is only about 5% of the penetration in high-country, and personal computer usage is only about 2% relative to high-income countries.

Table 2.2: Indicators of Technology Diffusion

	Older Technology			Newer Technology		
	Electric Power Consumption (KwH/capita)	Telephone Mainlines (per 100 people)	Road Density (km of road/100 km^2)	Internet User (per 1000 people)	PCs (per 1000 people)	Mobile Phones (per 100 people)
High-Income	9,609	54	41.2	527	579	77
Upper-middle	3,454	23	11.9	196	113	48
Lower-middle	1.448	19	14.5	95	45	24
Low-Income	375	3	19	44	11	4

Source: World Bank; Global Economic Prospect 2008

International trade and factor movements play a critical role in within-country technology diffusion by increasing a country's exposure to innovations, and by increasing its capability to absorb these new technologies. Existing literature has mostly focused on trade and FDI as potential factors of technology diffusion.[6] In addition to trade and FDI, this study highlights the importance of international labor movements. According to Artuc et al. (2014), migration stocks have increased by 30% between 1990 and 2000. In the U.S., approximately 15% of scientists and engineers are foreign-born. Of these foreign-born scientists and engineers over 75% migrated from developing countries. Despite their contribution to innovation in developed countries, the migration of highly skilled individuals represents a significant problem for developing countries by limiting their ability to process and apply new information. With 24% of tertiary educated workers migrating in 2010, the size of the Brain Drain in developing countries is more than twice as large as in developed countries. For some developing countries, the Brain Drain even reaches 90% or more.[7] Yet, migration has the potential to enhance technology diffusion at home. For instance, migrants send back remittances that can either be invested or consumed. Currently, remittances represent the second-largest flow of capital across the world, and account for almost a third of all international capital flows Yang (2011). As such, remittances entail a large potential to increase the absorptive capacity in the receiving country. Further, migrants may accumulate human capital abroad and spread their knowledge upon return. For example, in 2000, ca 40% of firms at the Hinschu Science-Based Ind. Park in Taiwan were started by U.S. educated re-migrants (O'Neil, 2003). But even without re-migration, workers can facilitate technology diffusion through information sharing within networks (Kerr, 2008).

[6]see for example Coe and Helpman (1995) and Keller and Yeaple (2009). The next section provides a detailed discussion of existing literature and through which channels technology diffusion is affected.

[7]Source: Bruecker, Capuano, and Marfouk (2013). Brain Drain is defined as migration of individuals with tertiary education as share of country's total population with tertiary education. Countries with a Brain Drain of ca. 90% in 2010 include Haiti (85%), Antigua and Barbuda (89%), Barbados (92%), and Guyana (99%).

A priori, which effect dominates is unclear, and might further depend on a migrant's skill level. On the one hand, high skilled migration drains a country of its human capital, leaving less skilled workers behind who are unable to adopt new technology. On the other hand, high skilled migrants typically receive higher paid jobs, resulting in a higher ability to remit, which in turn increases the home country's ability to absorb new technology. Besides skill level, a migrant's destination may be critical. For example, migrants in developed countries are more likely to be exposed to new technology relative to migrants in developing countries. This exposure might facilitate diffusion across and within borders. Consequently, I highlight the role of migration in the aggregate, by skill level, and by destination.

The analysis is carried out by first creating a measure of within-country technology diffusion from the Cross-country Historical Adoption of Technology (CHAT) data set by Comin, Hobijn, and Rovito (2006). The data set contains usage intensities by country for a variety of technologies over time. I create the diffusion measure as the average growth rate of usage intensities for selected technologies within a country. Then, I use panel fixed effects regression of lagged 5 year averages to identify the effects of international factor movements on technology diffusion. By using 5 year averages I remove concerns about slowly adjusting variable (see e.g. Cheng and Wall, 2005), and regressing lagged values of international factor movements reduces the concerns about simultaneity.

Results show that international trade and factor movements do not significantly affect technology diffusion in developed countries. Supporting evidence from existing country-studies is mixed. For example, Keller and Yeaple (2009) find significant spillover effects of FDI on U.S. manufacturing firms. In addition they find evidence of spillovers from imports, yet much weaker compared to spillovers from FDI. In contrast, results by Djankov and Hoekman (1998) support the findings in this paper. Their study finds no evidence of technology spillovers for Czech manufacturing and non-manufacturing firms. I test my results for robustness along 2 dimensions: First, I conduct Extreme Bounds Analysis (EBA) to test the sensitivity of the analysis to omitted variables. Second, I examine how the exclusion of strategically selected countries affects the results. Both robustness tests confirm the insignificant role of international factor movements in technology diffusion. In addition, EBA suggests that domestic investments (private + public) are the main driver of within-country technology diffusion in developed countries.

Similar to developed countries, FDI and trade do not play a significant role in the developing world. Again, support from existing literature is mixed. While Blalock and Gertler (2008) find that FDI creates technology diffusion to local suppliers in Indonesia, Grether (1999) finds no evidence of spillover effects from FDI for Mexican manufacturing plants. Moreover, Grether finds no relationship between international trade and technology diffusion. In contrast to trade and FDI, international labor movements significantly accelerate technology diffusion in developing countries. A one percent increase in migration increases the

average growth rate of technology usage by 0.31%. But what aspect of migration drives technology diffusion back home, a migrant's skill level or choice of destination country? Looking at migration by skill level does not explain the effect of international labor movement on technology diffusion. In contrast, technology diffusion in developing countries benefits from the destination of the migrant: a one percent increase in migration to OECD countries increases the average growth rate of technology usage by 0.36%. In other words, "who" migrates does not matter, but the choice of the destination country does. As in the case of developed countries, these results are robust to re-defining the sample of developing countries, and the inclusion of additional regressors.

The rest of the paper is organized as follows: Section 2) outlines the channels through which international trade and factor movements affect technology diffusion and reviews the existing literature. Section 3) describes the data, with a particular focus on the derivation of the technology diffusion measure. Section 4) outlines the estimation strategy, before Section 5) discusses the results.

2.2 Channels of Technology Diffusion

International trade and factor movements may contribute to within-country diffusion in two ways: by increasing the exposure to new technology, and by increasing the capability to absorb these technologies. There are several models that have been proposed to explain technology diffusion, including work by Nelson and Phelps (1966), Rivera-Batiz and Romer (1991) or Aghion and Howitt (1992).[8] This paper estimates a general form of what might be a common reduced-form equation of these diffusion models:

$$TUI = f(T, FDI, M, X) + u \tag{2.1}$$

where TUI is the growth of technology usage intensity, X is a vector of control variables, and T, FDI, and M refer to trade, foreign direct investments, and migration respectively. Especially trade and FDI are typically considered determinants of technology diffusion, with mixed empirical evidence. For example, Coe and Helpman (1995) and Coe, Helpman, and Hoffmaister (1997) study the effects of imports on technology diffusion in developed and developing countries respectively. Both studies find a significant effect of trade on technology diffusion. Clerides, Lach, and Tybout (1998) analyze the causal links between exporting and productivity using firm-level panel data in Colombia, Mexico and Morocco. The authors find evidence that exporters reduce the costs of breaking into foreign markets for domestically oriented producers, however they do not appear to help these producers become more efficient. Moreover, Park (2004) shows that

[8] Grossman and Helpman (1993) and Keller (2004) provide an overview of both theoretical and empirical work on technology diffusion.

trade becomes insignificant once student flows are accounted for. Regarding FDI, Keller and Yeaple (2009) suggest that foreign investments lead to substantial productivity gains for domestic U.S. manufacturing firms. In addition, they find some evidence for imports-related spillovers, yet weaker than for FDI. In contrast, Harrison and Aitken (1999) show that foreign investment is positively correlated with foreign-owned plant productivity in Venezuela, but causes negative spillovers to plants with domestic ownership, causing the overall effect to be negligible.

In general, trade can accelerate technology diffusion through providing a larger variety of products, it enhances the international discussion of production process and organizational behavior, and trade provides new knowledge that would otherwise be costly to acquire (Grossman and Helpman, 1993). FDI may positively affect technology diffusion in two ways. First, foreign investments in a company can increase diffusion as new shareholders try to maximize profits and dividends through influencing production processes (see e.g. Blalock and Gertler, 2008). Second, FDI can affect productivity through knowledge transfers. A company's internal knowledge can then spread to other companies through imitation, or a combination of employees gaining new knowledge in foreign owned firms and labor turnover (see e.g. Fosfuri, Motta, and Rønde, 2001).

Yet, trade and FDI may have limited effects on within-country diffusion for two reasons. First, FDI and trade may cause negative spillovers to existing firms through a business stealing effect (e.g. Mankiw and Whinston (1986) and Grossman and Helpman (1991)). A business stealing effect occurs when the loss of income suffered by owners of the FDI/import competing firms means less demand and less profits for all remaining industries. For example, Harrison and Aitken (1999) attribute the negative spillover from foreign to domestic enterprises as a business-stealing effect. Second, FDI and trade tends to be geographically concentrated around metropolitan areas. For example Broadman and Recanatini, 2001 show that more than two-thirds of the FDI stock in Russia in 2000 was concentrated in Moscow and three surrounding areas. Similarly, the Federal Reserve Bank of India reports that almost 50% of all FDI flows go to the Mumbai and Delhi area in 2007, while Cheung and Ping, 2004 find that almost 90% of all FDI flows to China are concentrated in the coastal region. Thus, international trade and FDI increase the exposure to new technology in certain regions, but exposure is not sufficient to ensure that technology diffuses throughout the country.[9] Successful diffusion of foreign technology depends on a country's absorptive capacity, which not only depends on a country's physical capital, but also its human capital.

Therefore, this paper considers migration as an additional factor of technology diffusion to trade and FDI. First, migrants can provide important knowledge upon their return, or share information within networks. For example Park (2004) shows that foreign students who acquire technological knowledge through education or post-school job experience abroad contribute to R&D spillovers to their home country when they return.

[9] Lipsey and Sjöholm, 2005 provide a discussion about the ambiguous results regarding the effects of FDI on the host country

Moreover, his study casts doubt on the role of trade in R&D spillovers, as it becomes insignificant when student flows are included. In addition, Kerr (2008) finds evidence for knowledge diffusion through ethnic networks. He shows that foreign manufacturing output increases with an elasticity of about 0.3 to higher ethnic research in the US. Second, migration might contribute to technology diffusion through remittances or a Brain Gain. Remittances increase the resource envelope in the home country, which in turn increases the ability to purchase new technology, and frees up resources that can then be invested in education to obtain a skill level necessary for technology adoption. Brain Gain describes human capital gains due to higher expected returns from education. Wages abroad are often higher compared to domestic wages. Thus migration increases the expected returns to human capital, which increases the incentive to invest in education. This leads to a Brain Gain if not all of these additional high skilled workers migrate. The size of this Brain Gain can be large: Batista, Lacuesta, and Vicente (2012) show that a 10 percentage point increase in the probability of own future migration improves the probability of completing intermediate secondary schooling by nearly 4 percentage points in Cape Verde. Finally, migrants might contribute to technology diffusion indirectly by strengthening trade and investment linkages with more advanced economies. For example, Gould, 1994 suggests that immigrant links are important in increasing bilateral trade flows between migrants' home countries and the U.S., while Javorcik et al., 2011 find that U.S. FDI abroad is positively correlated with the presence of migrants from the host country. If these results can be generalized for other countries, traditional estimates of the effect of trade and FDI on technology diffusion might be overestimated due to the omission of migration.

In contrast to these positive effects, work by McCulloch and Yellen (1977) or Bhagwati and Hamada (1974) show that high skilled emigration has detrimental effects on the economy as it depletes a country of its human capital. While more recent literature has moved away from this strictly negative view of a brain drain, the effects of migration on technology diffusion are, a priori, not clear, and seem to depend on the country being studied (see Boeri, 2012 for an overview).

Among the few cross-country studies relating emigration to technology diffusion is Lodigiani (2008). The author estimates the effects of skilled diaspora on the transfer of ideas using a panel dataset covering 92 countries between 1980 and 2000. She provides evidence for a positive effect of skilled migration on adoption in countries far from the U.S. technology frontier. My study extends the work by Lodigiani in several dimensions. First, Lodigiani only considers transfers between the U.S. and the origin countries. In contrast, this study looks at the relationship between technology diffusion and international factor movements at a global scale. Further, I allow for idiosyncratic effects between developed and developing countries. Finally, I disentangle the aggregate effect of migration on technology diffusion in a skill effect and a location effect. I find that the effect of migration on technology diffusion does not depend on the migrants' skill level, but

on the location they choose. This result suggests that the positive effect of migration picked up in Lodigiani might not be due to the skill level of the migrants, but due to choosing the U.S. as the reference country.

2.3 Data

2.3.1 International Trade and Factor Movements

Data on international trade and factor movements (trade, FDI and migration) are as indicated in Table A.2.1. The migration data collected by Bruecker, Capuano, and Marfouk (2013) is in 5 year intervals between 1980 and 2010 and available through the Institute for Employment Research (IAB). Consequently, I compute 5 year averages for trade and FDI, where the year 1980 refers to the average of the period 1978 - 1982. Two features make the IAB migration data particularly interesting for this study: it contains information about the skill level of the migrants, and about the number migrants to OECD countries. This division allows a more detailed analysis of the driving force behind the role of migration in technology diffusion: destination or skills of the migrant.

2.3.2 Measuring Technology Diffusion

I compute technology diffusion from the Cross-country Historical Adoption of Technology (CHAT) data introduced by Comin, Hobijn, and Rovito (2006). The data contain information on usage intensities of over 115 technologies in 150 countries between 1800 and 2002. Technologies are defined in broad categories and represent capital goods that are used to produce a final good or service.[10] In this way, the paper does not examine the impact of technology usage on productivity, but to what extent technologies embodied in goods and services diffuse through economies. According to the Global Economic Prospects in 2008, general availability of technology is an important aspect in development, especially in poor, rural areas. For example, trade of goods and internal migration are heavily constrained by poor infrastructure in such areas. The introduction of simple communication technologies is of great value both as a substitute for internal migration and to assure that the movement of people or goods is worthwhile. Moreover, the availability of communication technologies has reduced informational asymmetries, increased producers' revenues and lowered consumers' costs. In addition, these technologies are increasingly used to enable financial intermediation, which is critical to development but has largely been unavailable due to lacking infrastructure.

Before I introduce the diffusion measure, two drawbacks of the CHAT data should be discussed. First, due to its scale, the CHAT data set includes many missing observations. To limit the extent of missing

[10] This is similar to the interpretation of technology in e.g. Romer (1990)

observations, I exclude technologies for which more than 75% of the countries in the sample don't have any observations. This reduces the data set to 18 technologies listed in Table A.2.2. Second, some of the technologies in the sample become obsolete over time. Technologies can become obsolete for two reasons. First, technologies may be replaced with newer versions, i.e. Schumpeter's idea of creative destruction (see Aghion and Howitt, 1992). Second, a country may undergo structural changes that makes the use of a certain technology redundant (Abramovitz and David, 2001). For example, usage intensities of agricultural technologies in developed countries may decline due to their transformation to manufacturing and service economies.

Regardless of the reason, accounting for obsolete technologies is important to ensure that changes in usage intensities are due to international factor movements rather than outdated technologies. While changes in international trade and factor movements have the potential to slow down the growth of usage intensities it is unreasonable to believe that they reduce the existing stock of technologies. For instance, a decline in a country's trade volume in a given year might slow down the diffusion of certain technologies in that year (or subsequent years), but it does not reduce the stock of already existing technologies. To account for obsolete technologies, I first determine the intertemporal technology frontier for each country and calculate annual growth rates up to this frontier.[11] In this paper technology frontier refers to the point in time at which each country's usage intensity of a certain technology is highest. The growth rate of a technology's usage intensity proxies for technology diffusion:

$$Diff_{i,j,t} = \frac{A_{i,j,t} - A_{i,j,t-1}}{A_{i,j,t-1}} \; \forall \; A_{i,j,t} < max\{A_{i,j}\} \tag{2.2}$$

where $A_{i,j,t}$ is the usage intensity of technology i at time t in country j, and $max\{A_{i,j}\}$ is the maximum usage intensity of technology i at any given time in country j. In a last step, I average the growth rates of all usage intensities to obtain the measure:

$$Diff_{j,t} = \frac{1}{I} \sum_{i=1}^{I} Diff_{i,j,t} \tag{2.3}$$

Several studies, including Nelson and Phelps (1966) and Benhabib and Spiegel (2005) suggest that the distance from the technology frontier matters for diffusion. As a general rule: technology diffuses slower when closer to the technology frontier. Table 2.3 shows growth rates and average usage intensity relative to the frontier for several technology categories and separates between developed and developing countries.

[11] Comin and Hobijn (2009a) suggest 3 ways to deal with obsolete technologies: a) Use information on the invention date of the new technology to censor the data for the dominated technology, b) Observe when the distribution of technology across countries becomes stable, and c) Use a different censoring year per technology and country which corresponds to the year when the technology reaches the maximum adoption level in the country. This paper uses the latter approach.

For the period 1980 - 2000, developed countries use on average 65% of their frontier intensity. The usage intensity relative to the frontier in developing countries is slightly lower at 61%. Both country groups are relatively close to their frontier in the categories agriculture and transportation, while the use of general purpose and telecommunication technologies only make up around 50% of the frontier. Regardless of the technology category, developing countries are further away from their frontier than developed countries.

The larger distance from the frontier of developing countries is also reflected in the growth rate of usage intensities. In line with Nelson and Phelps (1966), Benhabib and Spiegel (2005) and others, developing countries catch up faster to their frontier relative to developed countries. Technology diffusion in developing countries is 33%, and approximately twice as fast as in developed countries. The difference in diffusion is particularly large in agricultural and general purpose technologies.

Table 2.3: Descriptives: Technology Usage Intensities

	Growth rate of Usage Intensity		Distance to Frontier	
	Developed Countries	Developing Countries	Developed Countries	Developing Countries
Aggregate	0.15	0.33	0.65	0.61
	(0.13)	(0.55)	(0.16)	(0.16)
N	150	440	150	440
Agriculture	0.04	0.18	0.85	0.78
	(0.06)	(1.08)	(0.15)	(0.18)
N	125	395	127	405
Transportation	0.04	0.07	0.81	0.78
	(0.03)	(0.15)	(0.15)	(0.19)
N	133	319	134	327
General Purpose	0.27	0.74	0.52	0.49
	(0.37)	(1.87)	(0.20)	(0.24)
N	142	397	144	407
Telecommunication	0.17	0.30	0.59	0.51
	(0.17)	(0.62)	(0.20)	(0.21)
N	150	440	150	440

Growth of Technology Usage, and Usage Intensity as share of Technology Frontier. Table A.2.2 describes technology categories; Sample includes 30 developed and 88 developing countries between 1978 and 2002 in 5 year averages; Standard Deviations in parenthesis;

2.3.3 Descriptives

By combining CHAT data and data on international factor movements I construct an unbalanced panel data set of 88 developing and 30 developed countries for the period 1980 - 2000 in 5 year intervals.[12] For a list of countries in the sample, please refer to Table A.2.3.

[12]For trade: the year 1980 refers to the average trade volume for the period 1978 - 1982. FDI and subsequent years are analogous.

Developing countries are slightly further behind their own technology frontier relative to developed countries, but growth rates of technology diffusion are approximately twice as fast. This implies that the level of technology usage in developing countries is catching up with developed countries.[13] Trade and FDI flows are 21% and 29% larger in developed countries relative to developing countries in the sample. Total emigration from developed countries is approximately 2.5 times larger relative to developing countries, with the majority of individuals migrating to OECD countries (4.8% and 1.6% respectively). These numbers are approximately in line with findings by the UN Population Facts 2013 who estimate North - North migration to make up ca 80% of Northern migration, and South - North to be just over 50% of all Southern migration.[14] Separating migrants into skill groups indicates that the propensity to migrate is highest among the high skilled population. Even though migration of high skilled individuals makes up 70% of the total high skilled population for some developing countries in the sample, on average, the emigration among high skilled individuals is comparable to developed countries

Table 2.4: Summary Statistics

	Developed Countries	Developing Countries
Growth of Usage Intensity	0.15	0.33
	(0.13)	(0.55)
Distance to Frontier	0.65	0.61
	(0.16)	(0.16)
Trade (% of GDP)	79.96	66.22
	(63.32)	(35.60)
FDI Inflow (% of GDP)	2.29	1.77
	(3.25)	(2.59)
Total Emigration (% of Pop.)	6.07	2.46
	(6.33)	(3.79)
Emigration to OECD (% of Pop.)	4.82	1.56
	(4.86)	(2.71)
Low Skilled Emigr. (% of Low Skilled Pop.)	6.67	1.73
	(8.07)	(2.95)
Med. Skilled Emigr. (% of Med. Skilled Pop.)	4.55	3.45
	(4.98)	(6.35)
High Skilled Emigr. (% of High Skilled Pop.)	11.18	13.54
	(9.32)	(13.14)
N	138	369

Sample includes 30 developed and 88 developing countries between 1978 and 2002 in 5 year averages (see Table A.2.3). Table A.2.1 contains variable definitions; S.D. in parenthesis;

[13]This result is in line with the Global Economic Prospects, which states that technological progress in both low- and middle-income countries has increased more rapidly than in high-income countries since the early 1990s.

[14]North refers high income countries: see http://publications.iom.int/bookstore/free/WMR2013_EN.pdf for details

2.4 Estimation

The benchmark regression model takes the form

$$Diff_{jt} = \beta_0 + \beta_1 Frontier_{jt} + \beta_2 FDI_{jt-1} + \beta_3 Trade_{jt-1} + \beta_4 Migration_{jt-1} + \mu_t + \delta_j + u_{jt} \tag{2.4}$$

where $Diff_{jt}$ is the growth rate of usage intensities at time t in country j. $Frontier$ measures the distance of a country's technology usage from its technology frontier. It is included to account for the empirically observed fact that the speed of diffusion depends on the already existing level of technology in an economy. Depending on the specification, $Migration$ measures one of three things: Total emigration from country j as a percentage of total population, total emigration from country j to OECD countries as a percentage of total population, and emigration from country j by skill level (high, medium and low) as a percentage of the country's population with the respective skill level. Finally, μ_t and δ_j represent country and time fixed effects. I include both country and time fixed effects to reduce potential endogeneity stemming from unobserved factors that are unlikely to change over time, such as geographical proximity or institutional quality, or that are common to all countries, such as the global economic climate.

The estimation of equation (2.4) warrants some discussion. First, technology diffusion and the covariates could be determined simultaneously. Second, omitted factors, such as education, are likely to be correlated with both technology diffusion and other covariates. To deal with omitted variables, in addition to including fixed effects, I test the results of the benchmark specification for robustness using Extreme Bounds Analysis. Specifically, I test the results for robustness by including a country's GDP, investments, capital stock, credit-to-GDP ratio and educational level. The first four might affect technology diffusion as they expand an economy's resource envelope. A larger envelope allows an economy to allocate more resource towards R&D and technology diffusion. Education affects technology diffusion as higher human capital facilitates the implementation and usage of new technologies.

Simultaneity can be an issue because international factor movements might affect diffusion as described in Section 2, and vice versa. For instance, FDI could be attracted to countries in which technology diffusion, and thus productivity, is growing relatively fast. This would lead to a positive correlation of FDI and diffusion that does not provide evidence for FDI spillovers. Alternatively, it could be that FDI is attracted to backward countries to capture these markets. In that case, the correlation of diffusion and FDI might be negative. To avoid the possibility of technology diffusion attracting international production factors, I regress diffusion on lagged values of international trade and factor movements. The rationale behind this

strategy is that last period's FDI can have an effect on diffusion today, but today's speed of diffusion cannot affect variables in the past.

A last issue for all time-series based growth regressions is how to filter out the business cycle effects in order to concentrate on the long-term relations that are relevant for economic growth. The most common technique is to take five-year averages of the data.[15] This approach has the additional advantage that it allows for the possibility of slow adjustment of some of the variables. For example, Cheng and Wall (2005) argue that dependent and independent variables cannot fully adjust in a single year's time.

2.5 Results

In this section I will provide insight into the determinants of within-country technology diffusion by estimating regression equation (2.4) for developed and developing countries. Moreover, I test the results for robustness along two dimensions. First, I use extreme bounds analysis to examine the potential effects of omitted variables. Second, I test the sensitivity of the results to the definition of developed countries. For example, South Korea is considered a developed country in 2012, but it was not in 1995. Alternatively, the BRIC economies (Brazil, Russia, India, and China) are at the verge of development and might cloud the results for developing countries.

2.5.1 Benchmark Model

2.5.1.1 Total Migration

Columns 1) - 2) of Table 2.5 show the effect of FDI, trade, and migration on technology diffusion. Neither trade nor FDI contribute to technology diffusion in developed or developing countries. An explanation could be the geographical concentration of trade and FDI within large cities due to cluster effects, as shown by Broadman and Recanatini, 2001 and Cheung and Ping, 2004. As a consequence, trade and FDI increase the exposure in certain regions within a country, but do not contribute to diffusion throughout. Harrison and Aitken, 1999 and Djankov and Hoekman, 1998 provide an alternative explanation. Their study about Venezuelan and Czech firms finds evidence of positive spillover effects for FDI receiving firms but negative spillovers for domestically owned firms. Thus, the overall effect of FDI on technology diffusion is negligible.

International labor movements affect technology diffusion, however only in developing countries: a one percent increase in migration accelerates diffusion by 0.31%. In addition, the distance to the technology frontier has a significant effect on diffusion in developing countries: a one percent increase in the distance

[15] see for example Grier and Tullock (1989), Islam (1995), and Caselli, Esquivel, and Lefort (1996)

from the frontier speeds up diffusion by 0.95%. Thus, international labor movements are the only significant factor movements contributing to technology diffusion, and only in developing countries. This raises two kinds of questions: First, can the insignificant effect of migration in developed countries be explained by opposite effects of high and low skilled migrants on diffusion? For example, the migration of high skilled workers may lead to a brain drain causing a negative effect of diffusion, while the migration of low skilled workers may enhance diffusion through remittances. Second, what drives the positive effect of migration in developing countries? Are the results driven by the skill composition of migrants or do migrants' destination play a more important role in technology diffusion?

2.5.1.2 Migration by Skill

This section takes a closer look at the role of migrants' skill level in technology diffusion. On the one hand, high-skilled migration decreases a country's absorptive capacity by draining the economy of its human capital. On the other hand, skilled migrants may have greater exposure to new technology in their host country relative to their less skilled counterparts. Consequently, high skilled migration might be more effective in enhancing technology diffusion relative to less skilled migrants. Moreover, a migrant's skill level may affect within-country technology diffusion through the amount of remittances sent back. However, existing literature has not reached a consensus regarding the sign of this relationship. For example, Bollard et al. (2011) shows that remittance flows increase with a migrant's skill level. Thus, if the share of low-skilled migrants is large remittance flows may not be sufficient to raise the purchasing power at home to adopt new technology. In contrast, Faini (2007) and Niimi, Ozden, and Schiff (2010) show that high-skilled migrants tend to remit less.

Results in columns 3) and 4) of Table 2.5 do not suggest the presence of skill effects in either developed or developing countries. As for developing countries, skilled migration is approximately twice as large as in developed countries. However, 50% of all migrants from developing countries and almost 40% of high skilled workers from developing countries tend to stay within developing countries, according to World Bank data. Therefore, a large share of skilled migrants from developing countries is not exposed to new technology, which in turn limits the rate of diffusion. In developed countries, the Brain Drain is less pronounced relative to developing countries, and remittances are less important. Consequently, an increase in high-skilled migration relative to low-skilled migration does not significantly limit the absorptive capacity within the country. Additionally, developed countries are already relatively close to the technology frontier. Therefore, an increase in high-skilled migration relative to low skilled-migration does little to affect a developed country's exposure to new technology.

To sum up, the skill composition of migration does not significantly contribute to technology diffusion in the home country. Thus, who migrates is relatively unimportant for technology diffusion at home. The next section examines in how far a migrant's destination is more important for technology diffusion relative to their skill level.

2.5.1.3 Migration to OECD

Since the data do not suggest a skill effect of migration on technology diffusion, maybe a migrant's choice of destination country matters for technology diffusion. OECD countries are usually among the first adopters of new technologies, resulting in a higher likelihood of exposure of their immigrants.[16] Besides exposure, higher potential earnings in developed countries lead to relatively more remittances relative to developing countries. According to Ratha and Shaw (2007), remittances from developed to developing countries account for approximately 70% of all remittances, even though migration from developing countries is split almost evenly between developed and developing countries. These capital inflows facilitate the adoption of new technologies by increasing an economy's financial resources.

Columns 5 and 6 of Table 2.5 present the effects of international trade and factor movements on technology diffusion, using migration to OECD countries as a measure for international labor mobility. As in the previous cases, FDI and trade do not significantly affect diffusion. In contrast, migration to OECD countries has a positive impact on technology diffusion in developing economies. A one percent increase in migration to OECD countries increases diffusion by 0.36%. Thus, the effect of migration to OECD countries is almost identical to the effect of overall migration.

Having established the presence of a location effect of migration, columns 7 and 8 briefly re-examine the role of skilled migration, this time only accounting for skilled and unskilled migration to OECD countries. While the ratio of low-to-high skilled migration does not significantly affect diffusion in developed countries, a one percent increase in low-skilled migration relative to high-skilled migration in developing countries increases the rate growth rate of technology diffusion by 0.2%. Intuitively, an increase in the share of low skilled migration relative to high skilled migration increases both exposure to new technology and absorptive capacity of the home country without the negative consequences of a Brain Drain.

To summarize the main findings: Migration in developing countries is the only significant international factor movement affecting technology diffusion. This effect is explained by a location effect: technology diffusion in developing countries is entirely driven by the destination of the migrant, while the effect of a

[16] Comin and Hobijn (2010) report that developed countries adopt new technologies, on average, 15 years before the average adopter; developing countries 7 years after the average adopter.

migrant's skill level, in general, is insignificant. In other words, "who" migrates does not matter, but the choice of the destination country does.

Table 2.5: Estimation Results

	Total Migration		Migration by Skill		Migration to OECD			
	Developed	Developing	Developed	Developing	Developed	Developing	Developed	Developing
Frontier	-1.143	-0.945**	-1.020	-0.924*	-1.865	-1.082**	-0.987	-0.920*
	(0.910)	(0.487)	(0.956)	(0.489)	(1.204)	(0.498)	(0.927)	(0.495)
FDI	-0.053	0.043	-0.059	0.043	-0.092	0.046	-0.099	0.049
	(0.130)	(0.044)	(0.134)	(0.046)	(0.121)	(0.045)	(0.122)	(0.046)
Trade	-0.731	-0.065	-0.696	-0.084	-0.350	-0.080	-0.874	-0.108
	(0.665)	(0.266)	(0.738)	(0.273)	(0.747)	(0.269)	(0.645)	(0.273)
Total Migr	0.280	0.309***	-	-	-	-	-	-
	(0.165)	(0.103)	(-)	(-)	(-)	(-)	(-)	(-)
Low/High	-	-	-0.235	0.120	-	-	-	-
	(-)	(-)	(0.298)	(0.098)	(-)	(-)	(-)	(-)
Migr to OECD	-	-	-	-	1.384	0.364***	-	-
	(-)	(-)	(-)	(-)	(0.889)	(0.120)	(-)	(-)
Low/High	-	-	-	-	-	-	0.157	0.206**
to OECD	(-)	(-)	(-)	(-)	(-)	(-)	(0.284)	(0.105)
N	102	277	102	277	102	277	102	277

Standard errors clustered by country. Regressions include both country and year effects. Variables are in logs and defined in TableA.2.1, Sample includes 30 developed and 88 developing countries between 1978 and 2002 in 5 year averages; Standard Deviations in parenthesis; *, ** and *** denote 10, 5 and 1 %significance levels.

2.5.2 Robustness

2.5.2.1 Extreme Bounds Analysis

While this paper focuses on the effect of international trade and factor movements on technology diffusion, there are several other factors that have the potential to affect a countries exposure to new technology and its adaptive capacity. The omission of these factors can potentially cause biased estimates. To address this issue, this chapter carries out Extreme Bounds Analysis.

Traditionally, Extreme Bounds Analysis (EBA) is used to test robust empirical relations in the economic growth literature.[17] The underlying concern is that a variable can be found to have a significant effect in one specification, but the variable becomes insignificant once we add or omit certain other variables. Levine and Renelt (1992) addressed this problem by using EBA to identify robust empirical relations. The test considers a pool of N variables that have been identified to be related to the dependent variable. To identify

[17]see Sala-i Martin (1997) and Levine and Renelt (1992)

whether a particular variable z is robust, one estimates the regression

$$\gamma = \alpha_j + \theta_t + \beta_{yj}Y + \beta_{zj}Z + \beta_{xj}X_j + \epsilon \tag{2.5}$$

where Y is a vector of variables that always appears in the regression, Z is the variable of interest, and $x_j \in X$ is a vector of variables taken from the pool of N potentially influential variables. The model then needs to be estimated for all the possible combinations of $x_j \in X$. The two extreme bounds are defined as the lowest value of $\beta_{zj} - 2\sigma_{zj}$, and the highest value of $\beta_{zj} + 2\sigma_{zj}$. If the lower extreme bound and the upper extreme bound share the same sign, then variable z is said to be significant. Sala-i Martin (1997) developed an alternative, less strict, criteria. He argues that the robustness criteria should depend on the fraction of the density function lying on each side of the zero. If 95 percent of the density function for the estimates of β_{zj} lie on one side of zero, the variable is significant.[18]

Table A.2.4 shows results for the extreme bound analysis of both Leamer and Sala-I-Martin for Table 2.5. The z variable includes either trade, FDI, or migration. The vector Y contains those variables that did not enter z. Other variables that potentially affect technology diffusion are a country's GDP, credit-to-GDP ratio, education, investment-to-GDP ratio and capital stock relative to GDP. To conduct EBA, a combination of these variables is included in the X-Vector. GDP, investments, and the credit-to-GDP ratio might affect technology diffusion as they expand an economy's resource envelope. A larger envelope allows an economy to allocate more resource towards R&D and the adoption of new technologies. Education affects technology diffusion by facilitating the implementation and usage of new technologies. Finally, the capital stock affects both productivity and wages and may therefore cause an omitted variable bias. Table A.2.4 does not confirm the concerns about potential endogeneity from omitted variables. EBA suggests that the effect of international trade and factor movements on technology diffusion from the benchmark case are robust and do not depend on the inclusion of additional variables.

Besides robustness, EBA provides information about other factors of technology diffusion. Results show no evidence of a significant link between factor movements and technology diffusion in developed countries. Examining the additional 5 variables included in the EBA (GDP, credit-to-GDP ratio, education, investment-to-GDP ratio and capital stock relative to GDP) identifies a country's investment-to-GDP ratio as the major determinant of technology diffusion in developed countries. Investments significantly increase technology diffusion in every combination included, with the effect of increasing diffusion by 1%-2% for every 1% increase in investments.

[18] Sala-i Martin (1997) weighs both the coefficient and standard error by the integrated likelihood ratio to give more weight to the regression that are more likely true. Both Jan-Sturm and de Haan (2005) and Gassebner, Lamla, and Vreeland (2013) conduct their EBA without weights as all specification are equally likely to be "true"

2.5.2.2 Sample Selection

The definition for a developed country is rather vague. While there are several countries that clearly fall into the category of a developed country, sometimes the classification is less obvious. Moreover, development is a dynamic concept where countries can be re-assigned a new status. For example, the IMF reclassified Greece and Portugal from developing to developed countries in 1989. In 1997, Israel, Korea, and Singapore were added to the group of developed countries. After 1997, additions to the advanced country group include, amongst others, the Czech Republic. Since my sample period includes years well before any of these countries where assigned the status of developed countries I re-examine the effect of FDI, trade and migration with Greece, Portugal, Israel, Korea, Singapore, Czech Republic, Slovakia, Slovenia and Estonia as developing countries. Table A.2.5 show that re-categorizing these countries does not significantly change the results.

In a final robustness check, I drop the countries Brazil, Russia, India, and China from the list of developing countries. The BRIC countries include the 4 largest emerging economies, according to Morgan Stanley. Due to their tremendous growth potential and economic power the inclusion of these countries in the developing country category might cloud the effect of trade, FDI, and migration. Table A.2.6 shows that dropping these countries from the list of developing countries does not significantly change the results. FDI, trade and migration have the same effect on diffusion in developing countries relative to the benchmark case.

2.6 Conclusion

This paper examines the role of international trade and factor movements in determining within-country technology diffusion in developed and developing countries, with a particular focus on emigration. Many emerging economies, such as China and India, have technologically advanced cities and high-tech firms who do not lag far behind the technology level of developed countries. Yet, most of the population and most firms operate in a low-tech environment because the diffusion of technologies within countries is often slow. International trade and factor movements might contribute to within-country diffusion in two ways: by increasing the exposure to new technology, and by increasing the capability to absorb these technologies. For example, trade can accelerate technology diffusion through providing a larger variety of products, it enhances the international discussion of production process and organizational behavior, and trade provides new knowledge that would otherwise be costly to acquire. FDI may positively affect technology diffusion as new shareholders try to maximize profits and dividends through influencing production processes, and by enhancing knowledge transfers, which can then spread to other companies through labor turnover. Yet, the

presence of cluster effects can cause trade and FDI to be geographically concentrated, which in turn limits their ability to spread new technologies throughout the country.

While trade and FDI policies have become steadily more liberal throughout the world to capture some of the potential benefits associated with technology diffusion, immigration policies in receiving countries have grown quite restrictive (Faini, 2004). Yet, migration stocks have increased by 30% between 1990 and 2000, according to Artuc et al., 2014. On the one hand, this increase in international labor movements bears the potential to enhance technology diffusion through remittances, knowledge-sharing and return migration after accumulating human capital abroad. On the other hand, migrations drains the home country of its human capital necessary to adopt and implement new technologies. A priori, which effect dominates is unclear, and might further depend on a migrant's skill level or choice of destination country. Consequently, I highlight the role of migration in the aggregate, by skill level, and by destination.

The main findings of the paper indicate that trade and FDI do not contribute to technology diffusion within countries. In contrast, international labor movements enhance technology diffusion, however only in developing countries: a one percent increase in migration from developing countries accelerates the growth rate of technology usage within a country by 0.3%. Further, I examine the effect of a migrant's skill level and choice of destination to determine the main aspect of migration in facilitating technology diffusion. Results show that the skill level of migrants does not alter the speed of diffusion in developed or developing countries. In contrast, the choice of the host country matters for migration from developing countries. A one percent increase in migration from developing countries to OECD countries accelerates diffusion by 0.36%. These results suggest that a migrant's destination is more important to technology diffusion than its skill level. I test these results for robustness using extreme bounds analysis, and alternating the sample of developed and developing countries. Both tests confirm the initial results. Moreover, EBA suggests that domestic investment are the only significant channel of technology diffusion in developed countries.

The following policy implications may be derived from the results in this paper: worldwide, countries spend large amounts of resources to attract foreign firms, based on the premise that FDI leads to technology transfer and subsequent productivity gains for domestic firms. However, such large subsidies can only be justified if FDI, or imports for that matter, generate substantial positive externalities or technology spillovers for domestic firms (Keller and Yeaple, 2009). This study casts doubt on the potential of FDI to cause such externalities. Instead, developing countries might benefit from investing in the international exchange of human capital, especially with OECD countries.

As usual, some caveats apply. First, the paper is agnostic as to how migration affects diffusion in developed and developing countries. Potential reasons could include information transfers through networks and re-migration, or the transfer of remittances, for all of which data is limited. By gaining a better understanding

through which channel migration affects technology diffusion policies can be implemented to unleash the full potential of migration. Second, future research should put more emphasis on the overall welfare effects of migration on the economy. While this paper attests a positive link between migration and technology diffusion, the effects of migration on the economy as a whole are not clear.

Appendix 1

Table A.2.1: List of Variables

Name	Definition	Source
Tech. Diffusion	Growth of Usage intensity of country i at time t	CHAT: Author's calculation
Frontier	Distance to country i's technology frontier at time t	CHAT: Author's calculation
FDI Inflow	Net inflows (new investment inflows less disinvestment) in the reporting economy from foreign investors, as share of GDP	World Bank
Trade	Sum of exports and imports of goods and services measured as a share of GDP	World Bank
Credit	Credit to the private sector as a share of GDP	World Bank
Migr to OECD	Number of foreign born living in 20 OECD countries as share of home country i's population. 20 OECD destination countries: Australia, Austria, Canada, Chile, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, and United States.	IAB Brain Drain Data
Total Migr	Total Emigration rates from country i, all education levels	IAB Brain Drain Data
Migr Low	Low skilled emigration rates from country i	IAB Brain Drain Data
Migr Medium	Medium skilled emigration rates from country i	IAB Brain Drain Data
Migr High	High skilled emigration rates from country i	IAB Brain Drain Data
Education	Years of tertiary schooling	Barro & Lee
Capital Stock	Real Capital Stock as a share of GDP	Penn World Table
Public Investment	Public Investment as a share of GDP	Penn World Table
Private Investment	Private investment as a share of GDP	Penn World Table

Table A.2.2: List of Technologies

Category	Technology	Definition
Agriculture	Harvester	Number of self-propelled machines that reap and thresh in one operation
	Irrigated area	Irrigated area as a share of cultivated land
	Tractor	Number of wheel and crawler tractors used in agriculture
	Fertilizer	Metric tons of fertilizer consumed
Transportation	Rail I	Thousands of passenger journeys by railway
	Rail II	Geographical/route lengths of line open at the end of the year
	Rail III	Metric tons of freight carried on railways
	Vehicle I	Number of passenger cars in use
	Vehicle II	Number of commercial vehicles, typically including buses and taxis, in use
Telecommunication	Cellphone	Number of users of portable cell phones
	Newspaper	Number of newspaper copies circulated daily
	Radio	Number of radios
	Telephone	Number of mainline telephone lines
	TV	Number of television sets in use
	Cable TV	Number of households that subscribe to a multichannel television service delivered by a fixed line connection
General Purpose	Internet	Number of people with access to the worldwide network
	Computer	Number of self-contained computers designed for use by one person
	Electricity	Gross output of electric energy in KwHr

Definitions are taken from Comin and Hobijn (2009b)

Table A.2.3: List of countries

Developed Countries			Developing Countries			
Australia	Greece	Portugal	Albania	Dominican Republic	Malawi	Saudi Arabia
Austria	Iceland	Singapore	Argentina	Ecuador	Malaysia	Senegal
Belgium	Ireland	Slovakia	Armenia	Egypt	Mali	Sierra Leone
Canada	Israel	Slovenia	Bangladesh	El Salvador	Mauritania	South Africa
Czech Republic	Italy	South Korea	Belize	Gabon	Mauritius	Sri Lanka
Denmark	Japan	Spain	Benin	Gambia	Mexico	Sudan
Estonia	Luxembourg	Sweden	Bolivia	Ghana	Moldova	Swaziland
Finland	Netherlands	Switzerland	Botswana	Guatemala	Mongolia	Syria
France	New Zealand	United Kingdom	Brazil	Honduras	Morocco	Tajikistan
Germany	Norway	United States	Bulgaria	Hungary	Mozambique	Tanzania
			Burundi	India	Namibia	Thailand
			Cambodia	Indonesia	Nepal	Togo
			Cameroon	Iran	Niger	Tunisia
			C.A.R.	Jordan	Pakistan	Turkey
			Chile	Kazakhstan	Panama	Uganda
			China	Kenya	Paraguay	Ukraine
			Colombia	Kuwait	Peru	Uruguay
			Congo, Dem.Rep.	Kyrgyzstan	Philippines	Venezuela
			Congo, Rep.	Laos	Poland	Vietnam
			Costa Rica	Latvia	Romania	Yemen
			Ivory Coast	Lesotho	Russia	Zambia
			Croatia	Liberia	Rwanda	Zimbabwe

Sample includes 30 developed countries and 88 developing countries between the period 1978 and 2002 in 5 year averages.

Table A.2.4: Extreme Bound Analysis

Z-Variables	Avg β	Avg s.e.	Avg t-score	Min β	Min s.e.	Max β	Max s.e.	Leamer	Sala-I-Martin
Developed Countries									
FDI	-0.087	0.122	-0.728	-0.123	0.110	-0.049	0.137	Robust	Robust
Trade	-1.059	0.651	-1.687	-1.494	0.598	-0.564	0.724	Robust	Robust
Total Migration	0.188	0.155	1.214	0.077	0143	0.309	0.162	Robust	Robust
Developing Countries									
FDI	0.034	0.045	0.757	.0023	0.044	0.044	0.047	Robust	Robust
Trade	-0.190	0.291	-0.647	-0.304	0.307	-0.074	0.266	Robust	Robust
Total Migration	0.329	0.098	3.364	0.272	0.097	0.371	0.098	Robust	Robust
Developed Countries									
FDI	-0.141	0.119	-1.213	-0.163	0.109	-0.113	0.133	Robust	Robust
Trade	-1.096	0.667	-1.705	-1.526	0.640	-0.583	0.779	Robust	Robust
Low/High Migration	-0.253	0.236	-1.095	-0.373	0.238	-0.148	0.234	Robust	Robust
Developing Countries									
FDI	0.043	0.046	0.919	0.031	0.045	0.053	0.048	Robust	Robust
Trade	-0.242	0.301	-0.798	-0.355	0.318	-0.134	0.274	Robust	Robust
Low/High Migration	0.146	0.105	1.390	0.102	0.103	0.190	0.108	Robust	Robust
Developed Countries									
FDI	-0.114	0.112	-1.038	-0.140	0.100	-0.088	0.120	Robust	Robust
Trade	-0.808	0.671	-1.272	-1.286	0.586	-0.330	0.724	Robust	Robust
Migration to OECD	1.064	0.867	1.231	0.665	0.779	1.483	0.917	Robust	Robust
Developing Countries									
FDI	0.035	0.045	0779	0.022	0.043	0.046	0.045	Robust	Robust
Trade	-0.196	0.296	-0.659	-0.297	0.312	-0.089	0.269	Robust	Robust
Migration to OECD	0.408	0.124	3.286	0.313	0.117	0.478	0.129	Robust	Robust
Developed Countries									
FDI	-0.1145	0.113	-1.052	-0.138	0.100	-0.088	0.132	Robust	Robust
Trade	-1.157	0.632	-1.830	-1.564	0.588	-0.659	0.722	Robust	Robust
Low/High to OECD	0.199	0.271	0.780	0.058	0.318	0.352	0.234	Robust	Robust
Developing Countries									
FDI	0.040	0.046	0.869	0.028	0.044	0.050	0.048	Robust	Robust
Trade	-0.235	0.298	-0.785	-0.356	0.313	-0.121	0.273	Robust	Robust
Low/High to OECD	0.243	0.111	2.287	0.195	0.105	0.281	0.114	Robust	Robust

Standard errors clustered by country. Regressions include both country and year effects. Variables are in logs and defined in TableA.2.1. FDI, Trade, and Emigration sequentially included in the y-vector with the other variables being included in the z-vector. A combination of the variables GDP, credit, education, capital stock, and investment are added. Sample includes 30 developed and 88 developing countries between 1978 and 2002;

Table A.2.5: Robustness: Re-classification

	Total Migration		Migration by Skill		Migration to OECD			
	Developed	Developing	Developed	Developing	Developed	Developing	Developed	Developing
Frontier	-1.609	-1.226**	-1.785	-1.203**	-2.241*	-1.357***	-1.640	-1.192**
	(1.086)	(0.474)	(1.184)	(0.470)	(1.250)	(0.483)	(1.085)	(0.480)
FDI	-0.066	0.048	-0.087	0.049	-0.084	0.050	-0.099	0.054
	(0.120)	(0.045)	(0.111)	(0.046)	(0.107)	(0.045)	(0.110)	(0.046)
Trade	-0.613	0.021	-0.393	0.019	0.173	0.007	-0.736	-0.011
	(0.692)	(0.262)	(0.765)	(0.268)	(1.016)	(0.265)	(0.684)	(0.270)
Total Migr	0.182	0.309***	-	-	-	-	-	-
	(0.164)	(0.100)	(-)	(-)	(-)	(-)	(-)	(-)
Low/High	-	-	-0.439	0.114	-	-	-	-
	(-)	(-)	(0.316)	(0.097)	(-)	(-)	(-)	(-)
Migr to OECD	-	-	-	-	1.838	0.376***	-	-
	(-)	(-)	(-)	(-)	(1.331)	(0.115)	(-)	(-)
Low/High							0.161	0.208***
to OECD							(0.268)	(0.107)
N	78	301	78	301	78	301	78	301

Standard errors clustered by country. Regressions include both country and year effects. Variables are in logs and defined in TableA.2.1, Sample includes 21 developed and 97 developing countries between 1978 and 2002 in 5 year averages; Standard Deviations in parenthesis; *, ** and *** denote 10, 5 and 1 %significance levels.

Table A.2.6: Robustness:BRIC

	Developing	Developing	Developing	Developing
Frontier	-0.980**	-0.955*	-1.112**	-0.948*
	(0.491)	(0.489)	(0.500)	(0.495)
FDI	0.041	0.042	0.044	0.049
	(0.044)	(0.046)	(0.044)	(0.046)
Trade	-0.044	-0.057	-0.053	-0.092
	(0.276)	(0.283)	(0.281)	(0.285)
Total Migr	0.312***	-	-	-
	(0.104)	(-)	(-)	(-)
Low/High	-	0.097	-	-
	(-)	(0.097)	(-)	(-)
Migr to OECD	-	-	0.358***	-
	(-)	(-)	(0.122)	(-)
Low/High				0.175*
to OECD				(0.104)
N	264	264	264	264

Standard errors clustered by country. Regressions include both country and year effects. Variables are in logs and defined in TableA.2.1, Sample includes 84 developing countries between 1978 and 2002 in 5 year averages; Standard Deviations in parenthesis; *, ** and *** denote 10, 5 and 1 %significance levels.

Chapter 3

The Macroeconomic Consequences of Remittances

3.1 Introduction

Remittances have become an increasingly important channel through which wealth is transferred across the world, as migrant workers and immigrants repatriate portions of their earnings back to their home countries. Over the last two decades these flows have grown remarkably, representing the second-largest flow of capital across the world (after FDI), and accounting for almost a third of all international capital flows (Yang, 2011). As such, remittances represent a critical component of both household and national budgets, as they free up scarce domestic resources that can be allocated to consumption, investment, and other expenditures. These inflows assume even more importance in environments where recipients otherwise have limited access to domestic credit markets, or where such markets are not well developed. The objective of this paper is to examine the mechanism through which remittances are absorbed by households that receive them and, how, in turn, these allocation decisions affect the macro-dynamic adjustment of recipient economies.

Table 3.1 shows the average share of remittances and private-sector credit in GDP for (i) 73 countries divided into geographical sub-groups, and (ii) the top-15 remittance-recipient countries for the period 1995-2014.[19] Irrespective of geographical sub-division, remittances accounted for a significant proportion of national incomes, with a range between 8-11% of GDP. For the top-15 remittance recipients, however, these flows represented 21% of GDP. On the other hand, the average share of private-sector credit in these countries during this periods was only about 37% (and about 28% for the top-15 remittance recipients). By comparison, the average private credit-to-GDP ratio in high-income countries was almost twice as high, at 71%. The relatively large share of remittances and low share of private-sector credit in GDP underscore the importance of understanding how these variables interact to affect resource allocation decisions.

[19]This group includes countries that received, on average, at least 3 % of their GDP in the form of remittances during 1995-2014. Data Source: The World Bank.

A priori, however, the transmission mechanism through which remittances work into household allocation decisions is difficult to predict. On the one hand, remittances, by relaxing borrowing constraints, might lower the marginal utility of wealth and cause an increase in the consumption of all normal goods, including leisure. This may have adverse consequences for investment and capital accumulation. On the other hand, they may alter the relative price of investment goods, causing an increase in capital accumulation and labor. Further, the relative magnitudes of these effects may depend critically on the distribution of asset-ownership across households. In other words, credit-constrained households who have little or no ownership of capital may react very differently to an inflow of remittances relative to households who own capital or are not credit constrained.

Table 3.1: Remittances and Private-Sector Credit (% of GDP), 1995-2014

	Rem/GDP	Credit/GDP
Latin America	7.9	46.1
Sub-Saharan Africa	9.9	16.1
Middle East and North Africa	10.4	49.4
Europe and Central Asia	11.4	31.5
East Asia	10.2	46.4
South Asia	7.8	33.3
Top-15 Remittance Recipients	21.0	27.9

Given the sheer magnitude of remittance flows to developing countries, their economic impact has naturally become an important area of research.[20] However, there is little consensus among economists on the usage and absorption of remittances at the household level. While Durand et al. (1996), Brown and Ahlburg (1999), and Combes and Ebeke (2011) find that remittances primarily finance household consumption, Woodruff and Zenteno (2007), Yang (2008), Bansak and Chezum (2009), and Alcaraz, Chiquiar, and Salcedo (2012) find that remittances are used for financing investments, mainly in education and entrepreneurship. Recent evidence from household survey data collected by the Development Prospects Group of The World Bank further underscores this ambiguity. For example, household survey data from The World Bank's Africa Migration project indicates that between 18-50% of remittances were used for business investment in 2009. On a similar vein, Adams and Cuecuecha (2010) document a reduction in expenditure on non-durables and an increase in expenditures on durables for remittance-receiving families in Guatemala. On the other hand, Acosta, Fajnzylber, and Lopez (2008) survey a larger group of Latin American countries to find that this pattern shows a lot of variation both across and within countries, especially when one controls

[20]The current literature on the macroeconomic impact of remittance inflows is also related to the much broader literature on the effect of international transfers, which dates back to the work of Keynes (1929) and Ohlin (1929) on the "Transfer Problem", and includes a variety of such transfers, such as aid, resource discoveries, FDI, among others; See, for example, Turunen-Red and Woodland (1988), Van Wincoop (1993), Brock (1996), and Chatterjee, Sakoulis, and Turnovsky (2003).

for geography (rural versus urban) and distributional issues. Using a calibrated DSGE model, Durdu and Sayan (2010) show that while remittances dampen economic fluctuations in Mexico, they have the opposite effect in Turkey.[21] These studies seem to indicate that there is significant variation in the usage of remittances across recipients (households or countries) which, in turn, may lead to very different macroeconomic outcomes.

We argue in this paper that in the presence of binding borrowing constraints, the distribution of ownership of capital plays an important role in determining how remittance inflows are channeled into economic activity. Specifically, we consider two types of households facing binding credit constraints in a small open-economy DSGE model: those that own physical capital (and thereby firms) but have limited access to credit markets, called *entrepreneurs*, and those that have no ownership of capital or access to credit markets, deriving their income solely from supplying labor, called *wage earners* (hand-to-mouth households). We show that with this specification, remittances accruing to entrepreneurs tend to expand aggregate economic activity, by increasing investment and the demand for labor. By contrast, when hand-to-mouth wage earners are the principal recipient of remittance inflows, aggregate economic activity *contracts*, driven by a decline in labor supply, which in turn lowers the return on investment. In general, the distribution of remittances across households who are either entrepreneurs or wage earners matters for its aggregate effects when credit constraints are binding: recipients who do not own productive assets tend to respond in a way that is contractionary for the aggregate economy, while recipients with ownership of productive assets tend to respond in a way that is expansionary. In other words, the larger the remittance-share of wage earners, the more contractionary is the economy's dynamic response (and vice-versa).

The underlying preference structure and the presence of credit constraints are two key drivers of the results described above. First, our baseline model specification assumes that hand-to-mouth wage earners are characterized by Cobb-Douglas preferences over their consumption and labor-leisure choices. As such, this preference structure generates an income effect when this group of agents receive remittance inflows, leading to a decline in labor supply which, in turn, helps propagate the contraction over the business cycle. We examine the importance of this channel by extending the baseline specification to include GHH preferences for wage earners, thereby shutting off the income effect (the marginal rate of substitution between consumption and leisure is zero in the GHH utility specification). Indeed, we find that the presence or absence of the income effect matters: when hand-to-mouth wage earners receive remittances, the absence of an income effect leads to the entire remittance flow to be consumed, with no other aggregate consequences for the economy.

[21] Further, while Catrinescu et al. (2009) and Mundaca (2009) find remittances to be beneficial for long-run growth, Chami, Fullenkamp, and Jahjah (2005), Faini (2007), and Barajas et al. (2009) find this relationship to be either neutral or negative. Giuliano and Ruiz-Arranz (2009) and Bettin and Zazzaro (2012) find beneficial effects of remittances conditional on the degree of financial development in the recipient country.

On the other hand, when entrepreneurs are the principal recipients, the absence of an income effect for wage earners increases the expansionary effect of remittances relative to the case of Cobb-Douglas utility. Second, to emphasize the role played by credit constraints, we examine an alternative specification of the baseline model where these constraints are *absent*, with all agents having unrestricted access to capital markets. We find that the presence of binding credit constraints amplify the effects of remittance inflows relative to when these constraints are absent, irrespective of which group of agents (wage earners or entrepreneurs) receives the remittances. Indeed, as we shall discuss below, the presence of binding credit constraints plays an important role in improving the model's fit to the data. We also consider the case where remittances may be counter-cyclical in nature (with inflows increasing on the realization of a negative productivity shock in the recipient country). Here, we show that the larger the share of remittances that accrue to entrepreneurs, the more muted are the effects of a negative productivity shock on output, investment, and labor supply. In other words, the ability of remittances to smooth business cycles depends critically on their distribution between the two groups of agents.[22]

Given that there are two potential groups of agents in our model that may be recipients of remittance inflows, it is important to consider the welfare consequences of the distribution of remittances. Here, we consider two questions: (i) How is one group affected when the other receives all remittances? In other words, if wage earners are the principal beneficiaries of a remittance inflow, how does that affect the well-being of entrepreneurs (and vice versa)? and (ii) how does the distribution of remittances between wage earners and entrepreneurs affect aggregate welfare for the economy? We find that when entrepreneurs receive remittances, wage earners are better off throughout the transition path. In contrast, when wage earners receive remittances, entrepreneurs are always worse off. With respect to aggregate welfare, when entrepreneurs (wage earners) receive remittances, welfare rises (falls) along the transition path.

The quantitative analysis is conducted by using quarterly data for the period 1993-2011 from Philippines, which serves as a good candidate for a representative remittance-recipient country. For example, during the sample period, it received, on average, about 8% of its GDP in the form of remittances, and had an average private-sector credit-to-GDP ratio of about 32%, which is consistent with the corresponding sample averages presented in Table 3.1.[23] The numerical evaluation of our model specification is conducted at two levels. First, we establish that the parameterization of our model specifications (with and without credit constraints)

[22] Another potential channel through which remittances might be absorbed is expenditures on housing and real estate. Several studies provide anecdotal evidence on the importance of remittances for local housing markets; see Sáenz (2007), Ratha and Mohapatra (2007), and Serageldin and Guerra (2008). However, data on real estate prices, investment, rental rates, etc., in remittance-receiving countries are not systematically available. This prevents a meaningful quantitative analysis of the link between remittances and real estate. An alternative version of this paper with housing included in the model specification is available upon request.

[23] Mandelman (2013) also uses data for Philippines to examine the link between remittances and monetary and exchange rate policies. Our emphasis, however, is quite different from that paper, with a focus instead on the distribution of remittances and the role played by credit constraints.

yield steady-state equilibrium quantities that are comparable to the corresponding sample averages for Philippines. Second, we examine the model's fit by comparing the implied moments and correlations from the two specifications (with and without credit constraints) to their counterparts in the data. Here, we combine data on outward migration patterns from the Philippines with bilateral remittance inflows to calibrate the internal distribution of remittances (i.e., between wage earners and entrepreneurs), and show that the resulting model fit is relatively better than those generated by the two polar cases (where only one group of agents is the principal recipient). We also examine the sensitivity of the model fit to (i) the presence or absence of binding credit constraints, and (ii) the underlying preference structure, i.e., Cobb Douglas or GHH utility. In general, the model specification with binding credit constraints performs significantly better than the one without these constraints when comparing the key moments and correlations from the data. Finally, we provide support for our model's main mechanisms by comparing the trends for remittance flows and growth rates of real GDP and private investment in Philippines and Malaysia during the Asian crisis of 1997-1998 and the Global financial crisis of 2008-2009.

This paper contributes to a growing body of work that links remittances to the aggregate economy. For example, Acosta, Lartey, and Mandelman (2009), Durdu and Sayan (2010), Mandelman and Zlate (2012), and Mandelman (2013), respectively focus on the link between remittances and the Dutch Disease, sudden stops, cross-border migration, and the responses of monetary and exchange rate policies. Our paper adds to this literature by highlighting several determinants of the dynamic absorption of remittances that have not been studied systematically in the literature, namely (i) the internal distribution of remittances between heterogeneous agents (based on their relative ownership of capital and access to credit markets), (ii) the presence of binding credit constraints, and (iii) the underlying preference structure of recipients. Our quantitative results are also consistent with the recent empirical findings of Yang (2008), Giuliano and Ruiz-Arranz (2009) and Aggarwal, Demirgüç-Kunt, and Pería (2011), who document that remittances affect economic outcomes by relaxing liquidity constraints in countries with less developed financial systems. Finally, by highlighting the conditions under which remittance inflows can generate either an economic contraction or expansion, we take a step towards reconciling the ambiguity in the literature on the use of remittances.

The rest of the paper is organized as follows. Section 2 outlines the benchmark open-economy DSGE model with heterogeneous households facing binding borrowing constraints and an inflow of remittances from abroad. Section 3 presents the calibration of the model and a discussion of the steady-state equilibrium. Section 4 presents the simulation of the effects of unanticipated temporary remittance shocks and a welfare analysis, while Section 5 discusses the case of the countercyclicality of remittances. Section 6 examines the

model fit to the data, and Section 7 presents some suggestive evidence to support the main mechanisms of the model. Finally, Section 8 concludes.

3.2 Analytical Framework

We consider a small open economy that produces a single traded good and is populated by two types of households. The first category of households supply labor to the production sector, do not own any physical capital, and are *rule-of-thumb* consumers, i.e., they have no access to borrowing or capital markets. As such, these households consume their entire flow of income from wages and remittance receipts every period. We label these households as *wage earners*. The second category of households own physical capital (and firms), and employ labor to produce the economy's final output. These households are referred to as *entrepreneurs*. A critical feature characterizing entrepreneurs in this economy is that they are credit-constrained (have limited access to borrowing), but also receive remittance flows from abroad. Therefore, heterogeneity among households is driven by their ownership (or lack) of physical capital and the differential credit constraints they face. For simplicity, we assume that there is no government in this economy.

3.2.1 Hand-to-Mouth Wage Earners

Households in this category are indexed by h, and being rule-of-thumb consumers, they allocate time between work and leisure, solving a static utility maximization problem every period:

$$U(C_t^h, l_t) = \frac{\left[\left(C_t^h\right)^{1-\eta}(1-l_t)^{\eta}\right]^{1-\sigma}}{1-\sigma} \tag{3.1}$$

subject to

$$C_t^h = w_t l_t + vTR_t \tag{3.2}$$

where C_t^h is consumption, l_t represents the total allocation of time to work, w_t is the hourly real wage rate, TR_t is the aggregate inflow of remittances from abroad, and $v \in [0, 1]$ denotes the share of this inflow received by households in this category. Therefore, when $v = 1$, all remittance inflows into the economy accrue to wage earners. Wage earners do not own any physical capital and their income is derived solely from employment in the production sector and their share in aggregate remittance inflows.

These households maximize (3.1), subject to (3.2), while taking the aggregate remittance inflow and its distribution, v, as given. This leads to the following optimality conditions:

$$U_c\left(C_t^h, l_t\right) = \lambda_t^h \tag{3.3a}$$

$$-\frac{U_l\left(C_t^h, l_t\right)}{U_c\left(C_t^h, l_t\right)} = w_t \tag{3.3b}$$

Eq. (3.3a) equalizes the marginal utility from consumption to that of household income, where λ_t^h is the shadow price associated with the constraint (3.2). Eq. (3.3b) expresses the marginal rate of substitution between consumption and the labor-leisure choice.

3.2.2 Entrepreneurs

This category of households, referred to as entrepreneurs, are indexed by e. In contrast to wage earners, they have ownership of physical capital (and therefore firms), limited access to credit markets, and produce the economy's final good by using their stock of physical capital, employing labor (from wage-earners described in Section 2.1), and a standard neoclassical technology:

$$Y_t = e^{A_t} K_{t-1}^{\mu} l_t^{1-\mu},\ \mu \in (0,1) \tag{3.4}$$

where Y_t represents the flow of output at time t, K_{t-1} denotes the stock of physical capital inherited from the previous period, and l_t denotes the current employment of labor-hours that are supplied by wage-earners. A_t represents a stochastic productivity shock. The stock of capital accumulates according to

$$K_t = I_t + (1-\delta) K_{t-1} \tag{3.5}$$

where δ is the rate of depreciation of physical capital and I_t is the current flow of private investment. We also assume that installing physical capital is a costly activity for entrepreneurs, with these costs represented by a convex adjustment cost function:

$$\Phi\left(I_t, K_{t-1}\right) = I_t + \frac{\Psi}{2}\left(\frac{I_t}{K_{t-1}} - \delta\right)^2 K_{t-1},\ \Psi \geq 0 \tag{3.6}$$

where Ψ is the adjustment cost parameter.

Entrepreneurs maximize utility from consumption over an infinite horizon

$$E_o \sum_{t=0}^{\infty} (\beta)^t U\left(C_t^e\right),\ \beta \in (0,1) \tag{3.7}$$

where C_t^e represents their consumption and β is their discount factor. The instantaneous utility function is specified as

$$U\left(C_t^e\right) = \frac{\left(C_t^e\right)^{1-\sigma}}{1-\sigma} \tag{3.8}$$

Note that entrepreneurs do not face a time-allocation decision between work and leisure like wage-earners. Instead, being final goods producers, they generate a demand for labor employment. The instantaneous budget constraint for entrepreneurs is given by

$$B_t = \left(1+r^*\right) B_{t-1} + C_t^e + w_t l_t + \Phi\left(I_t, K_{t-1}\right) - Y_t - (1-v)\, TR_t \tag{3.9}$$

where B_t is their stock of debt (accumulated through an internationally traded bond), $(1-v)$ represents their share of aggregate remittances, and r^* is the (world) interest rate on borrowing.

We assume that entrepreneurs, even though they own capital and firms, are credit constrained with respect to their borrowing decisions:

$$B_t \leq m_t E_t(q_{t+1} K_t) \tag{3.10}$$

where q_t is the shadow (market) price of capital, and m_t is the time-varying fraction of the expected market value of capital that defines the upper limit on borrowing for entrepreneurs, i.e., loan-to-capital (LTC).[24]

A representative entrepreneur in this sector maximizes (3.8), subject to (3.9) and (3.10). This leads to the following optimality conditions

$$U_c\left(C_t^e\right) = \left(1+r^*\right)\left[\beta E_t\left\{U_c\left(C_{t+1}^e\right)\right\} + \lambda_t^e\right] \tag{3.11a}$$

$$\frac{\partial Y_t}{\partial l_t} = w_t \tag{3.11b}$$

$$q_t = 1 + \Psi\left(\frac{I_t}{K_{t-1}} - \delta\right) \tag{3.11c}$$

$$q_t = \left[(1-\delta)\,\beta + m_t \lambda_t^e\right] E_t q_{t+1} - \beta E_t\left[\left\{\Phi_K\left(I_{t+1}, K_t\right) - \frac{\partial Y_{t+1}}{\partial K_t}\right\} U_c\left(C_{t+1}^e\right)\right] \tag{3.11d}$$

where λ_t^e is the shadow price associated with the credit constraint (3.10). Eq. (3.11a) represents the Euler equation for consumption of entrepreneurs, while (3.11b) equates the marginal product of labor (purchased

[24] One issue with small open economy models with a fixed world interest rate and discount factor is that the marginal utility of wealth is constrained to be a constant along the transition path, with foreign asset holdings approximating infinity. To close these models, the literature has used different strategies, ranging from an endogenous world interest rate that depends on the stock of debt or the debt-GDP ratio (Eaton and Gersovitz, 1981), an endogenous discount factor (Mendoza, 1991), transactions costs for bond-holdings, or a binding borrowing constraint; see also Turnovsky (1997b) and Schmitt-Grohé and Uribe (2003). Any one of these features is sufficient to close these models. In our specific context, the existence of a binding credit constraint for entrepreneurs is sufficient to impose an upper bound on the accumulation of debt as the model converges to its steady state.

from wage earners) to the real wage rate. Eq. (3.11c) expresses the instantaneous shadow price of capital, while (3.11d) describes its evolution over time.

3.2.3 Remittances

Following Acosta, Lartey, and Mandelman (2009) and Mandelman (2013), we model aggregate remittance flows as

$$TR_t = TR_t^c + TR_t^d \tag{3.12}$$

The first term on the right-hand side of (3.12), TR_t^c, represents the endogenous part of remittances and is countercyclical. The intuition is as follows: we assume that a fraction of the home-born foreign residents have distant ties with their families, and they send resources only if they consider that these households back home are about to face severe economic hardship. Similar to Acosta, Lartey, and Mandelman (2009), we assume that countercyclical remittances are given by $TR_t^c = Y_t^{\xi}$, where $\xi < 0$ is the elasticity of remittances with respect to aggregate output. The second term, TR_t^d is the exogenous component of remittances. Exogenous fluctuations in remittances are independent of economic conditions in the recipient country, and can occur due to productivity improvements or real exchange rate appreciations in the economy where migrants are typically employed.

3.2.4 Current Account

The aggregate resource constraint (market-clearing condition) for the economy is derived by combining the budget constraints of wage earners and entrepreneurs, given by (3.2) and (3.9):

$$B_t = (1 + r^*) B_{t-1} + C_t + \Phi (I_t, K_{t-1}) - Y_t - TR_t \tag{3.13}$$

where $C_t = C_t^h + C_t^e$ is aggregate consumption, at time t. According to (3.13), the economy accumulates debt to finance any excess expenditures (consumption, investment, and debt-servicing) over income (production and remittance receipts).

3.3 Calibration

Given the complexity of the baseline specification described in Section 2, we proceed to analyze it numerically. The model is solved using quarterly data from Philippines for the period 1993Q1-2011Q3. Philippines serves as a representative remittance-recipient country, with the shares of remittances (8.1%) and private credit

(32%) in GDP during the sample period that are in line with corresponding global averages for remittance-recipient countries (see Table 3.1). Quarterly data on output, investment, consumption and the trade balance (net exports) are from the IFS database. The data are denominated in Philippine Pesos and converted to real values using a GDP Deflator (2005=100, Source: IFS). Monthly remittance data are obtained from the Philippines Central Bank, and transformed from U.S. Dollars to Philippine Pesos using the average monthly US-Peso exchange rate (Source: Philippines Central Bank). Subsequently, the data is aggregated to quarterly frequency and converted to real values using the GDP Deflator. Moments are seasonally adjusted using Stata's sax12 command, and detrended using the Hodrick-Prescott (1997) filter. Labor employment data for Philippines are not available after the third quarter of 2011, and this restricts the length of our sample for calibration purposes.

We begin by calibrating the model to derive the benchmark steady-state equilibrium. Table 3.2 describes the model's parameterization: the intertemporal elasticity of substitution in consumption is given by $1/\sigma$. We set $\sigma = 2.25$ to get an elasticity of 0.4, consistent with the findings of Guvenen (2006). Following Mandelman (2013), we set the fraction of time allocated to work in the steady state equal to 1/2, which pins down the value of η at 0.45. The annual world interest rate is set at 4%, and the credit constraint parameter $\bar{m} = 0.125$ yields an equilibrium share of private credit in GDP of about 0.32, which is consistent with the corresponding sample average for Philippines. The capital share in production, μ, is set at the standard value of 0.4 and the quarterly depreciation rate, δ is set at 0.025. The rate of time preference β is set to 0.985 to ensure that $\beta(1 + r^*) < 1$, i.e., the credit constraint is always binding and the model is closed. The adjustment cost parameter Ψ is set to 0.2 to match the investment volatility relative to the volatility of output. The remittance share in GDP is calibrated to equal 8.1%, to match the corresponding sample average in the data.

The stochastic processes used in the model are for total factor productivity, the loan-to-capital (LTC) ratio, and the exogenous components of remittance flows.[25] The process for the productivity shock is estimated using the Solow residuals in Philippines for our sample period, according to

$$A_t = \rho^A A_{t-1} + \varepsilon_t^A \tag{3.14}$$

where ρ^A denotes the persistence of the productivity shock, and the stochastic term ε_t^A represents normally distributed and serially uncorrelated innovations.

The LTC ratio (credit constraint) is characterized by the following law of motion

[25]The Appendix provides additional information on the estimation of the model's underlying stochastic processes.

Table 3.2: Baseline Calibration

Parameter	Description	Value
σ	Intertemporal elasticity of substitution in consumption	2.25
η	Labor-share in utility	0.48
Ψ	Adjustment cost for investment	0.20
r^*	World interest rate (quarterly)	0.01
μ	Capital share in production	0.40
δ	Depreciation rate for physical capital (quarterly)	0.025
β^e, β^h	Rate of time preference	0.985
$\bar{m}$	Borrowing constraint parameter (entrepreneurs)	0.125
ρ^A	Persistence of productivity shock (estimated)	0.68
ρ^{TR}	Persistence of remittance shock (estimated)	0.40
ρ^m	Persistence of credit shock (estimated)	0.90
σ^A	Standard deviation of productivity shock	0.0118
σ^{TR}	Standard deviation of remittance shock	0.1257
σ^m	Standard deviation of credit shock	0.0071
Calibrated Variables		
I/Y	Private Investment-GDP ratio	0.25
B/Y	Private credit (debt)-GDP ratio	0.32
TR/Y	Remittance-GDP ratio	0.081

$$m_t = \bar{m} \exp(\tilde{m}_t) \tag{3.15a}$$

where $\bar{m}$ is the steady-state LTC ratio, and $\tilde{m}_t$ describes the stochastic process for this ratio:

$$\tilde{m}_t = \rho^m \tilde{m}_{t-1} + \varepsilon_t^m \tag{3.15b}$$

where the innovations ε_t^m are normally distributed and serially uncorrelated, and ρ^m denotes the persistence of the credit shock. The persistence of the credit shock is estimated by constructing a series for the real value of business credit relative to the capital stock in Philippines for our sample period.

Finally, recalling (3.12), the exogenous component of remittances evolves according to

$$TR_t^d = \overline{TR} \exp(\widetilde{TR}_t) \tag{3.16a}$$

where $\overline{TR}$ determines the steady-state level of exogenous remittances. The stochastic part $\widetilde{TR}_t$ follows an AR(1) process:

$$\widetilde{TR}_t = \rho^{TR} \widetilde{TR}_{t-1} + \varepsilon_t^{TR}, \quad \rho^{TR} \in (0, 1) \tag{3.16b}$$

where ρ^{TR} denotes its persistence and ε_t^{TR} represents an exogenous white-noise shock, which is normally distributed and serially uncorrelated. The persistence parameter for remittances is estimated using the Overseas Cash Remittance data series, obtained from the Philippines Central Bank, and converted to Pesos in units of 2005 prices.[26] The estimated values of ρ^A, ρ^m, and ρ^{TR} as well as the standard deviations for each shock are reported in Table 3.2.

3.4 Exogenous Remittance Shock

In this section, we consider a temporary exogenous shock to remittance inflows. Specifically, we consider the economy's dynamic response in two polar cases: when all remittance inflows accrue to (i) wage earners, i.e., $v = 1$, and (ii) entrepreneurs, i.e., $v = 0$. In other words, our objective is to understand how the distribution of remittances affects its dynamic absorption. Further, we conduct this exercise in three different contexts, to examine the sensitivity of the results to different model specifications. To this end, we start with our baseline model specification with hand-to-mouth wage earners and credit-constrained entrepreneurs with Cobb-Douglas preferences (Figure 3.1), but then extend the framework to (i) GHH preferences (Figure 3.2), and (ii) a comparison to a model specification *without* any credit constraints for either type of agent (Figures 3.3 and 3.4). This case underscores the role played by credit constraints in determining the aggregate response to a remittance shock. All figures are plotted as percentage deviations from the steady-state equilibrium and all shocks represent one standard deviation changes from their baseline levels. The unit of time plotted in the figures represent quarters.

3.4.1 Baseline Model

Figure 3.1 plots the economy's response for an unanticipated, exogenous, but temporary increase in remittance inflows in the baseline model (hand-to-mouth wage earners, credit-constrained entrepreneurs, and Cobb-Douglas preferences). In the case where wage earners are the principal recipients ($v = 1$, solid line), the economy contracts temporarily, with output, investment and labor supply declining from their pre-shock steady-state levels. Since wage earners are hand-to-mouth and do not own any capital, the permanently higher remittance inflow leads to an instantaneous upward jump in their consumption. The higher consumption level, in turn, lowers the benefit of working, causing wage earners to cut back on their labor supply. The decline in labor supply raises the real wage for wage-earners, which further helps supplement the rise

[26] In the model, we assume that total remittances is given by the sum of counter-cyclical and exogenous remittances. In the data, it is not possible to distinguish between the two types of remittances. Therefore we use total remittances to estimate the stochastic process for exogenous remittances. As a robustness check, we include the Solow residual in the AR(1) process to account for the countercyclical part and find very similar estimates for the persistence and the standard deviation.

in their consumption. This adversely affects entrepreneurs by reducing the marginal product of capital, which consequently results in a lower rate of investment and a decline in output over time. This forces entrepreneurs to absorb the contraction by reducing their own consumption. Overall, aggregate consumption increases in the short run, as the increase in consumption of wage earners more than offsets the decline for entrepreneurs. The decline in output and investment reduces borrowing by entrepreneurs, which in turn improves the current account for the economy.

When entrepreneurs receive the entire temporary remittance inflow ($v = 0$, dashed line), the economy's short-run adjustment is in sharp contrast to when wage earners are the principal recipients. Since entrepreneurs do not face a labor-leisure trade-off, the inflow of remittances increases the resources available for investment and also relaxes their borrowing constraint. As a result, both investment and borrowing increases on impact of the shock. The increase in investment also increases the demand for labor by raising its marginal product (and thereby the real wage). Since wage earners are not the recipients of the remittance inflow, the income effect from the higher wage rate (which tends to increase leisure) exactly offsets for the substitution effect (increasing labor supply), resulting in no net adjustment in their labor-leisure choice. These effects taken together cause a temporary expansion of aggregate output, which in turn facilitates an increase in consumption for both wage earners and entrepreneurs.

In summary, Figure 3.1 indicates that the dynamic effect of remittances depend critically on who the recipient is and their relative ownership of physical capital. Recipients who do not own productive assets and have no access to borrowing tend to respond in a way that is *contractionary* for the aggregate economy, while recipients with ownership of productive assets and (imperfect) access to credit markets tend to respond in a way that is *expansionary* for the economy. In general, the larger the share of remittance flows that accrue to hand-to-mouth wage earners (i.e., as $v \to 1$), the more contractionary the effects will be for the aggregate economy, and vice versa.

3.4.2 GHH Preferences

In this section, we conduct a robustness check on the dynamic response of the baseline model to an exogenous remittance shock. Since the baseline model is characterized by Cobb-Douglas utility for wage earners, this gives rise to an income effect when this group is the principal recipient of remittance inflows. To examine the role of the income effect we modify the baseline model to introduce GHH preferences for wage earners:

$$U(C_t^h, l_t) = \frac{\left[\left(C_t^h\right) + \psi\left(1 - l_t\right)^{\eta}\right]^{1-\sigma}}{1-\sigma} \tag{3.17}$$

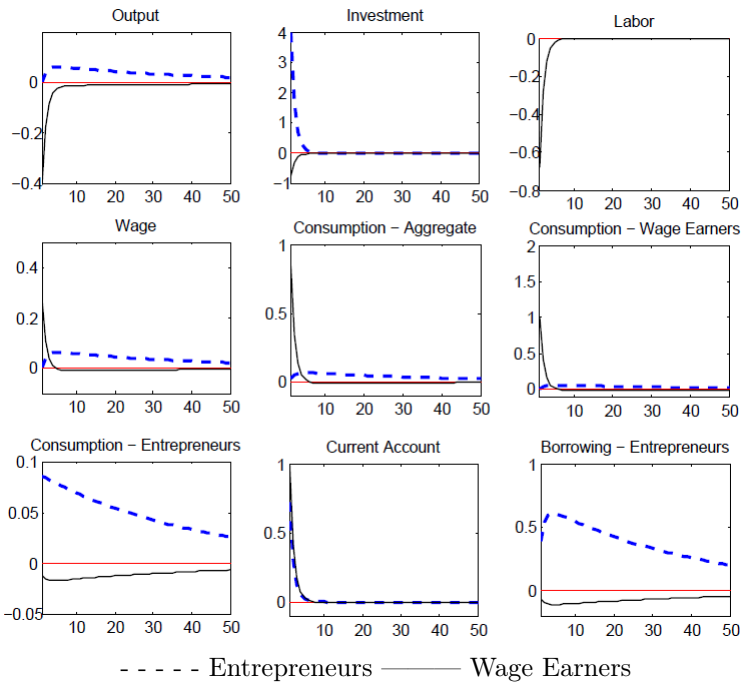


Figure 3.1: Exogenous Remittance Shock (Cobb-Douglas Utility)

The main difference between (3.1) and (3.17) is the absence of an income effect in the GHH case, since the marginal rate of substitution between consumption and leisure is zero. Under this specification, we set η at 2.2 and ψ at 2.6, so that the fraction of time allocated to labor is the same as in the baseline model with Cobb-Douglas preferences.

Figure 3.2 depicts the dynamic response of the economy to a temporary, but exogenous remittance shock. As in Figure 3.1, we plot the dynamic responses in two polar cases, i.e., when wage earners receive the entire remittance inflow ($v = 1$), and when entrepreneurs are the only recipients ($v = 0$). Under GHH preferences, wage earners experience no income effect when remittances accrue to them. As a result, there is no response in their labor supply and the entire remittance inflow is consumed. Consequently, entrepreneurs remain unaffected by this shock and there is no change in the level of output and investment. Aggregate consumption increases as the hand-to-mouth wage earners consume the entire remittance inflow, with no other real consequence for the economy. On the other hand, when entrepreneurs are the principal recipient of remittances, the economy's dynamic response is expansionary and stronger than under the baseline Cobb-Douglas preferences. This is primarily due to the absence of an income effect in the wage earner's GHH utility preferences. Now, as the remittance inflow relaxes the entrepreneur's credit constraint, and increases investment, the higher demand for labor (and the increase in the real wage rate), causes wage earners to increase their labor supply. This, in turn, further increases the marginal product of capital for entrepreneurs,

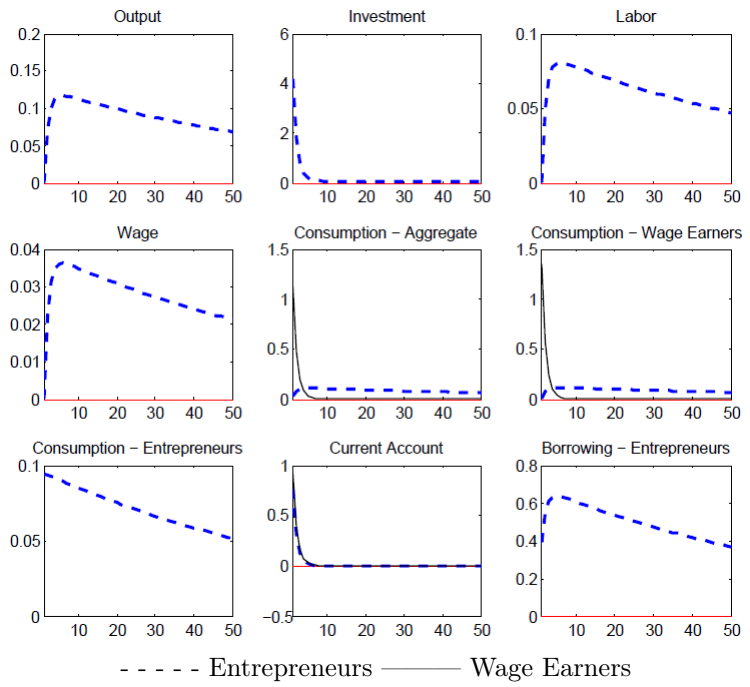


Figure 3.2: Exogenous Remittance Shock (GHH Utility)

leading to a temporary expansion of output that is larger than in the baseline model with Cobb-Douglas utility. Therefore, the underlying utility specification for wage earners is important in characterizing the impact of remittance inflows. When wage earners receive remittances, the lack of an income effect under GHH preferences lead to a proportionate increase in consumption for this group, with no other macroeconomic consequences. By contrast, under Cobb-Douglas preferences, the economy's dynamic response to the same shock is contractionary. On the other hand, when entrepreneurs receive remittances, the economy expands as in the baseline case, but with the GHH preferences leading to a larger expansion than under Cobb-Douglas preferences.

3.4.3 Model Without Credit Constraints

To understand better the role played by credit constraints in the absorption of remittance inflows, we examine in this section a version of the model where wage earners and entrepreneurs do not face an upper limit on their borrowing. In other words, we assume that both agents can borrow as much as they want from international capital markets, and then analyze their dynamic response to an underlying remittance shock. In the absence of the binding credit constraint in (3.10), we use a debt-elastic interest rate specification to close the model, as in Eaton and Gersovitz (1981). Specifically, the instantaneous budget constraint for wage earners is now

modified to

$$B_t^h = (1 + r_t^h)B_{t-1}^h + C_t^h - w_t l_t - vTR_t \tag{3.18}$$

where r_t^h is the net real interest rate on debt for wage earners, which in turn is an increasing function of their group-specific outstanding debt:

$$r_t^h = r^* + F(B_t^h - \overline{B}^h), \quad F'(.) > 0 \tag{3.19a}$$

where $F(.)$ is an interest rate premium which takes the following form:

$$F(.) = \varphi\left(e^{B_t^h - \overline{B}^h} - 1\right), \ \varphi \geq 0 \tag{3.19b}$$

In (3.19b), $\overline{B}^h$ denotes the steady-state level of debt for wage earners, and φ is a parameter that measures the sensitivity of the borrowing rate to a deviation of the current stock of debt from its steady-state level. However, in making allocation decisions, wage earners treat their group-specific interest rate, r_t^h, as exogenously given. In the steady state, as B_t^h converges to $\bar{B}^h$, the interest rate premium $F(.)$ goes to zero and the borrowing rate converges to the world interest rate, r^*. Further, since wage earners are no longer rule-of-thumb households in this specification, they maximize intertemporal utility over an infinite horizon:

$$E_0 \sum_{t=0}^{\infty} (\beta^h)^t U(C_t^h, l_t), \quad \beta^h \in (0, 1) \tag{3.20}$$

where β^h is the rate of time preference for wage earners, and $U(C_t^h, l_t)$ is given by (3.1).

For entrepreneurs, the instantaneous budget constraint (3.9) now takes the form

$$B_t^e = (1 + r_t^e)\, B_{t-1}^e + C_t^e + w_t l_t + \Phi\left(I_t, K_{t-1}\right) - Y_t - (1 - \nu)\, TR_t \tag{3.21}$$

where B_t^e is their stock of debt, and r_t^e is their group-specific interest rate on borrowing, given by

$$r_t^e = r^* + H(B_t^e - \overline{B}^e), \quad H'(.) > 0 \tag{3.22a}$$

The interest rate premium for entrepreneurs takes a form analogous to that for wage earners:

$$H(.) = \varphi\left(e^{B_t^e - \overline{B}^e} - 1\right) \tag{3.22b}$$

where $\bar{B}^e$ is the steady-state stock of debt for entrepreneurs. Entrepreneurs, in making allocation decisions, treat their group-specific interest rate, r_t^e, as exogenously given. As the economy converges to its steady state equilibrium, $B_t^e \to \bar{B}^e$, we have $r_t^h = r_t^e = r^*$. The economy's aggregate stock of private-sector debt is then given by $B_t = B_t^h + B_t^e$. Note that in this specification, there are no credit constraints for either group of agents. The evolution of the current account under this model specification is then given by

$$B_t = (1 + r_t^h)B_{t-1}^h + (1 + r_t^e)\, B_{t-1}^e + C_t + \Phi\left(I_t, K_{t-1}\right) - Y_t - TR_t \tag{3.23}$$

We calibrate the equilibrium in the model without credit constraints to ensure that the investment-GDP and remittance-GDP ratios match the equilibrium quantities obtained for the baseline model (with hand-to-mouth wage earners and credit-constrained entrepreneurs). In doing so, we set β^h and β to 0.985 and the interest rate premium parameter φ to 0.00075 to match the trade balance volatility in the data.

Our objective here is to understand better the role played by binding credit constraints in the absorption of remittance inflows. Therefore, we will compare the dynamic response of the recipient economy when there are no credit constraints with the baseline model under the two polar cases: when (i) all remittances accrue to wage earners ($v = 1$, Figure 3.3), and (ii) all remittances accrue to entrepreneurs ($v = 0$, Figure 3.4). The dashed line in each figure represents an economy *without* credit constraints for both wage earners and entrepreneurs, and the solid line is the response from the baseline mode, with hand-to-mouth wage earners and credit-constrained entrepreneurs. We retain the baseline assumption of Cobb-Douglas preferences for wage earners in this section.

In general, Figures 3.3 and 3.4 indicate that the presence of binding credit constraints in the baseline model works to *amplify* the dynamic response of the economy to an exogenous remittance shock, relative to a model without any borrowing constraints. For example, when wage earners are the principal recipients (Figure 3.3), the inflow of remittances is a pure lumpsum transfer from abroad, which has a very small income effect in the absence of credit constraints. Consequently, this mutes the response of their labor supply, leading to a much smaller decline in investment and output relative to when these agents are hand-to-mouth (completely shut off from credit markets). When entrepreneurs receive the remittance inflow (Figure 3.4), the absence of credit constraints imply that remittances substitute for borrowing, which in turn mutes the effect on investment and output relative to when these agents face binding credit constraints. Wage earners, being unconstrained with respect to their borrowing, now reduce their labor supply due to the income effect caused by higher wages. Over all, when entrepreneurs receive remittances but do not face binding credit constraints, the economy's response is still expansionary, albeit much smaller in magnitude

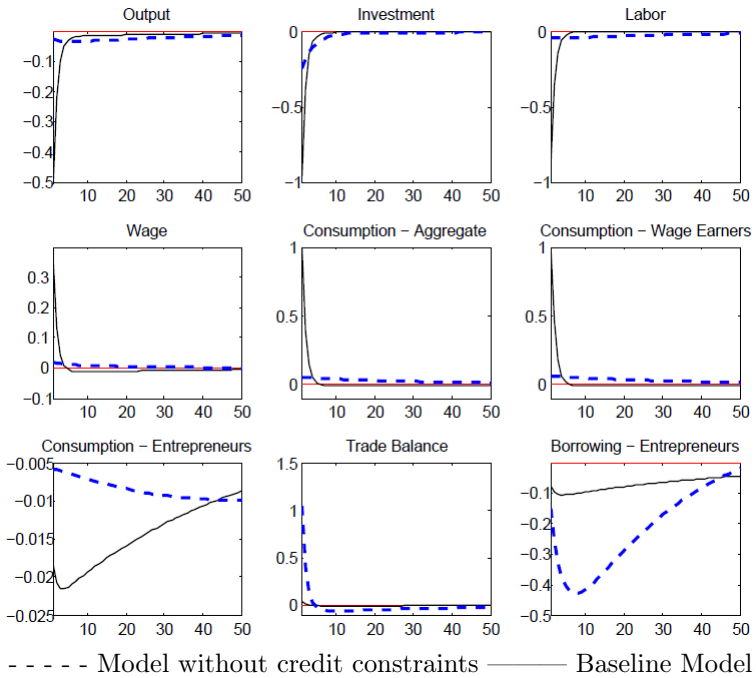


Figure 3.3: Exogenous Shock to Remittances, v=1 (Wage Earners, CD Utility)

than the baseline model with binding credit constraints. Therefore, both Figures 3.3 and 3.4 point to the role played by binding credit constraints in amplifying the effects of a remittance shock to the economy.[27]

3.4.4 Welfare

In this section, we analyze the welfare consequences of remittances, especially taking into account their distribution between entrepreneurs and wage earners. Specifically, we ask the following questions: how is the intertemporal welfare path of entrepreneurs (wage-earners) affected when all remittances accrue to wage earners (entrepreneurs)? In other words, how is the welfare for a group of agents affected when the *other* group receives all remittance inflows? Further, how is total welfare for the economy affected by the distribution of remittances between entrepreneurs and wage earners? We characterize these effects in Figure 3.5 for the baseline model with credit constraints. The model is simulated with three shocks: productivity, credit, and remittances (exogenous), and the intertemporal welfare paths plotted over time. When entrepreneurs receive all remittance inflows ($v = 0$), wage earners are better off throughout the transition path. This is because of the expansionary effect of remittances when they accrue to entrepreneurs: output and wage income increases, which enables wage earners to increase their consumption in transition. On the other

[27]The result that credit constraints can amplify the dynamic response from an underlying shock has been studied in other contexts; See, for example, a recent contribution by Liu, Wang, and Zha (2013). In the context of remittances, Durdu and Sayan (2010) find that the presence of credit constraints amplify the effects of remittances in the short-run for Turkey.

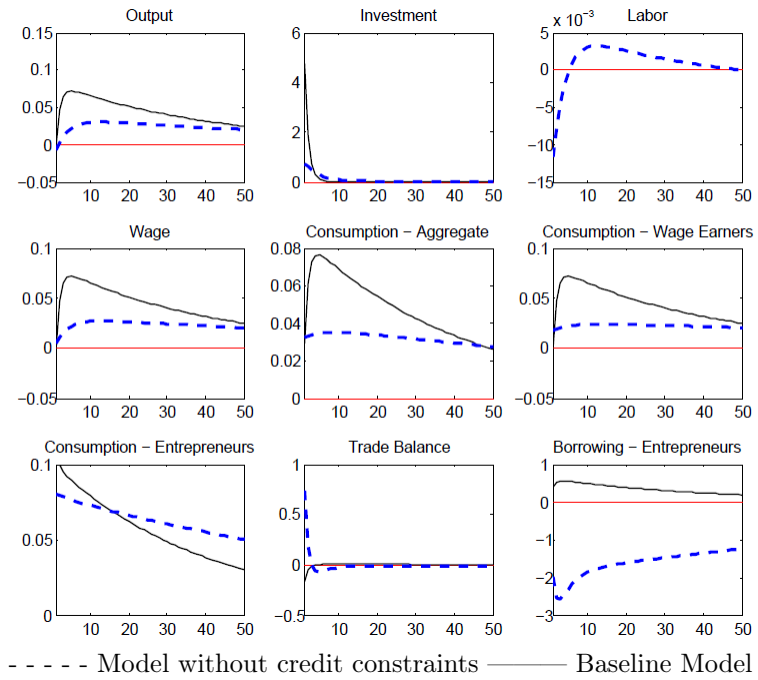


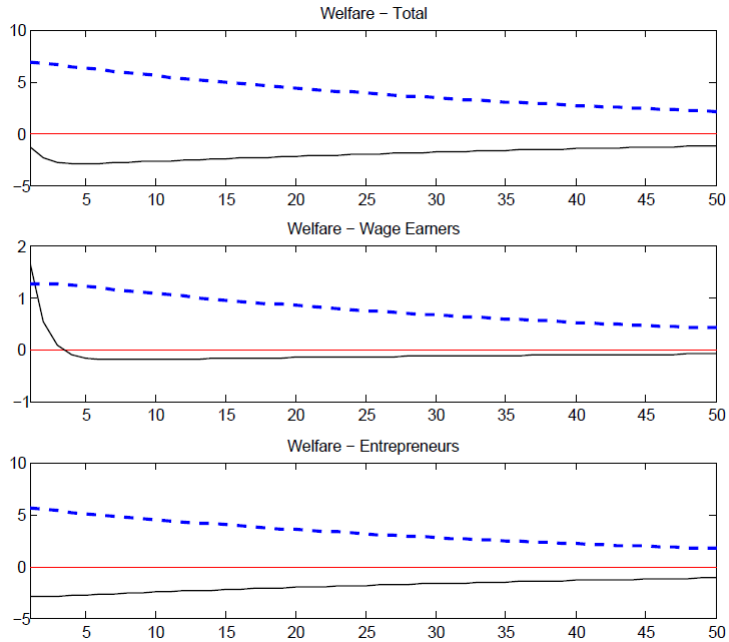
Figure 3.4: Exogenous Shock to Remittances, v=0 (Entrepreneurs, CD Utility)

hand, when all remittances go to wage earners ($v = 1$), entrepreneurs are worse-off throughout the entire transition path. This happens because of the contractionary effect of remittances when wage earners are the principal recipients: output and investment decline, along with the consumption of entrepreneurs. Over all, the distribution of remittances matter for aggregate welfare: when entrepreneurs are the principal recipients, welfare increases in transition, while in the case of wage earners, the aggregate economy is always worse off.

3.5 Countercyclical Remittance Shock

Figure 3.6 illustrates the economy's response when there is a temporary but countercyclical increase in remittances. Specifically, we consider the case where a negative productivity shock in the recipient country generates an increase in remittance inflows from abroad. Noting (3.12), countercyclical remittances are given by $TR_t^c = Y_t^{\xi}$, where $\xi < 0$ is the elasticity of remittances with respect to aggregate output. We use the mode value obtained from the Bayesian estimation in Mandelman (2013) for Philippines, and set $\xi = -1.98$.[28] As before, we compare the two polar cases regarding the distribution of remittances, i.e., $v = 0$ and $v = 1$: the dashed lines represent the response of the economy when entrepreneurs receive the

[28]The specification used by Mandelman (2013) is slightly different in that he defines the elasticity with respect to the real wage rather than output. We choose aggregate output as remittances are received by both wage earners and capital owners in our model.



- - - - - Principal recipients: Entrepreneurs ——— Principal recipients: Wage Earners

Figure 3.5: Transitional Welfare Paths

remittance shock, while the solid lines depict the case where wage earners are the principal recipients. Since the underlying dynamics are being driven by a negative productivity shock, the economy contracts in both cases. When remittances accrue to entrepreneurs, the declines in output, investment, and labor supply are smaller relative to when wage earners are the principal recipients. Credit-constrained entrepreneurs are able to use the remittances to smooth both investment and consumption, thereby enabling the economy to absorb the negative productivity shock faster. In contrast, when wage earners receive the countercyclical increase in remittance flows, the economy's contraction is larger and the transition longer. Entrepreneurs in this case are unable to smooth the negative productivity shock, and investment and output decline more and remain below the steady state for longer. Figure 3.6 underscores the fact that the ability of remittances to smooth business cycle fluctuations depends critically on their distribution across heterogeneous agents.[29]

3.6 Model Fit

Up to this point, our analysis has focused primarily on highlighting the model's dynamic behavior for two extreme assumptions regarding the distribution of remittances, i.e., when $v = 0$ (all remittances accrue to entrepreneurs), and $v = 1$ (all remittances accrue to wage earners). While this is useful to understand the

[29] We have also considered the case of a procyclical shock to remittances, where a positive productivity shock in the recipient economy shock leads to an increase in remittance inflows. The results are a mirror image of the countercyclical case, and hence have not been reported here. They are, however, available from the authors on request.

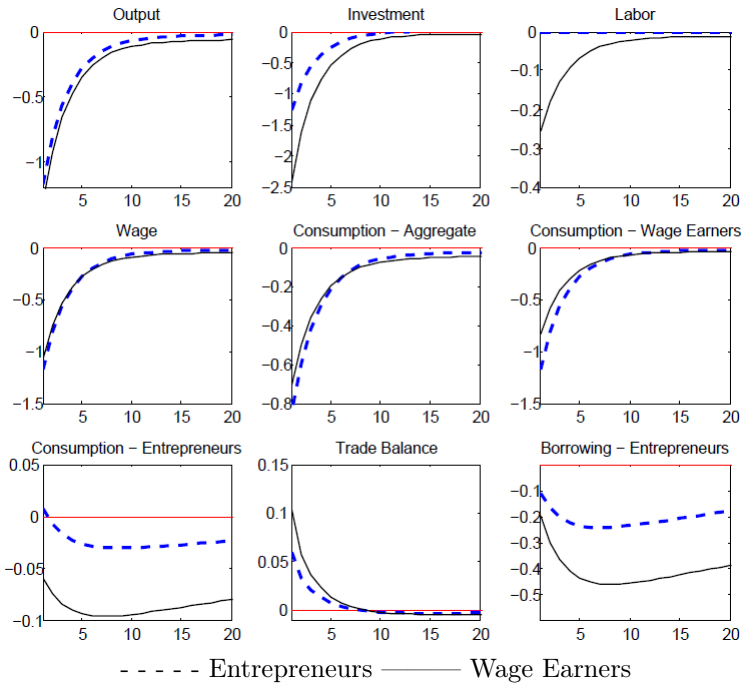


Figure 3.6: Countercyclical Remittances

model's underlying mechanisms, it is clearly not realistic, as remittances may be distributed internally among both group of agents. Given the nature of available data in Philippines, it is not possible to observe directly the internal distribution of remittances among wage earners and entrepreneurs. However, an understanding of the distribution parameter v is crucial to examining the model's fit with the data. We therefore employ an indirect approach to pin down this parameter, by looking at patterns of bilateral remittance inflows and outward migration for Philippines. It has been well documented that migrants with higher levels of education come from wealthy families and also have more inter-regional mobility than those with low educational attainment.[30] Then, a plausible way to start would be with the premise that migrants from Philippines who move to distant countries might come from wealthy families and also likely have high levels of educational attainment. Therefore, the share of remittance inflows into Philippines from these migrants would represent financial flows to their families back home, who in turn, are likely to have ownership of capital and some degree of access to credit markets. (i.e., the entrepreneurs in our model). This approach can then give us indirect information on the internal distribution of remittances in Philippines.

[30]The relationship between education and mobility has been studied, among others, by Dahl (2002), Hunt (2004), Malamud and Wozniak (2012), Machin, Salvanes, and Pelkonen (2012); also see Bauernschuster et al. (2014). The link between educational attainment and parental or family wealth in the context of economic development goes back to Galor and Zeira (1993). Black, Devereux et al. (2011) and Kinsler and Pavan (2011) provide comprehensive reviews of the empirical literature on this issue.

Between 1990-2010, the share of outward migration from Philippines to the US and EU was about 83 percent, with about 68 percent of these migrants reporting a tertiary level of education.[31] During this period, the average share of remittance inflows into Philippines from the US and EU was about 67 percent; See Figure 3.7.[32] Given our premise that migrants from Philippines to the US and EU are likely to come from wealthy families, we set the remittance distribution parameter, v, to 0.3, implying that 70 percent of remittance inflows in our model accrue to households who own capital, i.e., entrepreneurs. As we will see below, $v = 0.3$ provides a much better fit for the model relative to the extreme cases of $v = 0$ or $v = 1$.

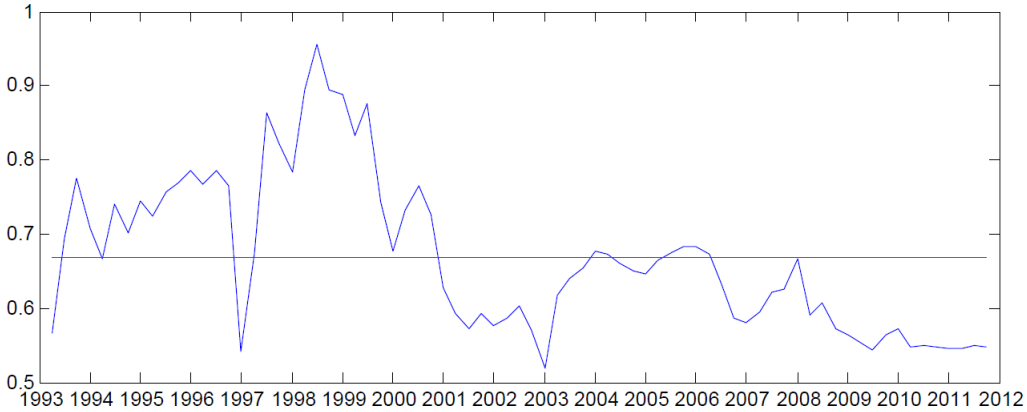


Figure 3.7: Share of Total Remittances from US and EU for Philippines, 1993-2011

Table 3.3 presents a comparison of the volatility and implied correlations of the key macroeconomic variables under the two model specifications (with and without credit constraints) and for three scenarios for the distribution of the remittance shock, i.e., $v = 0$ (entrepreneurs are the principal recipients), $v = 0.3$ (our calibrated value, with 70 percent of remittances going to entrepreneurs), and $v = 1$ (wage earners are the principal recipients), with those calculated from the data for Philippines for the period 1993Q1 to 2011Q3. The model's moments have been generated from productivity, credit, and remittance shocks. The model is log-linearized around the steady-state and the moments are calculated using de-trended series. Over all, Table 3.3 suggests that (i) the model specification with binding credit constraints fits the data significantly better than the specification without credit constraints, thereby underscoring the importance of these constraints in understanding the dynamic implications of remittance inflows, and (ii) the calibrated value of $v = 0.3$, with 70 percent of remittance inflows accruing to households with ownership of capital, fits the data relatively better than the polar cases of $v = 0$ and $v = 1$. Moreover, both our model specifications

[31] A tertiary level of education implies a higher than high-school leaving certificate or equivalent. Source: Institute for Employment Research (2013); See: http://www.iab.de/en/daten/iab-brain-drain-data.aspx

[32] Source: Filipino Central Bank and Institute for Employment Research (2013). The remittance data were transformed from U.S. Dollars to Philippine Pesos using the average monthly US-Peso exchange rate. Subsequently, the data were aggregated to quarterly frequency, converted to real values using a GDP Deflator, and seasonally adjusted using Stata's sax12 command.

matches well the observed negative correlation between the current account and GDP for Philippines. The countercyclicality between the current account and GDP in emerging markets has been recently documented as an important stylized fact in the open-economy DSGE literature.[33]

Table 3.3: Model Fit: Standard Deviations and Correlations (CD Utility)

A. Baseline Model with Credit Constraints

	Data	$v = 0$	$v = 0.3$	$v = 1$
$sd(Y)$	1.26	1.32	1.35	1.45
$sd(C)/sd(Y)$	0.78	0.75	0.74	0.83
$sd(I)/sd(Y)$	3.82	4.32	3.82	3.34
$sd(TR)/sd(Y)$	10.82	7.36	7.19	6.64
$sd(NX/Y)$	2.70	1.05	1.04	1.04
$Corr(I, Y)$	0.42	0.36	0.39	0.53
$Corr(TR, Y)$	-0.09	-0.07	-0.15	-0.33
$Corr(TR, C)$	0.14	0.06	0.14	0.54
$Corr(TR, I)$	0.36	0.56	0.40	-0.18
$Corr(NX/Y, Y)$	-0.11	-0.07	-0.07	-0.09

B. Baseline Model without Credit Constraints

	Data	$v = 0$	$v = 0.3$	$v = 1$
$sd(Y)$	1.26	1.74	1.75	1.78
$sd(C)/sd(Y)$	0.78	0.20	0.20	0.20
$sd(I)/sd(Y)$	3.82	3.49	3.49	3.54
$sd(TR)/sd(Y)$	10.82	5.95	5.86	5.65
$sd(NX/Y)$	2.70	0.99	1.04	1.19
$Corr(I, Y)$	0.42	0.87	0.87	0.88
$Corr(TR, Y)$	-0.09	-0.07	-0.07	-0.08
$Corr(TR, C)$	0.14	-0.01	-0.00	0.00
$Corr(TR, I)$	0.36	0.05	0.04	-0.09
$Corr(NX/Y, Y)$	-0.11	-0.09	-0.10	-0.13

Table 3.4 examines the sensitivity of the model fit to the underlying preference structure of the model, i.e., whether the utility function is characterized by Cobb-Douglas or GHH preferences. The robustness check is performed under the two model specifications, i.e., in the presence and absence of binding credit constraints, and with the distribution of remittances set to its calibrated value of $v = 0.3$. As can be seen from Table 3.4, the model specification with binding credit constraints again outperforms the one without these constraints, irrespective of the underlying preference structure. A comparison of the two preference specifications suggests that the Cobb-Douglas case fits the data marginally better than the GHH case. Over all, Tables 3.3 and 3.4 underscore the importance of binding credit constraints in understanding the absorption of remittance inflows and, at least, in the case of Philippines, suggest that the interior allocation of remittances is skewed towards households who have ownership of capital.

[33]See, for example, Chinn and Prasad (2003), Neumeyer and Perri (2005), and Aguiar and Gopinath (2007).

Table 3.4: Model Fit: Sensitivity to Preferences

Cobb-Douglas (CD) vs. GHH Utility Function, v=0.3

	Data	CD (CC)	CD (NC)	GHH (CC)	GHH (NC)
$sd(Y)$	1.26	1.35	1.75	1.81	1.86
$sd(C)/sd(Y)$	0.78	0.74	0.20	0.75	0.40
$sd(I)/sd(Y)$	3.82	3.82	3.49	3.15	3.52
$sd(TR)/sd(Y)$	10.82	7.19	5.86	5.62	5.45
$sd(NX/Y)$	2.70	1.04	1.04	1.05	1.15
$Corr(I,Y)$	0.42	0.39	0.87	0.52	0.89
$Corr(TR,Y)$	-0.09	-0.15	-0.07	-0.08	-0.08
$Corr(TR,C)$	0.14	0.14	-0.00	0.15	-0.05
$Corr(TR,I)$	0.36	0.40	0.04	0.41	0.01
$Corr(NX/Y,Y)$	-0.11	-0.07	-0.10	-0.10	-0.04

Note: CC: Model with credit constraints, NC: Model without credit constraints

3.7 Discussion

The main mechanism suggested by our model specification is that an increase in remittances accruing to hand-to-mouth workers (with no ownership of capital or access to credit markets) has a contractionary effect on the economy, while the reverse holds when owners of capital (with some access to credit markets) are the main recipient. To provide some suggestive evidence on whether the main channel investigated in this analysis is plausible or not, we compare the behavior of Philippines with Malaysia, a country which is geographically close but receives a very small share of its GDP in the form of remittances (approximately 0.46 percent of GDP, on average) compared to Philippines (8.1 percent of GDP). Specifically, we compare the growth paths of real GDP and private investment in these countries during 1993-2014, and focus on two important events during this period: the 1997-98 Asian financial crisis, and the 2008-2009 Global financial crisis. The idea here is to compare the intertemporal behavior of real GDP and private investment for two countries, one that receives, on average, about 8 percent of its GDP in the form of remittances (Philippines), and the other that receives only about 0.5 percent (Malaysia).

Figures 3.8 and 3.9 plot the growth rates of real GDP and private investment, respectively, for Philippines and Malaysia. Recalling Figure 3.7, we note that remittance inflows from the US and EU to Philippines *increased* dramatically during the 1997-1998 Asian crisis and *decreased* during the 2008-2009 Global financial crisis**.** In contrast, Malaysia did not experience any significant fluctuation in its remittance receipts (not shown, due to scale). It is interesting to note that the contraction of real GDP and private investment was significantly smaller for Philippines compared to Malaysia during the Asian Crisis, when remittance inflows to Philippines from the US and EU went up sharply. On the other hand, when remittance inflows from the US and EU declined during the Global financial crisis of 2008-2009, the differences in the contraction of

real GDP and investment between Philippines and Malaysia were not that significant. These trends suggest that remittances indeed might have a business-cycle smoothing effect, given that their level in Philippines is significantly higher than in Malaysia. Further, the fact that the contraction of real GDP and private investment was smaller in Philippines during 1997-98 may also suggest that its internal distribution was skewed towards households who have ownership of capital and access to credit markets. By relaxing binding credit constraints, remittances in Philippines may have enabled recipients to partially offset the contractionary effects of the underlying crisis, as our model predicts. Indeed, Yang (2008) documents a large increase in remittances from overseas Filipinos during the Asian financial crisis (driven by real appreciations in currencies of destination countries like the US), and shows that this increase was associated with higher investments in capital-intensive entrepreneurship, human capital, and labor supply among recipient households in Philippines. While there are surely general equilibrium factors at play in this comparison, we take these facts as suggestive evidence supporting the central mechanism characterized in this paper. Specifically, our results in Sections 4 and 5 that the effect of remittances are more expansionary when entrepreneurs are the principal recipients, and the ability of remittances to smooth the contractionary effects of a negative productivity shock when its internal distribution is skewed towards entrepreneurs is broadly consistent with the trends in Figures 3.8 and 3.9. Further, the pattern of migration and remittance inflows into Philippines discussed in Section 6 also supports the hypothesis that a majority of remittance inflows accrue to households with ownership of capital which, according to our model, would enhance the ability of remittances to smooth business cycle shocks.

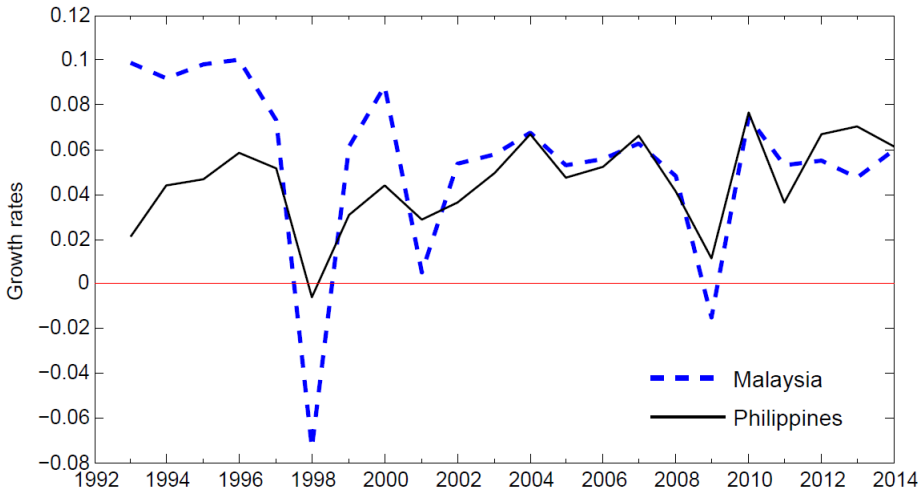


Figure 3.8: Growth Rate of Real GDP, 1993-2014

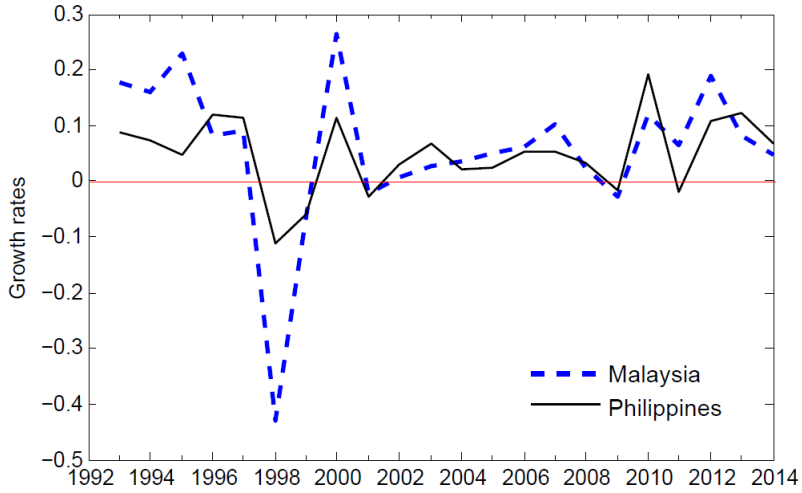


Figure 3.9: Growth Rate of Real Private Investment, 1993-2014

3.8 Conclusions

This paper analyzes the interaction between credit constraints and the ownership of a productive asset like capital in determining the aggregate effects of remittance inflows. In particular, we model a small open economy which is characterized by two types of households: hand-to-mouth wage earners, who have no ownership of capital or access to credit markets, and entrepreneurs, who own capital, but face binding borrowing constraints in credit markets. Given this set up, we show that the dynamic absorption of a temporary increase in remittance inflows depends critically on (i) the internal distribution of remittances between wage earners and entrepreneurs, (ii) the presence or absence of binding credit constraints, and (iii) the underlying preference structure for wage earners, i.e., the presence or absence of an income effect. Specifically, when remittance flows accrue to wage earners, their response tends to be contractionary for the economy. In contrast, when entrepreneurs are the principal recipients, the effects tend to be expansionary. The magnitude of these effects, however, depend on the presence or absence of binding credit constraints and an underlying income effect: the presence of credit constraints works to amplify the effect of remittances relative to when these constraints are absent, while the presence of an income effect tends to mute the effect of remittance inflows, irrespective of their internal distribution among agents. Further, when remittance inflows are countercyclical, their ability to smooth business cycle fluctuations depend on their internal distribution: the larger the share for entrepreneurs, the larger is the smoothing effect of remittances. Using quarterly data from the Philippines for the period 1993 to 2011, we show that the model specification with binding credit constraints compares relatively better with respect to the key moments and correlations in the data,

relative to the model without credit constraints. We use data on migration patterns and bilateral remittance inflows to calibrate the internal distribution of remittances, and show that this leads to an improvement in the model's overall fit. Finally, we examine the welfare consequences of the distribution of remittances.

We distinguish our paper from the existing literature by highlighting the quantitative significance of several new channels through which external transfers are absorbed by an emerging economy, namely the internal distribution of remittances among heterogeneous households, the presence of binding credit constraints and an income effect that determines the allocation of time between work and leisure. In contrast, previous studies have generally assumed that households have no access to credit and firms (or households that own them) are not constrained in their ability to borrow. In taking a more pragmatic approach towards credit constraints and asset ownership, we highlight the importance of these factors in understanding how household allocation decisions are made with respect to remittance receipts. In doing so, we underscore the need for more micro-level evidence for understanding the dynamic implications of remittances. Finally, an important issue from which we abstract is the endogeneity of remittance inflows: one can conceptualize remittances as wage income received from abroad when household labor supply is allocated across national borders. Such an analysis would require a multi-country set-up and the modeling of the costs of migration. While these are interesting and relevant issues, they are beyond the scope of this paper. We look forward to pursuing these ideas in future work.

Appendix 2

The nominal GDP, investment, and consumption series are converted into real units by dividing the corresponding nominal series with the GDP deflator for constant 2005 prices.

Capital Stock: The capital stock is generated using a perpetual inventory method. The nominal investment series has been converted into 2005 prices and seasonally adjusted for constructing the capital stock data. For the perpetual inventory method, we use a yearly depreciation rate of 8 percent, as in Meza and Quintin (2007). To set the initial capital stock, we follow Young (1995) and Meza and Quintin (2007) and assume that the growth rate of investment in the first five years of the series is representative of the growth rate of investment in previous years.

Labor Input: We use total employment, general level series from the International Labour Organization.

Remittances: Overseas Filipinos' Cash Remittances in US Dollars converted to Pesos in units of 2005 prices, from the Central Bank of Philippines.

Total Factor Productivity: The data on TFP have been constructed as

$$A_t = \log(y_t) - \alpha \log(k_{t-1}) - (1-\alpha)\log(l_t)$$

where y_t is GDP in 2005 prices, k_t is capital stock in 2005 prices and l_t is total hours worked. The TFP series is then linearly detrended and the residuals are used to estimate the AR(1) process for the productivity shock.

Business Credit: We construct the real value of business credit in 2005 prices by dividing the private credit series with the GDP deflator, obtained from the Central Bank of Philippines. Since the credit constraint on firms takes the form

$$B_t \leq m_t E_t(q_{t+1} K_t),$$

we calculate the series for m_t as the ratio of the real value of private credit divided by the capital stock, where both series are in units of 2005 prices.

Chapter 4

Public Capital and Refugee Distribution Across Countries

4.1 Introduction

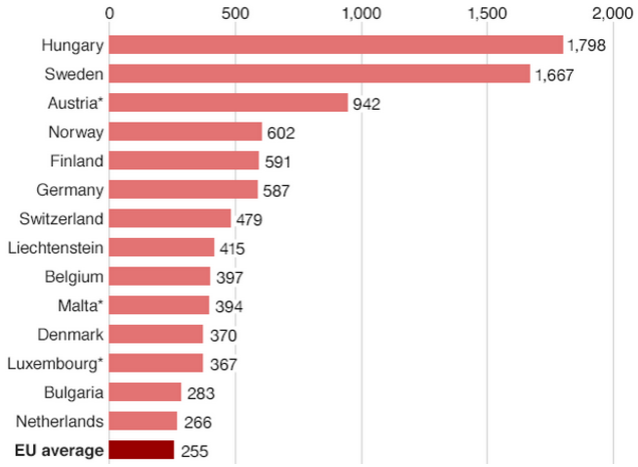
In light of the recent refugee situation in Europe, this paper analyzes the impact of government policies on refugee distribution in a model where public goods are subject to congestion externalities. More than a million migrants and refugees arrived in Europe in 2015 (compared to 280,000 in 2014), leading to the largest migration of displaced people since the end of World War II. The large influx of refugees places a burden on European countries at two fronts: First, so called Frontline States, including Greece, Italy or Bulgaria suffer disproportionally by the first arrival of new refugees from conflict areas such as Syria, Afghanistan or Kosovo (see Table 4.1).

Table 4.1: First Arrivals of Refugees in 2015: By Frontline State

Greece	Italy	Bulgaria	Other	Total
857,363	153,842	31,174	4,220	1,046,599

Source: International Organization for Migration;
"Other" include Spain, Malta and Cyprus

Second, once refugees set foot in one of these Frontline States, they transit towards Western Europe where the majority files asylum claims. Figure 4.1 lists countries by asylum application per capita. While Germany received the largest number of asylum claims in 2015 (476,000 out of 1,294,000), the countries hit hardest by the refugee influx as share of total population are Hungary, Sweden and Austria.



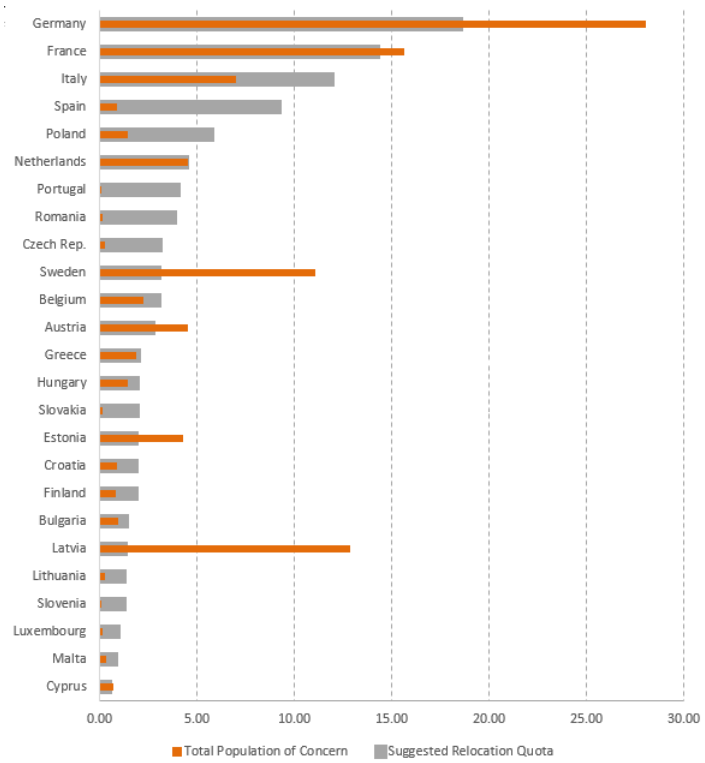
Source: Eurostat; *Data only covers Jan to Nov

Figure 4.1: Asylum Application per 100,000 Capita: 2015

As countries are struggling to cope with the migration inflow, the European Union is developing plans to optimally distribute refugees across countries. In September 2015, EU ministers approved a plan to relocate up to 120,000 people from Greece and Italy, two of the three countries with most migrant arrivals in Europe.[34] The plan assigns each member state a number of refugees based on its economic strength, population, unemployment, and the number of asylum application it has approved over the last five years.[35] A country's population and GDP account for 80% of the formula used to calculate the quota as larger populations and economies are generally better suited to carry the burden of refugee inflows. Figure 4.2 lists both the actual number of asylum seekers as well as the quota set by the EU under the relocation plan.

[34]The plan proposed to relocate 50,400 and 15,600 refugees from Greece and Italy, respectively. The remaining 54,000 were meant to be relocated from Hungary, but Hungary did not want to be considered a Frontline State. Consequently, they will be relocated either from Greece or Italy within a year's time.

[35]http://europa.eu/rapid/press-release_MEMO-15-5038_en.htm



Sources: UNHCR Mid-Year Trends 2015; European Commission - European Agenda on Migration

Figure 4.2: EU-Relocation Scheme

As Figure 4.2 illustrates, only Germany, France, Netherlands, Sweden, Austria, Cyprus and the Baltics have met the quota suggested by the EU. Moreover, Table 4.2 reveals that these country not only match the quota (except for Netherlands) but are host country to asylum seekers and refugees beyond the suggested scheme. Part of the reason for the high number of asylum applications in these countries are economic incentives for refugees. Rotte, Vogler, and Zimmermann (1997) or Hatton (2004) show, for example, that GDP in the destination country is a significant predictor of asylum applications.

Despite their higher ability to absorb refugee inflows, the disproportional amount of refugees in these relatively high income countries challenges economic performance and domestic population. One way in which the sharp refugee influx puts a burden on the host economies is through the increased usage of public services and the associated negative externalities. For example, the quality of service provision declines with higher demand for public services such as healthcare or education. Moreover, there can be detrimental effects of refugees on the environment through depleting natural habitat for construction. In urban areas, added congestion, degradation of housing or neighborhoods, and a perceived decline in security may accompany the arrival of refugees.

The objective of this paper, therefore, is to study the design and impact of optimal government policies on growth and welfare when (i) refugees are sub-optimally distributed across countries and (ii) the presence of refugees causes additional congestion externalities for public services. As such, this paper is related to two strands of literature. First, the paper is related to the literature on production benefits of public capital. Motivated by Aschauer (1989), research extensively analyzed the role of productive government investment on growth and welfare.[36] As in Turnovsky (1997a), I analyze a closed economy framework in which public capital has productive benefits. Moreover, public capital is subject to congestion, where the usage of an individual affects the services derived by others.[37] In contrast to Turnovsky (1997a), this paper does not focus on fiscal policy measures to achieve optimal economic growth, but rather uses government policies to achieve an optimal distribution of refugees across countries. As such, a further distinction of this paper is the inclusion of migration between two countries, which endogenously affects the degree of congestion in each economy.

Second, this paper is related to the literature on host country effects of migration.[38] Most of this literature focuses on labor market outcomes of migration. For example, Card (1990) shows in a natural experiment that immigration had virtually no effect on labor market outcomes on natives in Miami. In contrast, Cohen-Goldner and Paserman (2011) show negative wage outcomes of Russian immigrants in Israel in the long run. More recently, Ceritoglu et al. (2015) show that the unexpected inflow of Syrian refugees to Turkey have caused negative employment outcomes, with almost no effect on wages. Other areas of interest include the effects of immigration on prices (e.g. Lach (2007) and Cortes (2008)), housing (e.g. Sá (2015) and Balkan and Tumen (2015)), or worker productivity (e.g. Paserman (2013)). More closely related to the concept of migration and congestion, Gould, Lavy, and Paserman (2009) show that the presence of immigrants in the class room has significant negative spillovers on domestic students in Israel. In addition to negative spillovers on human capital, Baez (2011) finds that the presence of refugees has negative health consequences for local children in Tanzania. These studies support the premise of this paper that refugee migration may lead to congestion of publicly provided services.

The inclusion of refugee migration in a model where public services are subject to congestion yields new insights into how different government policies affect refugee distribution, and in turn the economy's equilibrium behavior. I find that shocks to public investment, tax rates and refugee policies (transfer payments and movement costs) are not equally suited to achieve the optimal equilibrium outcome as derived by the central planner. First, a negative shock to public investment in the North leads to a reduction in its long

[36] see for example Barro (1990), Futagami, Morita, and Shibata (1993), Baxter and King (1993), Glomm and Ravikumar (1994), and Turnovsky (1997a)

[37] Other studies analyzing congestion effects on growth and welfare include Barro and Sala-i Martin (1992), Edwards (1990) and Turnovsky and Fisher (1995)

[38] see Docquier and Rapoport (2012) for an overview of the consequences of migration for the home country

run stock relative to private capital. The lower stock of public capital reduces the productivity of Northern private capital, which in turn discourages private investment, and leads to a substitution towards consumption. As the reduction in public investment reduces both public and private capital, output decreases and causes Northern welfare payments to refugees to decline. Consequently refugees gradually migrate towards the South. While this policy option slows down steady state growth rates relative to the centralized solution it increases welfare levels of Northern households. In contrast, a positive shock to public investment in the South achieves the same gradual redistribution of refugees with increasing steady state growth rates and declining welfare levels of Southern households.

Second, I consider a positive shock to Southern income taxes. The increase in income taxes lowers the tax return on private capital and leads households in the South to substitute away from investment towards consumption. As a result, the private capital stock falls, which in turn leads to a long run increase in the public-to-private capital and consumption-to-capital ratio. Moreover, the capital-to-output ratio falls, implying an increase in income relative to private capital. Since refugees receive a constant share, T, of Southern income relative to private capital their incentive to relocate to the South increases. While Southern households experience a welfare gain associated with a positive income tax shock, steady state growth rates decline. Shocks to consumption taxes in this framework are non-distortionary, and thus not suited to achieve the "first-best" allocation of refugees.

Finally, shocks to refugee policies achieve an instantaneous redistribution of refugees from the North to the South without significantly affecting any other macroeconomic variables (including steady state growth and welfare levels). The higher share of refugees in the South reduces the productivity of public capital via congestion, which in turn decreases the marginal productivity of private capital and discourages private investment. In the North, the outflow of refugees leads to a reduction of congestion, causing the public-to-private capital ratio to decrease over time. The impact of congestion on public capital productivity, however, is marginal, leading to no significant changes in the macroeconomic variables. This result is robust to variations in the congestion parameter and can be explained by the relatively low share of refugees relative to domestic population. Consequently, equilibrium responses are mainly driven by the shocks directly, instead of the subsequent changes to public goods congestion associated with refugee movements.

The rest of the paper is organized as follows: Section 2 presents the analytical framework. Sections 3 and 4 characterize the central planner's and the decentralized solution, respectively. Section 5 discusses equilibrium changes and transitional dynamics to policy shocks. Moreover, welfare changes are analyzed. Section 6 provides a general interpretation of the results in light of the recent refugee situation in Europe before Section 7 concludes.

4.2 Analytical Framework

I consider two closed, refugee-receiving economies, populated by N infinitely lived representative households. The representative household in each country maximizes intertemporal utility from a private consumption good, C:

$$U_i(C_i) = \int_0^\infty [ln(C_i)]\, e^{-\beta t} dt,\ i \in \{s, n\} \tag{4.1}$$

Further, households in each country produce output using a Cobb-Douglas production function employing their individual stock of private capital and the economy-wide stock of public services as factors of production:

$$Y_i = A_i K_i^{\alpha i} K_{ig}^{s\,1-\alpha i},\ \ 0 < \alpha < 1 \tag{4.2}$$

where α is the share of private capital, K, used for production, and K_{ig}^s are public capital services. The available stock of public capital services is non-excludable, but is subject to rivalry in the form of congestion. Particularly, the productivity of public capital services depends on its economy-wide usage. Since refugees cannot be excluded from access to public services both refugees as well as the domestic population contribute to public goods congestion:[39]

$$\begin{aligned} K_{sg}^s &= K_{sg}\left(\tfrac{1}{N+sL}\right)^{1-\sigma_s} \\ K_{ng}^s &= K_{ng}\left(\tfrac{1}{N+(1-s)L}\right)^{1-\sigma_n} \end{aligned} \quad 0 \leq \sigma_s, \sigma_n \leq 1 \tag{4.3}$$

where K_{ig} is the economy-wide stock of public capital, σ_i is the degree of relative congestion associated with the productivity benefits of public capital in country i, L is the total amount of refugees, and s is the share of refugees in the South.[40] Equation (4.3) implies that the larger the domestic population, and the larger the share of refugees, the higher public goods congestion, and in turn the lower the productive benefit derived from public capital.

Public and private capital accumulates by new investment into each capital good, net of depreciation, δ. Formally,

[39] i.e. refugees have access to the education and health care system, travel on domestic roads, etc., all of which increases congestion of the public good

[40] Function (4.3) is the standard specification in the median voter model of congestion: see for example Edwards (1990). It implies decreasing marginal congestion as long as $\sigma < 1$

$$\dot{K}_i = I_i - \delta_i K_i \tag{4.4a}$$

$$\dot{K}_{ig} = G_i - \delta_{ig} K_{ig} \tag{4.4b}$$

where I and G are the flow of private and public investment, respectively. Finally, each economy's aggregate resource constraint is given by

$$Y_i = C_i + C_{iM} + I_i + G_i + \psi_i(s, K) \tag{4.5}$$

where C_{iM} is refugee consumption in country i, and $\psi_i(s, K)$ is a sunk cost associated with refugee movements. Equation (4.5) states that final output can be used for household and refugee consumption, and to finance private and public investments as well as the refugee's moving costs. Refugees are assumed to have no ownership of capital or access to bond trading. As such, they consume their entire income each period, net of moving costs, where the only source of refugee income is in the form of government transfer payments, $T_i Y_i$:[41]

$$(1 + \tau_{nc}) C_{nM} = T_n Y_n - \chi_n (1 - s) K_n \tag{4.6a}$$

$$(1 + \tau_{sc}) C_{sM} = T_s Y_s - \chi_s s K_s \tag{4.6b}$$

where the second term on the left-hand side characterizes the refugee's moving costs, $\psi_n(s, K)$ in the North and South respectively. These costs are increasing with the share of refugees already in the country and with the host country's stock of private capital. The former property reflects the increasing difficulty of obtaining asylum due to quotas. The latter reflects the cost of integrating into society, which increases with the gap between refugees and domestic population in terms of social and human capital.[42]

In what follows, I will first describe the allocation problem in a centrally planned economy to derive the "first-best" benchmark equilibrium. Then, I will solve the allocation problem for a decentralized economy. This sequential analysis allows me to characterize the design of an optimal policy to reach the "first-best" equilibrium. The crucial difference between the social planner's (centralized) problem and the decentralized problem is the way congestion externalities are internalized. The social planner recognizes the relationship between public capital services and its economy-wide usage, $K_{ng}^s = K_{ng} \left(\frac{1}{N + (1-s)L} \right)^{1-\sigma_n}$ in the North and

[41] The assumption that refugees have no income from labor is a strong one, yet not unrealistic. According to Tino Sanandaji from the Stockholm School of Economics, it takes about 15 years for each refugee cohort to reach a 50% employment rate, after which the number stagnates.

[42] As in Barro (1991) private capital should be interpreted as a broad measure of private input, including physical capital, human capital, and aspects of privately owned knowledge.

$K^s_{sg} = K_{sg}\left(\frac{1}{N+sL}\right)^{1-\sigma_s}$ in the South, ex ante. In contrast, the representative household in the decentralized economy fails to internalize this relationship, although it holds ex post, in equilibrium. As a result, the resource allocation problem in the decentralized economy is sub-optimal. Optimal policy in the decentralized economy would then entail using policy instruments that enables a replication of the resource allocation in a centrally planned economy. As mentioned in the introduction (Figure 4.2), the European Union recently presented a refugee distribution scheme based on a country's GDP.[43] This paper analyzes government interventions that would achieve an optimal refugee distribution as derived under the "first-best" benchmark equilibrium. Government interventions considered in this paper include changes in government spending on the public good, changes in tax rates, as well as changes in refugee policies (transfer payments and movement costs).

4.3 A Centrally Planned Economy

4.3.1 The Basic Model without Refugees

To highlight the role of refugees in each economy I start by outlining the basic central planner model without refugees. Since the social planner in a centrally planned economy internalizes the effect of congestion before the optimization problem, I set $K^s_{ng} = K_{ng}\left(\frac{1}{N+(1-s)L}\right)^{1-\sigma_n}$ and $K^s_{sg} = K_{sg}\left(\frac{1}{N+sL}\right)^{1-\sigma_s}$. By normalizing $N = 1$, and assuming no refugees ($L = 0$) the production functions in (4.2) reduce to

$$Y_i = A_i K_i^{\alpha i} K_{ig}^{1-\alpha i}$$

The central planner maximizes utility of Northern and Southern households

$$U = \int_0^\infty \left[ln(C_n) + ln(C_s)\right] e^{-\beta t} dt$$

subject to

$$\begin{aligned} \dot{K}_i &= (1-g_i)Y_i - C_i - \delta_i K_i \\ \dot{K}_{ig} &= G_i - \delta_{ig} K_{ig} = g_i Y_i - \delta_{ig} K_{ig} \end{aligned}$$

[43] In addition to a country's GDP, the EU considers a country's population, unemployment rate and previously admitted refugees in her policy plan.

where g is the fraction of final output devoted by the government to public investment. The social planner makes the resource allocation decision for the representative household by choosing consumption and the accumulation of private and public capital, as well as the optimal fraction of final output devoted by the government to public investment, g. Maximization yields the following first order conditions:

$$\begin{aligned}
C_i: \quad \frac{1}{C_i} &= \lambda_i \\
g_i: \quad \lambda_i &= q_i \\
K_i: \quad \beta_i - \frac{\dot{\lambda}_i}{\lambda_i} &= \frac{\partial Y_i}{\partial K_i} - \delta_i \\
K_{ig}: \quad \beta_i - \frac{\dot{\lambda}_i}{\lambda_i} &= \frac{\partial Y_i}{\partial K_{ig}} - \delta_{ig}
\end{aligned}$$

where λ and q are the shadow prices of private and public capital respectively. The equilibrium growth rates for private capital, public capital and consumption are given by:

$$\begin{aligned}
\frac{\dot{K}_i}{K_i} &= (1 - g_i)\, y_i - c_i - \delta_i \\
\frac{\dot{K}_{ig}}{K_{ig}} &= g_i \frac{y_i}{k_{ig}} - \delta_{ig} \\
\frac{\dot{C}_i}{C_i} &= \frac{\partial Y_i}{\partial K_i} - \delta_i - \beta_i
\end{aligned}$$

where $k_{ig} = \frac{K_{ig}}{K_i}$, $c_i = \frac{C_i}{K_i}$, $c_{iM} = \frac{C_{iM}}{K_i}$, and $y_i = \frac{Y_i}{K_i}$. The steady state equilibrium of the centrally planned economy is characterized by $\frac{\dot{c}_i}{c_i} = \frac{\dot{k}_{ig}}{k_{ig}} = 0$:

$$\begin{aligned}
(1 - g_i)\, y_i - c_i - \delta_i &= g_i \frac{y_i}{k_{ig}} - \delta_{ig} \\
(1 - g_i)\, y_i - c_i - \delta_i &= \frac{\partial Y_i}{\partial K_i} - \delta_i - \beta_i \\
\frac{\partial Y_i}{\partial K_{ig}} - \delta_{ig} &= \frac{\partial Y_i}{\partial K_i} - \delta_i
\end{aligned}$$

These 6 equations describe the system of 6 stationary variables c_n, c_s, k_{ng}, k_{sg}, g_n and g_s.

4.3.2 The Centralized Model with Refugees

As in the model without refugees, the social planner in a centrally planned economy internalizes the effect of congestion before the optimization problem. However, in this section, the amount of refugees is $L > 0$. Therefore, the planner's utility and production function take the form

$$U = \int_0^\infty \left[ln(C_s) + ln(C_n) + ln(C_{sM}) + ln(C_{nM}) \right] e^{-\beta t} dt \tag{1a}$$

$$Y_s = A_s K_s^{\alpha s} \left[K_{sg} \left(\frac{1}{1+sL} \right)^{1-\sigma_s} \right]^{1-\alpha s} \tag{2a}$$

$$Y_n = A_n K_n^{\alpha n} \left[K_{ng} \left(\frac{1}{1+(1-s)L} \right)^{1-\sigma_n} \right]^{1-\alpha n} \tag{2b}$$

The social planner makes the resource allocation decision for the representative household and refugee by choosing consumption and the accumulation of private and public capital. Further, the social planner allocates the number of refugees optimally across both countries, and chooses the optimal fraction of final output devoted by the government to public investment, g:

$$\dot{K}_{ig} = G_i - \delta_{ig} K_{ig} = g_i Y_i - \delta_{ig} K_{ig} \tag{4.7}$$

The central planner's constraints are given by (6), (4.7) and

$$\begin{aligned} \dot{K}_n &= (1-g_n) Y_n - C_n - C_{nM} - \chi_n (1-s) K_n - \delta_n K_n \\ \dot{K}_s &= (1-g_s) Y_s - C_s - C_{sM} - \chi_s s K_s - \delta_s K_s \end{aligned} \tag{4.8}$$

Maximization yields the following optimality conditions:

$$C_i : \ \frac{1}{C_i} = \lambda_i \tag{4.9a}$$

$$g_i : \ \lambda_i = q_i \tag{4.9b}$$

$$\begin{aligned} s : \ \frac{T_n \frac{\partial Y_n}{\partial s} + \chi_n K_n}{T_n Y_n - \chi_n (1-s) K_n} &+ \lambda_n \left[\left(1 - \frac{T_n}{1+\tau_{nc}} \right) \frac{\partial Y_n}{\partial s} + \frac{\tau_{nc}}{1+\tau_{nc}} \chi_n K_n \right] = \\ \frac{-T_s \frac{\partial Y_s}{\partial s} + \chi_s K_s}{T_s Y_s - \chi_s s K_s} &- \lambda_s \left[\left(1 - \frac{T_s}{1+\tau_{sc}} \right) \frac{\partial Y_s}{\partial s} - \frac{\tau_{sc}}{1+\tau_{sc}} \chi_s K_s \right] \end{aligned} \tag{4.9c}$$

$$K_n: \quad \beta_n - \frac{\dot{\lambda}_n}{\lambda_n} = \frac{T_n \frac{\partial Y_n}{\partial K_n} - \chi_n(1-s)}{T_n \frac{Y_n}{C_n} - \chi_n(1-s)\frac{K_n}{C_n}} + \left(1 - \frac{T_n}{1+\tau_{nc}}\right)\frac{\partial Y_n}{\partial K_n} - \frac{\tau_{nc}}{1+\tau_{nc}}(1-s)\chi_n - \delta_n \tag{4.9d}$$

$$K_s: \quad \beta_s - \frac{\dot{\lambda}_s}{\lambda_s} = \frac{T_s \frac{\partial Y_s}{\partial K_s} - \chi_s s}{T_s \frac{Y_s}{C_s} - \chi_s s \frac{K_s}{C_s}} + \left(1 - \frac{T_s}{1+\tau_{sc}}\right)\frac{\partial Y_s}{\partial K_s} - \frac{\tau_{sc}}{1+\tau_{sc}} s\chi_s - \delta_s \tag{4.9e}$$

$$K_{ng}: \quad \beta_n - \frac{\dot{\lambda}_n}{\lambda_n} = \frac{T_n \frac{\partial Y_n}{\partial K_{ng}}}{T_n \frac{Y_n}{C_n} - \chi_n(1-s)\frac{K_n}{C_n}} + \left(1 - \frac{T_n}{1+\tau_{nc}}\right)\frac{\partial Y_n}{\partial K_{ng}} - \delta_{ng} \tag{4.9f}$$

$$K_{sg}: \quad \beta_s - \frac{\dot{\lambda}_s}{\lambda_s} = \frac{T_s \frac{\partial Y_s}{\partial K_{sg}}}{T_s \frac{Y_s}{C_s} - \chi_s s \frac{K_s}{C_s}} + \left(1 - \frac{T_s}{1+\tau_{sc}}\right)\frac{\partial Y_s}{\partial K_{sg}} - \delta_{sg} \tag{4.9g}$$

The optimality conditions in (4.9) can be interpreted as follows: Equation (4.9a) equates the marginal utility of consumption to the shadow price of private capital. Equation (4.9b) implies that the social planner chooses the optimal share of public expenditure to ensure that the shadow prices of private and public capital are equalized. Equation (4.9c) ensures that the marginal return of refugees from living in the South is equal to the marginal return from living in the North, while accounting for the additional congestion refugee migration causes. Equations (4.9d) - (4.9g) equate the return of private and public investment with the corresponding return of consumption. Using (4.7), (4.8), (4.9a), (4.9d), and (4.9e), the equilibrium growth rates for private capital, public capital and consumption are given by:

$$\frac{\dot{K}_i}{K_i} = (1-g_i)\, y_i - c_i - c_{iM} - \delta_i - \psi_i(s,1) \tag{4.10a}$$

$$\frac{\dot{K}_{ig}}{K_{ig}} = g_i \frac{y_i}{k_{ig}} - \delta_{ig} \tag{4.10b}$$

$$\frac{\dot{C}_n}{C_n} = \frac{T_n \frac{\partial Y_n}{\partial K_n} - \chi_n(1-s)}{T_n \frac{Y_n}{C_n} - \chi_n(1-s)\frac{K_n}{C_n}} + \left(1 - \frac{T_n}{1+\tau_{nc}}\right)\frac{\partial Y_n}{\partial K_n} - \frac{\tau_{nc}}{1+\tau_{nc}}(1-s)\chi_n - \delta_n - \beta_n \tag{4.10c}$$

$$\frac{\dot{C}_s}{C_s} = \frac{T_s \frac{\partial Y_s}{\partial K_s} - \chi_s s}{T_s \frac{Y_s}{C_s} - \chi_s s \frac{K_s}{C_s}} + \left(1 - \frac{T_s}{1+\tau_{sc}}\right)\frac{\partial Y_s}{\partial K_s} - \frac{\tau_{sc}}{1+\tau_{sc}} s\chi_s - \delta_s - \beta_s \tag{4.10d}$$

The steady state equilibrium of the centrally planned economy is characterized by $\frac{\dot{c}_i}{c_i} = \frac{\dot{k}_{ig}}{k_{ig}} = 0$, and can be derived from the dynamic equations in (4.10a) - (4.10d), and equations (4.9c) - (4.9g):

$$\left(1 - g_n - \frac{T_n}{1+\tau_{nc}}\right) y_n - c_n = \frac{T_n \alpha_n y_n - \chi_n(1-s)}{T_n \frac{y_n}{c_n} - \chi_n \frac{1-s}{c_n}} + \left(1 - \frac{T_n}{1+\tau_{nc}}\right)\alpha_n y_n - \beta_n \tag{4.11a}$$

$$\left(1 - g_s - \frac{T_s}{1+\tau_{sc}}\right) y_s - c_s = \frac{T_s \alpha_s y_s - \chi_s s}{T_s \frac{y_s}{c_s} - \chi_s \frac{s}{c_s}} + \left(1 - \frac{T_s}{1+\tau_{sc}}\right)\alpha_s y_s - \beta_s \tag{4.11b}$$

$$g_n \frac{y_n}{k_{ng}} - \delta_{ng} = (1-g_n)y_n - c_n - c_{nM} - \delta_n - \psi_n(s) \tag{4.11c}$$

$$g_s \frac{y_s}{k_{sg}} - \delta_{sg} = (1-g_s)y_s - c_s - c_{sM} - \delta_s - \psi_s(s) \tag{4.11d}$$

$$\begin{aligned} \frac{1}{c_n}\left[\left(1-\frac{T_n}{1+\tau_{nc}}\right)\frac{\partial y_n}{\partial s} + \frac{\tau_{nc}}{(1+\tau_{nc})}\chi_n\right] &+ \frac{T_n\frac{\partial y_n}{\partial s}+\chi_n}{T_n y_n - \chi_n(1-s)} = \\ -\frac{1}{c_s}\left[\left(1-\frac{T_s}{1+\tau_{sc}}\right)\frac{\partial y_s}{\partial s} - \frac{\tau_{sc}}{1+\tau_{sc}}\chi_s\right] &+ \frac{-T_s\frac{\partial y_s}{\partial s}+\chi_s}{T_s y_s - \chi_s s} \end{aligned} \tag{4.11e}$$

$$(1-g_n)y_n - c_n - c_{nM} - \delta_n - \psi_n(s) = \frac{T_n(1-\alpha_n)\frac{y_n}{k_{ng}}}{T_n\frac{y_n}{c_n} - \chi_n\frac{1-s}{c_n}} + \left(1-\frac{T_n}{1+\tau_{nc}}\right)(1-\alpha_n)\frac{y_n}{k_{ng}} - \delta_{ng} - \beta_n \tag{4.11f}$$

$$(1-g_s)y_s - c_s - c_{sM} - \delta_s - \psi_s(s) = \frac{T_s(1-\alpha_s)\frac{y_s}{k_{sg}}}{T_s\frac{y_s}{c_s} - \chi_s\frac{s}{c_s}} + \left(1-\frac{T_s}{1+\tau_{sc}}\right)(1-\alpha_s)\frac{y_s}{k_{sg}} - \delta_{sg} - \beta_s \tag{4.11g}$$

These 7 equations describe the system of 7 stationary variables c_n, c_s, k_{ng}, k_{sg}, s, g_n and g_s.

4.4 A Decentralized Economy

In this section I consider the case of a decentralized economy in which the representative agent in the North and South make their own resource allocation decisions. In contrast to the centralized economy, the representative agent takes the stock of public capital as given, and makes its allocation decision only with respect to consumption, private capital and government bond holdings. Moreover, the representative household does not internalize the externality associated with the congestion of public capital services. Therefore, the representative household maximizes

$$U = \int_0^\infty [ln(C_i)]\, e^{-\beta t} dt. \tag{1b}$$

subject to the household's accumulation constraint:

$$\dot{K}_i + \dot{B}_i = (1-\tau_{iy})(Y_i + rB_i) - (1+\tau_{ic})C_i - \delta_i K_i \tag{4.12}$$

where Y_i is given by equation (4.2), r is the interest earnings on government bonds B, and τ_y and τ_c are income and consumption tax rates, respectively. It is important to emphasize that the households fails to internalize the relationship $K^s_{ng} = K_{ng}\left(\frac{1}{1+(1-s)L}\right)^{1-\sigma_n}$ and $K^s_{sg} = K_{sg}\left(\frac{1}{1+sL}\right)^{1-\sigma_s}$, although it holds in equilibrium. The optimality conditions in this regime are given by:

$$C_i: \quad \frac{1}{C_i} = (1+\tau_{ic})\lambda_i \tag{4.13a}$$

$$K_i: \quad \beta - \frac{\dot{\lambda}_i}{\lambda_i} = (1-\tau_{iy})\frac{\partial Y_i}{\partial K_i} - \delta_i \tag{4.13b}$$

$$B: \quad \beta - \frac{\dot{\lambda}_i}{\lambda_i} = (1-\tau_{iy})r \tag{4.13c}$$

The interpretation of (4.13a) and (4.13b) is analogous to that of the centrally planned economy. Equation (4.13c) equates the rate of return on consumption to the return on government bond holdings.

In addition to the resource allocation problem of the representative households, refugees choose their distribution, s, across North and South, and their optimal consumption level by maximizing their utility subject to (4.6a) and (4.6b):

$$max\ U = ln\,(C_{nM}) + ln\,(C_{sM}) \tag{4.14}$$

$$s.t.\ C_{nM} = \frac{1}{1+\tau_{nc}}\left(T_n Y_n - \chi_n(1-s)K_n\right) \tag{4.15}$$

$$C_{sM} = \frac{1}{1+\tau_{sc}}\left(T_s Y_s - \chi_s s K_s\right) \tag{4.16}$$

The optimality conditions are given by

$$C_{iM}: \quad \frac{1}{C_{iM}} = \lambda_{iM} \tag{4.17}$$

$$s: \quad \frac{\lambda_{nM}}{1+\tau_{nc}}\chi_n K_n = \frac{\lambda_{sM}}{1+\tau_{sc}}\chi_s K_s \tag{4.18}$$

Substituting (4.17) in (4.18), and taking into account the refugee's budget constraints gives the optimal distribution of refugees for the decentralized case:

$$s = \frac{1}{2}\left[1 + \frac{T_s y_s}{\chi_s} - \frac{T_n y_n}{\chi_n}\right] \tag{4.19}$$

As in the centralized case, the growth rate of private and public capital are given by

$$\frac{\dot{K}_i}{K_i} = (1-g_i)\,y_i - c_i - c_{iM} - \delta_i - \psi_i(s) \tag{4.20a}$$

$$\frac{\dot{K}_{ig}}{K_{ig}} = g_i\frac{y_i}{k_{ig}} - \delta_{ig}. \tag{4.20b}$$

Additionally, the growth rate of consumption in the decentralized economy is given by

$$\frac{\dot{C}_i}{C_i} = (1-\tau_{iy})\alpha_i y_i - \delta_i - \beta_i \tag{4.20c}$$

and the evolution of s is given by the time derivative of (4.19):

$$\frac{\dot{s}}{s} = \frac{\frac{(1-\alpha_n)T_n y_n}{\chi_n(2s-1)+T_n y_n}\left(\frac{\dot{K}_{ng}}{K_{ng}} - \frac{\dot{K}_n}{K_n}\right) - (1-\alpha_s)\left(\frac{\dot{K}_{sg}}{K_{sg}} - \frac{\dot{K}_s}{K_s}\right)}{\frac{(\alpha_s-1)(1-\sigma_s)L}{(1+sL)s} - \frac{L(1-\alpha_n)(1-\sigma_n)T_n y_n + 2\chi_n(1+(1-s)L)}{s(1+(1-s)L)(\chi_n(2s-1)+T_n y_n)}} \tag{4.20d}$$

Finally, the evolution of government debt is determined by:

$$\dot{B}_i = (1-\tau_{iy})rB_i + G_i - (\tau_{iy}Y_i + \tau_{ic}(C_i + C_{iM}) - T_i Y_i) \tag{4.21}$$

Equation (4.21) states to the extent that interest payments on debt, and expenditure on the public good and refugee support exceed tax revenues, the government will finance the resulting deficit by issuing debt. Combining (4.12) with (4.21) yields the aggregate resource constraint for the economy given by (4.5)

4.4.1 Macroeconomic Equilibrium

As for the centralized economy, the steady state equilibrium of the decentralized economy is characterized by $\frac{\dot{c}_i}{c_i} = \frac{\dot{s}}{s} = \frac{\dot{k}_{ig}}{k_{ig}} = 0$, and can be derived from the dynamic equations in (4.20a) - (4.20c), and the optimal distribution of refugees given by (4.19):

$$(1-\bar{g}_n)y_n - c_n - c_{nM} - \delta_n - \psi_n(s) = \bar{g}_n \frac{y_n}{k_{ng}} - \delta_{ng} \tag{4.22a}$$

$$(1-\bar{g}_n)y_n - c_n - c_{nM} - \delta_n - \psi_n(s) = (1-\tau_{ny})\alpha_n y_n - \delta_n - \beta_n \tag{4.22b}$$

$$(1-\bar{g}_s)y_s - c_s - c_{sM} - \delta_s - \psi_s(s) = \bar{g}_s \frac{y_s}{k_{sg}} - \delta_{sg} \tag{4.22c}$$

$$(1-\bar{g}_s)y_s - c_s - c_{sM} - \delta_s - \psi_s(s) = (1-\tau_{sy})\alpha_s y_s - \delta_s - \beta_s \tag{4.22d}$$

$$\frac{1}{2}\left[1 + \frac{T_s y_s}{\chi_s} - \frac{T_n y_n}{\chi_n}\right] = s \tag{4.22e}$$

where $\bar{g}_i$ is the optimal share of final output devoted to public investment, as determined in Section 3. These 5 equations describe the system of the 5 stationary variables c_n, c_s, k_{ng}, k_{sg}, and s.

4.4.2 Optimal Government Policies

The European Union released a refugee relocation scheme in September 2015 to relieve some countries of the burden refugees put on them. The plan redistributes refugees across members of the EU according to a country's economic strength, population, unemployment rate and the number of previously approved asylum seekers.[44] For the relocated individuals, this means a temporary deviation from the Dublin Regulation, in particular the suspension of the criterion for determining the Member State responsible for examining an asylum application. Usually, the responsible Member State will be the state through which the asylum seeker first entered the EU. Due to this rule, countries in near proximity to the refugee's home country, as well as countries with relatively high living standards are the prime destination of asylum seekers.[45] As such, countries like Cyprus, France, Austria, Germany, or Sweden have received a disproportionally high share of asylum claims, relative to countries such as Croatia, Portugal, Spain or the Czech Republic.

The following section investigates potential government policies that provide refugees with incentives to file claims in relatively less advanced countries. In particular, three policy tools are analyzed: government spending on public goods, tax rates, and refugee policy tools (transfer payments and movement costs). Since refugees do not take into account the additional congestion they cause for the public good the distribution of refugees in the decentralized case is suboptimal compared to the centralized solution in Section 3. Given that government spending, tax rates and transfer payments affect the economy in different ways, the next section investigates which policy mix in the decentralized economy will replicate the first-best distribution of refugees attained by the social planer.

4.5 Government Policy and Transitional Dynamics: A Numerical Analysis

I begin the analysis of the framework laid out in Section 3 and 4 with a numerical characterization of both the centrally planned and decentralized economies. The starting point is the calibration of two refugee-receiving economies that differ in terms of their economic strength. Since the North is more advanced relative to the South, the social planner allocates a larger share of refugees to the North. This is in accordance with the plans by the EU that economically more advanced countries are better suited to deal with the economic burden associated with refugee inflows. In the decentralized economy, however, the share of refugees that seek asylum in the North is disproportionally large as they fail to internalize the externality associated with congestion. Consequently, I am interested in (i) the role played by government spending, tax rates and

[44] see European Commission Press Release: http://europa.eu/rapid/press-release_MEMO-15-5038_en.htm
[45] see for example Hatton (2004) and Rotte, Vogler, and Zimmermann (1997)

refugee policies to achieve the first-best distribution of refugees, (ii) which policy mix achieving this first-best distribution is most efficient in terms of welfare and growth, and (iii) the economies' behavior along the transition paths from the suboptimal to first-best equilibrium.

4.5.1 Equilibrium in a Centrally Planned Economy

The starting point is the steady-state equilibrium in the centrally planned economy. Table 4.2 describes the choices of the structural and policy parameters used to calibrate this benchmark economy:[46]

Table 4.2: Calibration of the Centrally Planned Economy

	North			South		
Discount Factor	$\beta = 0.04$			$\beta = 0.04$		
Depreciation Rates	$\delta = 0.08$	$\delta_g = 0.08$		$\delta = 0.08$	$\delta_g = 0.08$	
Production Parameters	$A = 0.35$	$\alpha = 0.75$	$\sigma = 0.3$	$A = 0.315$	$\alpha = 0.75$	$\sigma = 0.3$
Policy Parameters	$\chi = 0.00026$	$T = 0.005$	$\tau_c = 0$	$\chi = 0.00025$	$T = 0.005$	$\tau_c = 0$

The rate of time preference, β, is set at 0.04, and capital depreciation rates, δ and δ_g, are set at 8%, as is standard in the literature. The production parameters in both economies only differ with respect to their production technology, A. Since I assume the North to be more technologically advanced than the South I set $A_n = 0.35$ and $A_s = 0.315$, implying a 10% lower productivity level in the South. The output elasticity of private capital in both countries is set to 0.75, which implies a corresponding output elasticity of public capital equal to 0.25. This is in line with the empirical findings reviewed by Gramlich (1994). Moreover, I consider the case of partial congestion and set $\sigma_i = 0.3$ to serve as a benchmark case, but I will consider the sensitivity of the results to several values. Regarding the parameters associated with refugee migration, I set the total number of refugees, L, equal to 0.1, implying that the total amount of refugees is 10% of each country's population. Next, I set $T = 0.005$, implying that each country spends about 0.5% of its total output on refugees, which is in line with findings for Germany by the Cologne Institute for Economic Research. Finally, the cost-of-movement parameter, χ, is set to target a refugee distribution that is 10% higher in the North, to reflect the plan by the European Union to peg the refugee distribution to productivity differences.

Table 4.3 characterizes the steady-state equilibrium in a centrally planned economy without refugee migration (Panel A) and with refugee migration (Panel B). The presence of refugees leads to less domestic consumption and more government spending on public services. Thus, steady state growth rates in both

[46]The calibration of the model is for illustrative purposes, rather than approximating a real economy, though some of the equilibrium quantities, like the private-to-public capital ratio, private capital-to-GDP ratio and growth rates, lie in their corresponding empirically estimated ranges.

countries are slightly higher in an economy with refugee migration relative to an economy without. Finally, the optimal distribution of refugees in the centralized problem is almost 50:50 with 52% of refugees being located in the North.

Table 4.3: Steady State Equilibrium in the Centrally Planned Economy

		k_g	c	c_M	g	Refugees	K/Y	$\frac{(C+C_M)}{Y}$	Growth
Panel A: no Refugees	North	0.32	0.05	-	0.19	-	3.77	0.20	0.08
	South	0.32	0.05	-	0.19	-	4.19	0.22	0.06
Panel B: Refugees	North	0.32	0.03	0.001	0.22	0.52	3.80	0.10	0.09
	South	0.32	0.03	0.001	0.22	0.48	4.20	0.12	0.07

Table 4.4 illustrates the steady-state equilibrium in a centrally planned economy, for different values of the congestion parameter, σ_i. When $\sigma = 1$, the equilibrium outcome corresponds to a case without externalities. In this case, refugees only affect the equilibrium outcome of the centrally planned economy through their presence in the utility function of the planner.[47] Therefore, considering outcomes when $\sigma < 1$ provides useful insights into its role in resource allocation. As Table 4.4 shows, the only significant change in the planner's allocation decision involves the distribution of refugees. As a rule of thumb, the higher the sensitivity of public services to congestion by refugees (the lower σ), the lower the optimal share of refugees in the North. Intuitively, the central planner equates the marginal benefit of refugees from moving to the North and moving to the South. As σ decreases (and congestion increases), the productive benefits of public services goes down, resulting in a reduction of total output and thus refugee income, T_iY_i. At the same time, however, movement costs remain unaffected by this change. With $\chi_n > \chi_s$ and decreasing output (due to increasing congestion) the marginal benefit of refugees in the South eventually outweighs the marginal benefit of refugees in the North, resulting in an optimal refugee share $s > 0.5$.[48]

[47] Assuming that the central planner's goal is to maximize utility of the domestic population only, the equilibrium outcome would be identical to the outcome of Table 4.3, Panel A, i.e. the benchmark equilibrium without refugees.

[48] In a scenario in which $\chi_n = \chi_s$ and $\sigma = 0$ the optimal share of refugees in the North is larger than in the South. This is due to higher productivity, and thus refugee income, in the North.

Table 4.4: Sensitivity of Benchmark Results to variations in σ

		k_g	c	c_M	g	Refugees	K/Y	$\frac{(C+C_M)}{Y}$	Growth
$\sigma = 0$	North	0.32	0.03	0.001	0.22	0.43	3.80	0.11	0.09
	South	0.32	0.03	0.001	0.22	0.57	4.22	0.12	0.07
$\sigma = 0.3$	North	0.32	0.03	0.001	0.22	0.52	3.80	0.10	0.09
	South	0.32	0.03	0.001	0.22	0.48	4.20	0.12	0.07
$\sigma = 0.7$	North	0.32	0.03	0.001	0.22	0.62	3.77	0.10	0.09
	South	0.32	0.03	0.001	0.21	0.38	4.19	0.12	0.08
$\sigma = 1$	North	0.32	0.03	0.001	0.22	0.68	3.75	0.10	0.10
	South	0.32	0.03	0.001	0.21	0.32	4.18	0.12	0.08

4.5.2 Equilibrium in a Decentralized Economy

Discount factor, depreciation rates, and production parameters are chosen as in the centrally planned case (see Table 4.2). In addition, Table 4.5 describes the baseline policy parameters of the Decentralized Economy:

Table 4.5: Policy Parameters of the Decentralized Economy

North	$\chi = 0.00026$	$T = 0.005$	$\tau_c = 0$	$\tau_y = 0.1$	$g_n = \bar{g}_n$
South	$\chi = 0.00025$	$T = 0.005$	$\tau_c = 0$	$\tau_y = 0.1$	$g_n = \bar{g}_n$

I set the pre-shock fiscal policy parameters $\tau_y = 0.1$ and $\tau_c = 0$. Moreover, the parameters associated with transfer payments from the government to the refugees, T, and the moving cost parameter, χ, are set as in the centralized case. Finally, government spending, g, are set at their optimal level, $\bar{g}$, as determined by the social planner in the centralized economy (see Table 4.3).

Table 4.6 characterizes the steady-state equilibrium in a decentralized economy. The model does relatively well in matching the empirically observed public-to-private capital ratio (about 0.4 for both the North and the South), as well as the private capital-to-GDP ratio (3.59 in the North and 3.96 in the South). The consumption-to-private capital ratio, as well as the consumption-to-GDP ratio lie below their empirically observed counterparts. This, however, can be explained by the omission of capital adjustment costs from the model, which would slow down the accumulation of private capital. The failure by households to internalize the externality from congestion causes too much household consumption relative to the centralized case, which in turn leads to steady state growth rates below their optimal levels (as determined by the central planner). Finally, since refugees do not take into account the congestion of public services, 66% of refugees choose to locate in the more advanced North, implying that too few refugees are located in the South relative to the social optimal determined in Table 4.3, Panel B.

Table 4.6: Steady State Equilibrium in the Decentralized Economy

	k_g	c	c_M	Refugees	K/Y	$\frac{(C+C_M)}{Y}$	Growth
North	0.40	0.07	0.001	0.66	3.59	0.24	0.07
South	0.41	0.06	0.001	0.34	3.96	0.26	0.05

Due to the sub-optimal distribution of refugees in the decentralized case, I continue to examine possible policy changes that achieve a "first-best" refugee distribution as determined by the central planner (Table 4.3). The rest of the paper is organized as follows: First, I consider shocks to public investment in both the North and South that achieve an optimal refugee distribution. Second, I consider tax rate changes that achieve the "first-best" allocation. Finally, I consider changes in refugee policies. For all three cases, I evaluate welfare implications and analyze the decentralized economies' transitional dynamics from the benchmark equilibrium to an equilibrium that achieves the "first-best" distribution of refugees.

4.5.2.1 Long-run Effects of Government Spending Shocks (g)

Both North and South have the ability to achieve the "first-best" refugee distribution by using their own government spending, g, as a policy tool. In the North, a reduction in government spending from 0.22 to 0.17 accomplishes a refugee distribution in line with the central planner's problem. Figure 4.3 describes the transitional dynamics: A lower share of government investment into public services leads to a reduction in its long run stock relative to private capital. The lower stock of public capital reduces the long run productivity of private capital in the North, which in turn discourages private investment. This leads to a substitution away from private investment towards consumption, causing an increase in the consumption-to-capital ratio. As the reduction in public investment reduces both public and private capital, output decreases more than proportionally relative to consumption and private capital. Consequently, the private capital-to-output ratio and consumption-to-output ratio increase (not shown). While the reduction in public investment reduces the steady state growth rate, welfare in the North increases due to the household's substitution towards consumption. Finally, the reduction in output reduces refugees' income, TY, in the North, causing a redistribution towards the South. This redistribution marginally reduces congestion in the North, causing public capital productivity to increase. In contrast, the higher share of refugees in the South reduces the productivity of Southern public capital, which in turn reduces the marginal productivity of private capital and discourages private investment. The associated slow down of private capital accumulation (marginally) outweighs the lower productivity of public capital, resulting in a (marginally) increasing public-to-private capital ratio. As a result of the decrease in both capital stocks, output in the South falls disproportionally. Consequently,

the negative income effect slightly dominates the positive substitution effect and causes consumption in the South to fall.[49]

Southern policy intervention can achieve the "first best" refugee distribution by increasing public investment from 0.22 to 0.28. Figure 4.4 describes the transitional dynamics: A higher share of public investment leads to the increase in its long run stock relative to private capital. The higher stock of public capital enhances the long run productivity of private capital, which in turn encourages private investment. This leads to a substitution away from consumption towards private investment, causing an instantaneous drop in the consumption-to-capital ratio. As the increase in public investment raises both public and private capital, output expands more than proportionally relative to consumption and private capital. Consequently, the private capital-to-output ratio and consumption-to-output ratio fall (not shown). Moreover, the increase in output boosts refugees' income, TY, in the South, causing a redistribution towards the South. This redistribution marginally increases congestion in the South, causing an additional decrease in public capital productivity. Finally, while the increase in public investment raises the steady state growth rate, welfare in the South falls due to the household's substitution away from consumption. Equilibrium levels in the North are only marginally affected by lower congestion of public services resulting from refugee outflows. Table 4.7 reports the long run impact of shocks to public investment on the equilibrium resource allocation in the decentralized economy.

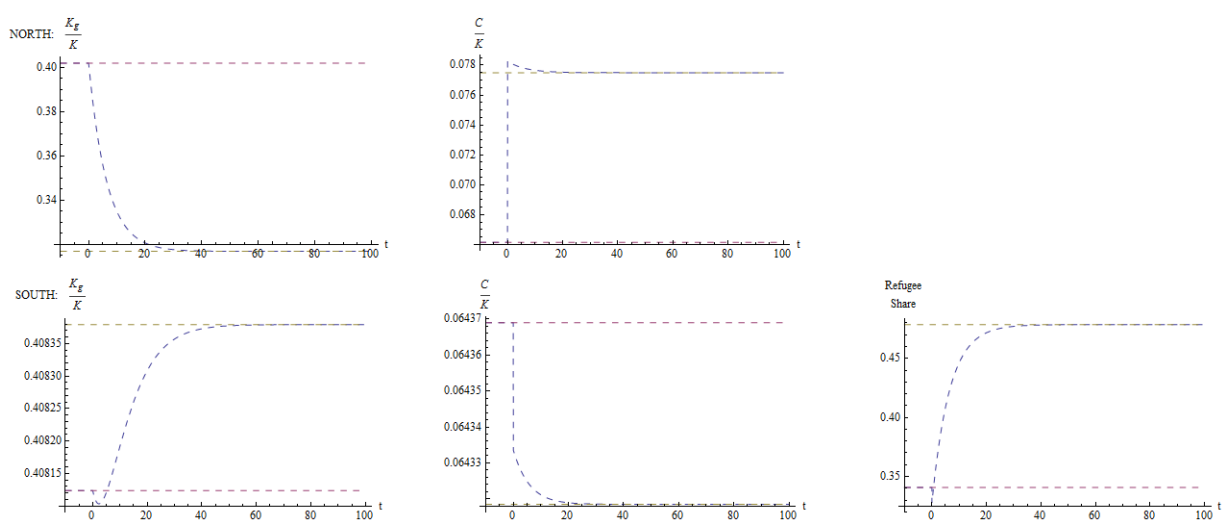


Figure 4.3: Decrease in Northern Government Spending ($g_n - 0.05$)

[49] Since the total number of refugees $L = 0.1$, the overall congestion externality caused by refugees is relatively small (regardless of σ). By increasing L, congestion increases and movement of refugees from the North to the South trigger a larger productivity decrease of Southern public capital. Thus, depending on the size of L, the decrease in productivity of private capital (due to the decrease in public capital productivity) may not outweigh the decrease in public capital productivity associated with higher congestion. Similar results could be achieved by keeping $L = 0.1$ and reducing σ sufficiently (below 0).

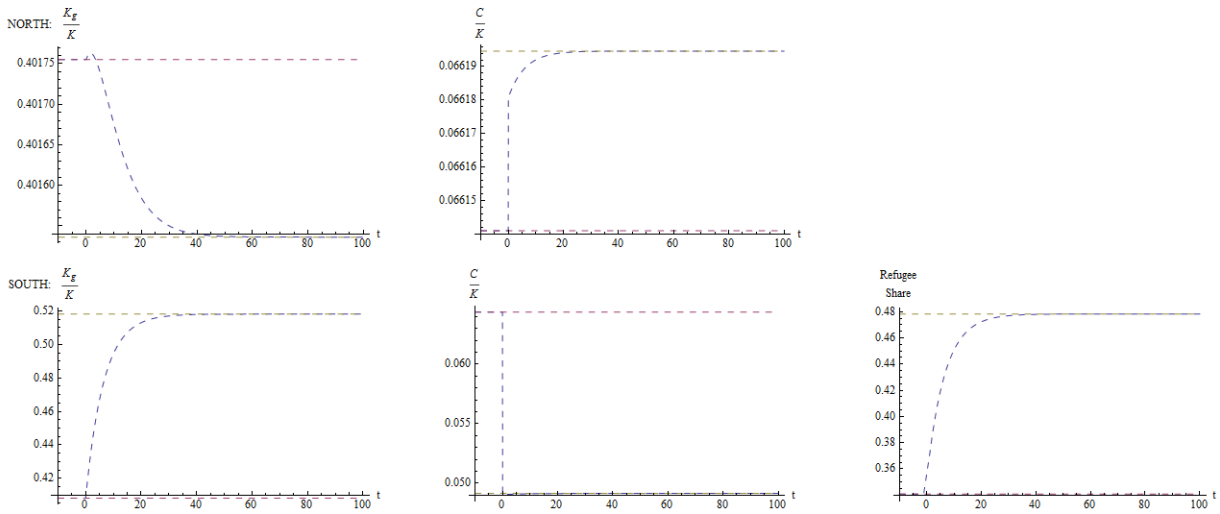


Figure 4.4: Increase in Southern Government Spending ($g_s + 0.06$)

4.5.2.2 Long-run Effects of Tax Shock

The consumption tax rate in this framework is non-distortionary and operates in a manner similar to a lump sum tax.[50] Thus, changes in the consumption tax only affects consumption levels of households and migrants in the respective country, without affecting capital or output. As a results, the consumption tax rate is not an appropriate policy tool to achieve the "first-best" refugee distribution (i.e. in equation (4.19): $\frac{\partial s}{\partial \tau_c} = 0$).

Instead, I focus on shocks to the Southern income tax rate that achieve a refugee distribution in line with the central planner's problem (Table 4.3). To achieve the optimal distribution an increase in the Southern tax rate from 10% to 25.8% is necessary.[51] Figure 4.5 describes the transitional dynamics: The higher tax on income lowers the tax return on private capital. This leads households in the South to substitute away from investment towards consumption, which in turn increases Southern welfare levels. As a result, the private capital stock falls, which in turn leads to a long run increase in the public-to-private capital and consumption-to-capital ratio. Moreover, the consumption-to-output ratio increases and long run growth in the South declines. Finally, the capital-to-output ratio falls, implying an increase in income relative to private capital. Since refugees receive a constant share, T, of Southern income relative to private capital their incentive to relocate to the South increases. This marginally affects the Northern economy through the congestion externality. The lower share of refugees in the North increases the productivity of public capital, which in turn increases the marginal productivity of private capital and encourages private investment. The associated accumulation of private capital (marginally) outweighs the higher productivity of public capital,

[50] see Turnovsky (1996) or Chatterjee and Ghosh (2011) for a more detailed discussion

[51] In order to achieve the optimal allocation of refugees $\Delta\tau_y > 0.1$ is necessary. Therefore, decreasing the Northern income tax rate by that amount would imply a subsidy, rather than a tax, which is not a realistic assumption.

resulting in a (marginally) decreasing public-to-private capital ratio. As a result of the increase in both capital stocks, output in the North rises disproportionally. Thus, the positive income effect slightly dominates the negative substitution effect and causes consumption in the North to increase. Table 4.7 reports the long run impact of the Southern income tax shock on the equilibrium resource allocation in the decentralized economy.

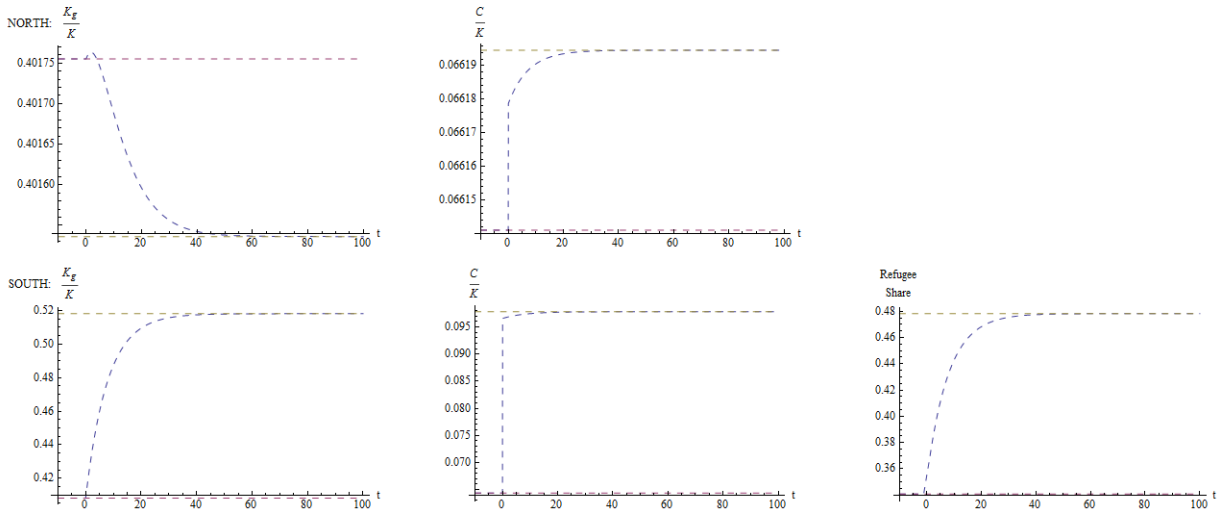


Figure 4.5: Increase in Southern Income Tax Rate ($\tau_y + 0.158$)

4.5.2.3 Long-run Effects of Refugee Policy Shocks

As in the case of government spending shocks, both North and South have the ability to achieve the "first-best" refugee distribution by using refugee policy tools (transfer payments and movement costs). In the North (South), a decrease (increase) in transfer payments to refugees by 5.5%, as well as an increase (decrease) in movement costs by 5.9% accomplishes a refugee distribution in line with the central planner.[52] The equilibrium values reported in Table 4.7, as well as the transitional dynamics, do not depend on which country implements the policy changes, or on the choice of policy tool (shock to transfer payments or shock to movement costs). This is because the required policy shocks achieving the social planner's distribution are (i) too insignificant to affect any of the macroeconomic variables (e.g. movements costs only change from 0.00026 to 0.00027), and are (ii) financed by government debt and do thus not affect the household's allocation decision. Hence, equilibrium changes within an economy are only caused by refugee movements and the associated congestion externality; however, these movements are identical regardless of the shock

[52] An example for a government policy which increases movement costs of refugees can include stricter acceptance criteria for asylum seekers or the introduction of refugee quotas.

or the country implementing them. Consequently, I will only describe a shock to Northern refugee transfer payment T_n (corresponding changes in the South, or changes to movement costs, will give identical results).

Table 4.7: Equilibrium in a Decentralized Economy: Long-run Effects of Policy Shocks

		k_g	c	c_M	Refugees	K/Y	$\frac{(C+C_M)}{Y}$	Growth
Decrease in g_n:-0.05	North	0.32	0.08	0.001	0.52	3.80	0.30	0.06
	South	0.41	0.06	0.001	0.48	3.97	0.26	0.05
Increase in g_s:+0.06	North	0.40	0.07	0.001	0.52	3.59	0.24	0.07
	South	0.52	0.05	0.001	0.48	3.75	0.19	0.06
Increase in τ_{sy}:+0.16	North	0.40	0.07	0.001	0.52	3.59	0.24	0.07
	South	0.52	0.10	0.001	0.48	3.75	0.37	0.03
Decrease in T_n:-5.5%	North	0.40	0.07	0.001	0.52	3.59	0.24	0.07
	South	0.41	0.06	0.001	0.48	3.97	0.26	0.05

A decrease in Northern transfer payments to refugees by 5.5% accomplishes a refugee distribution in line with the central planner's problem. Figure 4.6 describes the transitional dynamics: An decrease in refugee income in the North leads to an instantaneous jump of the Southern refugee share to the "first-best" level (see equation (4.19)). Equilibrium levels of the other variables in the South are only marginally affected by increasing congestion of public services resulting from refugee inflows. The higher share of refugees in the South reduces the productivity of public capital, which in turn decreases the marginal productivity of private capital and discourages private investment. The associated slow down of private capital accumulation (marginally) outweighs the lower productivity of public capital, resulting in a (marginally) increasing public-to-private capital ratio. In the North, the outflow of refugees leads to a reduction of congestion, causing the public-to-private capital ratio to (marginally) decrease over time.

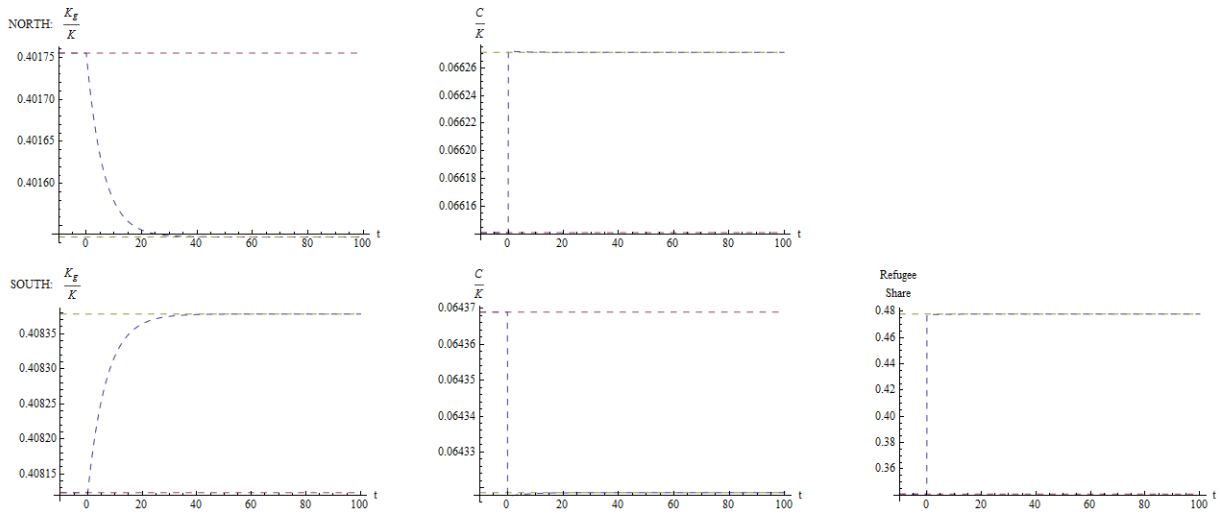


Figure 4.6: Decrease in Northern Refugee Income ($T_n - 0.0003$)

4.5.3 Welfare Comparison

Table 4.8 reports the impact of policy shocks (as described in Table 4.7) on long-run welfare, as well as the sensitivity of welfare results to changes in the congestion parameter, σ. It should be noted that changes in σ slightly affect the policy shocks needed to achieve the optimal refugee distribution as determined by the social planner. However, these changes are in the magnitudes of one thousands of the original changes (e.g. Δg_n changes from -0.05 to -0.049), and are therefore not explicitly reported.

4.5.3.1 Welfare Effects of Government Spending Shocks (g)

Decrease in g_n: Northern households' welfare increase by 5.91% due to their substitution away from private investment towards consumption. In contrast, welfare levels for Southern households decrease slightly as a result of increasing congestion: On the one hand, congestion leads to a substitution away from Southern private investment towards consumption. On the other hand, however, congestion reduces Southern output. This negative income effect slightly outweighs the positive substitution effect and Southern welfare levels decrease marginally by 0.03%. Refugees' welfare goes down by 0.65% in the North and 0.02% in the South as a result of the declining output. Overall, total welfare increases by 0.62%.

These welfare results change only moderately with changes in σ. In general, increasing σ reduces the congestion effect of refugees. Consequently, if $\sigma = 1$, the South is not affected by a decrease in Northern public investment, leaving welfare levels of both households and refugees in the South unchanged. In contrast, the decrease in g_n affects the North in two opposite ways. First, it directly reduces public capital productivity through less investment. Second, it increases public capital productivity indirectly through less congestion

associated with the refugee outflow. If $\sigma = 1$, this second effect is muted, leading to a stronger substitution away from private investment to consumption, which in turn leads to marginally larger welfare gains for Northern households relative to a case where $\sigma < 1$.

Increase in g_s : Southern households' welfare decreases by 9.86% due to their substitution away from consumption towards private investment. In contrast, welfare levels for Northern households increase slightly as a result of decreasing congestion. Refugees' welfare levels increase slightly by 0.03% in the North and 0.66% in the South as a result of increasing output. Due to the large welfare loss of Southern households overall welfare decreases by 1.2%.

Again, these welfare results are mostly robust to changes in σ. As σ increases, Northern household's welfare is affected less by Southern public investment shocks. A decrease in g_s affects the Northern economy solely through the congestion effects associated with refugee redistribution. Consequently, if $\sigma = 1$, Southern public investment shocks have no effect on the Northern economy, leaving welfare levels of both households and refugees unchanged. In contrast, the increase in g_s affects Southern welfare in two opposite ways. First, it directly increases public capital productivity through more investment, causing a substitution from consumption to investment. Second, it decreases public capital productivity indirectly through less congestion associated with the refugee outflow. If $\sigma = 1$, this second effect is muted, leading to a stronger substitution away from consumption to private investment, which in turn leads to marginally larger welfare losses for Southern households relative to a case where $\sigma < 1$.

Increase in τ_s: An increase in the income tax rate triggers a refugee redistribution from the North to the South. This only affects the North through decreasing congestion, which in turn raises welfare levels. As before, this effect becomes weaker as σ increases. In the South, an increase in the income tax lowers the return to private capital and leads to a reallocation towards consumption. Consequently, welfare levels for Southern households increase by 15.14%. As σ increases welfare levels slightly increase because the welfare effect associated with public capital congestion decreases. Refugees' welfare levels increase slightly by 0.02% in the North and 0.63% in the South as a result of increasing output. Overall, total welfare increases by 2.46%.

Decrease in T_n: The decrease in T_n mostly affects welfare levels of Northern refugees who experience a decline in welfare levels by 0.83%. Welfare levels in the South decrease slightly as the congestion of public services increases. In contrast, welfare levels in the North increase slightly by 0.07% as a result of less congestion. Overall, total welfare decreases by 0.3%.

Table 4.8: Welfare Analysis of Policy Shocks and Sensitivity to Congestion Parameter (in %Δ)

		Households			Refugees			
		North	South	Total	North	South	Total	Total
Decrease in g_n:-0.05	$\sigma = 0$	5.88	-0.04	2.91	-0.64	-0.03	-0.33	0.61
	$\sigma = \mathbf{0.3}$	**5.91**	**-0.03**	**2.93**	**-0.65**	**-0.02**	**-0.33**	**0.62**
	$\sigma = 0.7$	5.93	-0.01	2.95	-0.67	-0.01	-0.34	0.62
	$\sigma = 1$	5.96	0	2.96	-0.68	0	-0.34	0.62
Increase in g_s:+0.06	$\sigma = 0$	0.04	-9.76	-4.88	0.04	0.65	0.34	-1.18
	$\sigma = \mathbf{0.3}$	**0.03**	**-9.86**	**-4.94**	**0.03**	**0.66**	**0.35**	**-1.20**
	$\sigma = 0.7$	0.01	-10.0	-5.02	0.01	0.68	0.35	-1.22
	$\sigma = 1$	0	-10.1	-5.07	0	0.70	0.35	-1.23
Increase in τ_{sy}:+0.16	$\sigma = 0$	0.04	15.02	7.56	0.03	0.62	0.33	2.44
	$\sigma = \mathbf{0.3}$	**0.03**	**15.14**	**7.62**	**0.02**	**0.63**	**0.33**	**2.46**
	$\sigma = 0.7$	0.01	15.28	7.69	0.01	0.65	0.33	2.48
	$\sigma = 1$	0	15.39	7.74	0	0.67	0.34	2.50
Decrease in T_n:-5.5%	$\sigma = 0$	0.08	-0.04	0.02	-0.82	-0.04	-0.43	-0.30
	$\sigma = \mathbf{0.3}$	**0.07**	**-0.03**	**0.02**	**-0.83**	**-0.03**	**-0.43**	**-0.30**
	$\sigma = 0.7$	0.06	-0.01	0.02	-0.85	-0.01	-0.43	-0.30
	$\sigma = 1$	0.04	0	0.02	-0.88	0	-0.44	-0.30

Long-run welfare is measured by numerically evaluating the agent's utility function when C_t is on its equilibrium path, e.g. the Northern household's welfare is calculated by numerically evaluating $U = \int_0^\infty ln(c_t^n)e^{-\beta t}dt$, total household welfare is calculated by evaluating $U = \int_0^\infty [ln(c_t^n) + ln(c_t^s)]e^{-\beta t}dt$, and Total welfare is calculated by integrating the central planner's utility function $U = \int_0^\infty [ln(c_t^n) + ln(c_t^s) + ln(c_t^{nM}) + ln(c_t^{sM})]e^{-\beta t}dt$. Welfare changes are % changes relative to Pre-shock welfare of the decentralized solution.

Ranking Policy Shocks: The array of welfare gains and losses in Table 4.8 permits a convenient ranking of the policy shocks' performance in terms of economic welfare. An increase in the Southern income tax by 0.16 percentage points achieves the largest total welfare gain. However, this increase is mostly driven by Southern welfare gains. Moreover, the increase in τ_s decreases steady state growth rates from 5% to 3%. In contrast, a decrease in public investment in the North leads to the largest welfare gains for Northern households, and total welfare gains of 0.62%. However, the increase in g_n decreases steady state growth rates from 7% to 6%. An increase in Northern transfer payments to refugees achieves the "first-best" distribution instantaneously, however leads to moderate welfare losses of 0.3%. Finally, raising public investment in the South causes the largest welfare loss, yet increases steady state growth in the South from 5% to 6%. As such, policies are not equally suited to achieves the "first best" refugee distribution. Subsequently, I examine which combination of policies achieves an instantaneous realization of the "first best" refugee distribution together with steady state growth rates and welfare levels that are in line with the central planner's case.

The following Northern and Southern policy intervention cause an instantaneous jump to the "first best" refugee distribution and achieve steady state growth rates similar to the central planner's case: g_s increases

to 0.295, g_n increases to 0.293, τ_s is set to zero, $\tau_n = 0.008$, and T_n decreases by 5.7%. Figure 4.7 describes the transitional dynamics: The lower transfers to Northern refugees causes an instantaneous redistribution of refugees (see equation (4.19)). Tax rates and public investments are set to achieve the optimal growth rate without affecting the distribution of refugees. A higher share of public investment leads to the increase in its long run stock relative to private capital. The higher stock of public capital enhances the long run productivity of private capital, which in turn encourages private investment. This leads to a substitution away from consumption towards private investment, causing an instantaneous drop in the consumption-to-capital ratio. The drop in the consumption-to-capital ratio is larger and the increase in the public-to-private capital ratio smaller relative to the case of changes to g_i only because of the additional effect of lower taxes. The lower tax on income raises the tax return on private capital. This leads households to substitute away from consumption towards private investment. As a result, the private capital stock increases, which in turn leads to a weaker increase in the public-to-private capital ratio and a stronger drop in the consumption-to-capital ratio relative to Figure 4.7. Table 4.9 reports the long run impact of the optimal policy mix on the equilibrium resource allocation in the decentralized economy.

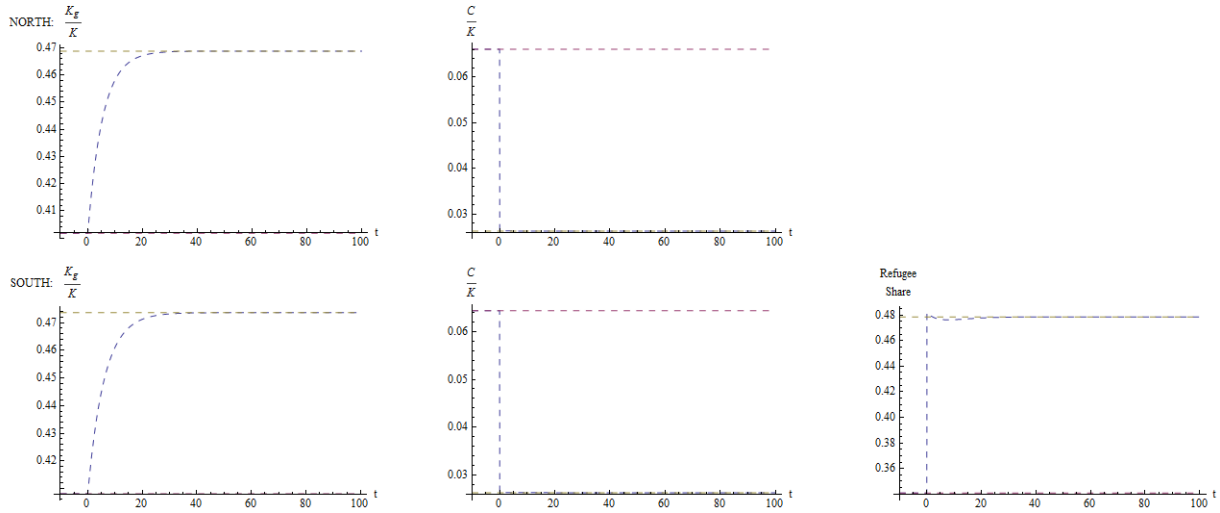


Figure 4.7: Optimal Policy Combination
(g_s+0.075, g_n+0.073, $\tau_s = 0$, $\tau_n = 0.008$, T_n-5.7%)

Table 4.9: Optimal Policy Combination

(g_s+0.075, g_n+0.073, $\tau_s = 0$, $\tau_n = 0.008$, T_n-5.7%)

	k_g	c	c_M	K/Y	$\frac{(C+C_M)}{Y}$	Growth	Δ Welfare
North	0.47	0.03	0.001	3.46	0.10	0.09	0
South	0.47	0.03	0.001	3.83	0.11	0.07	0

Long-run welfare is measured by numerically evaluating the agent's utility function when C_t is on its equilibrium path, e.g. the Northern household's welfare is calculated by numerically evaluating $U = \int_0^\infty ln(c_t^n)e^{-\beta t}dt$, total household welfare is calculated by evaluating $U = \int_0^\infty [ln(c_t^n) + ln(c_t^s)]e^{-\beta t}dt$, and Total welfare is calculated by integrating the central planner's utility function $U = \int_0^\infty [ln(c_t^n) + ln(c_t^s) + ln(c_t^{nM}) + ln(c_t^{sM})]e^{-\beta t}dt$. Welfare changes are % changes relative to the welfare of the centralized solution.

4.6 General Discussion

The preceding analysis shows that congestion via refugees does not significantly affect either economy. In achieving the optimal refugee distribution, North and South are only affected by the policy shocks directly (changes to g_i and τ_s), but not by the resulting refugee flows. This result holds regardless of the size of the congestion parameter σ. The reason for this is the modest size of total refugees $L = 0.1$. Increasing the total amount of refugees raises congestion, which in turn increases the effect of refugee flows on other macroeconomic variables. However, the share of refugees in 2014 amounts to less than 1% of the world's population (UNHCR). Even in the middle of the European refugee crisis in 2015, the refugee-to-population ratio is closer to 1%-2% than 10%.[53] These numbers imply, that empirically, L is closer to 0.01 than 0.1, resulting in congestion effects that are even smaller than those predicted by the model. As such, governments should not be concerned with potential congestion of the domestic infrastructure system. However, refugee migration can burden economies in several other ways.

First, there is a common perception among the native population that refugees, or immigration as a whole, increase crime rates. Recent research by the German Federal Office of Criminal Investigation, however, shows that refugees are not more likely to commit crimes than native Germans. Moreover, the report states that the most common crimes committed by refugees was not paying fares on public transportation (34%), followed by theft and fraud (33%). Similar results have been found for the US. For example, Miles and Cox (2014) and Treyger, Chalfin, and Loeffler (2014) find no correlation between immigration and crime rates, while Stowell et al. (2009) and Ousey and Kubrin (2009) establish a negative relationship between immigration and crime rates in US cities.

Second, refugees are believed to put a severe burden on national budgets. A study by the Cologne Institute for Economic Research (IW) found that additional spending of 50 billion euros is needed to shelter,

[53] according to the German interior ministry, the share of refugees relative to the German population is approximately 1.5%. According to Eurostat, the share of refugees in Hungary is approximately 1.8%

feed and train refugees in Germany in 2016 and 2017. Housing, food and welfare amount to 12,000 euros per refugee per year, according to the study. Language and integration classes add 3,300 euros annually per refugee, resulting in a total of 15,000 euros per person and year. Thus, the additional cost of refugees is approximately 0.8% of GDP, which is about half the size of German welfare expenses (Hartz IV). Moreover, government spending on refugee support can function as a small stimulus package for the economy since every euro spent by the government creates income for construction companies building refugee shelters, language schools and shops where refugees buy food.

Finally, and possibly the largest challenge associated with refugee migration, is creating additional housing to guarantee shelter and accommodation. According to Postbank, the growing number of refugees is starting to affect Germany's property market as a lack of housing leads to rising prices. The Cologne Institute for Economic Research (IW) estimates that 450,000 dwellings are needed to keep up with the current refugee inflow. Germany's Federal Housing Minister estimates additional expenses of $1.5 billion to accommodate asylum seekers. Despite the increase in housing demand, existing empirical research points towards a negative relationship between migration and housing. For example, Balkan and Tumen (2015) find that house prices slightly decreased upon the inflow of Syrian refugees into Turkey. These findings are supported by Sá (2015) and Braakmann (2013) who attribute the decline in UK housing prices to the mobility response of the native population. In light of these findings, a structural model with housing might provide additional insights in the macroeconomic consequences of refugee migration.

4.7 Conclusion

This paper analyzes the role of policy shocks to refugee distribution in a growing economy, where the accumulated stock of public capital is subject to congestion. Modeling two countries that differ in terms of productivity I show that (i) too many refugees choose to locate in the more advanced North relative to the "first-best" solution derived by the social planner, and (ii) the "first-best" distribution of refugees can be achieved by using public investment, income tax rates, and welfare payments to refugees as policy tools. Reducing public investment in the North gradually achieves a redistribution of refugees from the North to the South. While this policy option increases the welfare of Northern households it slows down steady state growth rates relative to the centralized solution. In contrast, an increase public investment in the South achieves the same gradual redistribution of refugees with increasing steady state growth rates in the South and declining welfare levels of Southern households. While consumption taxes in this framework are non-distortionary, and thus not suited to achieve the "first-best" allocation of refugees, an increase in the Southern income tax rate achieves the social planner's distribution in combination with Southern welfare

gains and a drop in steady state growth rates. Finally, shocks to refugee transfer payments or movement costs achieve an instantaneous redistribution of refugees from the North to the South without significantly affecting welfare levels or steady state growth rates.

Given that each policy leads to the "first-best" refugee distribution with conflicting outcomes for growth and welfare I study a policy mix that instantaneously achieves the optimal refugee distribution alongside welfare levels and steady state growth rates as derived by the central planner. I find that a combination of positive public investment shocks and negative shocks to transfer payment and income taxes are best suited to achieve socially optimal welfare levels, growth rates and refugee distribution.

Finally, this paper shows that congestion effects of refugees are too small to significantly affect either economy. Therefore, most of the dynamics in the model are caused directly by policy shocks, rather than by changes to public goods congestion associated with refugee movements. This result does not depend on the size of the congestion parameter, σ, but rather on the small share of refugees relative to the domestic population. Despite its marginal role in public goods congestion, refugee migration brings along other challenges to host economies. Especially the provision of refugee shelter and accommodation puts a burden on host economies. On the one hand, the growing number of refugees is predicted to affect property prices through increasing demand. On the other hand, existing empirical research points towards a negative relationship between migration and housing due to the mobility response of the native population. In light of these findings, a structural model with housing might provide additional insights in the macroeconomic consequences of refugee migration.

References

Abramovitz, Moses and P David. 2001. "Two centuries of American macroeconomic growth." *Stanford Institute for Economic Policy Research Policy Paper* (01-005).

Acosta, Pablo, Pablo Fajnzylber, and J Humberto Lopez. 2008. "Remittances and household behavior: evidence from Latin America." *Remittances and Development: Lessons from Latin America, World Bank* :133–169.

Acosta, Pablo A, Emmanuel KK Lartey, and Federico S Mandelman. 2009. "Remittances and the Dutch disease." *Journal of international economics* 79 (1):102–116.

Adams, Richard H and Alfredo Cuecuecha. 2010. "Remittances, household expenditure and investment in Guatemala." *World Development* 38 (11):1626–1641.

Aggarwal, Reena, Asli Demirgüç-Kunt, and Maria Soledad Martínez Pería. 2011. "Do remittances promote financial development?" *Journal of Development Economics* 96 (2):255–264.

Aghion, Philippe and Peter Howitt. 1992. "A Model of Growth through Creative Destruction." *Econometrica* 60 (2):323–51.

Aguiar, Mark and Gita Gopinath. 2007. "Emerging Market Business Cycles: The Cycle Is the Trend." *Journal of Political Economy* 115 (1):69–102.

Aker, Jenny C. and Marcel Fafchamps. 2015. "Mobile Phone Coverage and Producer Markets: Evidence from West Africa." *World Bank Economic Review* 29 (2):262–292.

Aker, Jenny C and Isaac M Mbiti. 2010. "Mobile phones and economic development in Africa." *Center for Global Development Working Paper* (211).

Alcaraz, Carlo, Daniel Chiquiar, and Alejandrina Salcedo. 2012. "Remittances, schooling, and child labor in Mexico." *Journal of Development Economics* 97 (1):156–165.

Artuc, Erhan, Frederic Docquier, Caglar Ozden, and Christopher Parsons. 2014. "A global assessment of human capital mobility: the role of non-OECD destinations." Policy Research Working Paper Series 6863, The World Bank.

Aschauer, David A. 1989. "Is public expenditure productive?" *Journal of monetary economics* 23 (2):177–200.

Baez, Javier E. 2011. "Civil wars beyond their borders: The human capital and health consequences of hosting refugees." *Journal of Development Economics* 96 (2):391–408.

Balkan, Binnur and Semih Tumen. 2015. "Immigration and Prices: Quasi-Experimental Evidence from Syrian Refugees in Turkey." .

Bansak, Cynthia and Brian Chezum. 2009. "How do remittances affect human capital formation of school-age boys and girls?" *The American economic review* 99 (2):145–148.

Barajas, Adolfo, Ralph Chami, Connel Fullenkamp, Michael Gapen, and Peter J Montiel. 2009. "Do workers' remittances promote economic growth?" *IMF Working Papers* :1–22.

Barro, Robert J. 1990. "Government Spending in a Simple Model of Endogenous Growth." *Journal of Political Economy* 98 (5 pt 2).

———. 1991. "A cross-country study of growth, saving, and government." In *National saving and economic performance*. University of Chicago Press, 271–304.

Barro, Robert J and Xavier Sala-i Martin. 1992. "Public finance in models of economic growth." *The Review of Economic Studies* 59 (4):645–661.

Batista, Catia, Aitor Lacuesta, and Pedro C. Vicente. 2012. "Testing the brain gain hypothesis: Micro evidence from Cape Verde." *Journal of Development Economics* 97 (1):32–45.

Bauernschuster, Stefan, Oliver Falck, Stephan Heblich, Jens Suedekum, and Alfred Lameli. 2014. "Why are educated and risk-loving persons more mobile across regions?" *Journal of Economic Behavior & Organization* 98:56–69.

Baxter, Marianne and Robert G King. 1993. "Fiscal Policy in General Equilibrium." *American Economic Review* 83 (3):315–34.

Benhabib, Jess and Mark M. Spiegel. 2005. "Human Capital and Technology Diffusion." In *Handbook of Economic Growth*, *Handbook of Economic Growth*, vol. 1, edited by Philippe Aghion and Steven Durlauf, chap. 13. 935–966.

Bettin, Giulia and Alberto Zazzaro. 2012. "Remittances and financial development: substitutes or complements in economic growth?" *Bulletin of Economic Research* 64 (4):509–536.

Bhagwati, Jagdish and Koichi Hamada. 1974. "The brain drain, international integration of markets for professionals and unemployment: A theoretical analysis." *Journal of Development Economics* 1 (1):19–42.

Black, Sandra E, Paul J Devereux et al. 2011. "Recent Developments in Intergenerational Mobility." *Handbook of Labor Economics* 4:1487–1541.

Blalock, Garrick and Paul J. Gertler. 2008. "Welfare gains from Foreign Direct Investment through technology transfer to local suppliers." *Journal of International Economics* 74 (2):402–421.

Boeri, Tito. 2012. *Brain drain and brain gain: the global competition to attract high-skilled migrants.* Oxford University Press.

Bollard, Albert, David McKenzie, Melanie Morten, and Hillel Rapoport. 2011. "Remittances and the brain drain revisited: The microdata show that more educated migrants remit more." *The World Bank Economic Review* 25 (1):132–156.

Braakmann, Nils. 2013. "Immigration and property prices: Evidence from England and Wales." Tech. rep., University Library of Munich, Germany.

Broadman, Harry G and Francesca Recanatini. 2001. "Is Russia restructuring? New evidence on job creation and destruction." *New Evidence on Job Creation and Destruction (July 17, 2001). World Bank Policy Research Working Paper* (2641).

Brock, Philip L. 1996. "International transfers, the relative price of non-traded goods, and the current account." *Canadian Journal of Economics* :163–180.

Brown, Richard PC and Dennis A Ahlburg. 1999. "Remittances in the South Pacific." *International Journal of Social Economics* 26 (1/2/3):325–344.

Bruecker, H., S. Capuano, and A. Marfouk. 2013. "Education, gender and international migration: insights from a panel-dataset 1980-2010." mimeo, Institute for Employment Research.

Card, David. 1990. "The impact of the Mariel boatlift on the Miami labor market." *Industrial & Labor Relations Review* 43 (2):245–257.

Caselli, Francesco, Gerardo Esquivel, and Fernando Lefort. 1996. " Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics." *Journal of Economic Growth* 1 (3):363–89.

Catrinescu, Natalia, Miguel Leon-Ledesma, Matloob Piracha, and Bryce Quillin. 2009. "Remittances, institutions, and economic growth." *World Development* 37 (1):81–92.

Ceritoglu, Evren, Gurcihan Yunculer, H Burcu, Huzeyfe Torun, and Semih Tumen. 2015. "The Impact of Syrian Refugees on Natives' Labor Market Outcomes in Turkey: Evidence from a Quasi-Experimental Design." .

Chami, Ralph, Connel Fullenkamp, and Samir Jahjah. 2005. "Are Immigrant Remittance Flows a Source of Capital for Development?" *IMF Staff Papers* :55–81.

Chatterjee, Santanu and Sugata Ghosh. 2011. "The dual nature of public goods and congestion: the role of fiscal policy revisited." *Canadian Journal of Economics/Revue canadienne d'économique* 44 (4):1471–1496.

Chatterjee, Santanu, Georgios Sakoulis, and Stephen J Turnovsky. 2003. "Unilateral capital transfers, public investment, and economic growth." *European Economic Review* 47 (6):1077–1103.

Cheng, I-Hui and Howard J. Wall. 2005. "Controlling for heterogeneity in gravity models of trade and integration." *Review* (Jan):49–63.

Cheung, Kui-yin and Lin Ping. 2004. "Spillover effects of FDI on innovation in China: Evidence from the provincial data." *China economic review* 15 (1):25–44.

Chinn, Menzie D and Eswar S Prasad. 2003. "Medium-term determinants of current accounts in industrial and developing countries: an empirical exploration." *Journal of International Economics* 59 (1):47–76.

Clerides, Sofronis K., Saul Lach, and James R. Tybout. 1998. "Is Learning By Exporting Important? Micro-Dynamic Evidence From Colombia, Mexico, And Morocco." *The Quarterly Journal of Economics* 113 (3):903–947.

Coe, David T. and Elhanan Helpman. 1995. "International r&d spillovers." *European Economic Review* 39 (5):859–887.

Coe, David T., Elhanan Helpman, and Alexander Hoffmaister. 1997. "North-south R&D spillovers." *The Economic Journal* 107 (440):134–149.

Cohen-Goldner, Sarit and M Daniele Paserman. 2011. "The dynamic impact of immigration on natives' labor market outcomes: Evidence from Israel." *European Economic Review* 55 (8):1027–1045.

Combes, Jean-Louis and Christian Ebeke. 2011. "Remittances and household consumption instability in developing countries." *World Development* 39 (7):1076–1089.

Comin, Diego A. and Bart Hobijn. 2009a. "The CHAT Dataset." Working Paper 15319, National Bureau of Economic Research.

———. 2009b. "The CHAT Dataset." Harvard Business School Working Papers 10-035, Harvard Business School.

———. 2010. "An Exploration of Technology Diffusion." *American Economic Review* 100 (5):2031–59.

Comin, Diego A., Bart Hobijn, and Emilie Rovito. 2006. "Five facts you need to know about technology diffusion." Nber working papers, National Bureau of Economic Research.

Cortes, Patricia. 2008. "The Effect of Low-Skilled Immigration on US Prices: Evidence from CPI Data." *Journal of political Economy* 116 (3):381–422.

da Silva, H. and A. Zainudeen. 2007. "Teleuse on a Shoestring: Poverty Reduction Through Telecom Access at the Bottom of the Pyramid." Ssrn working papers, Social Science Research Network.

Dahl, Gordon B. 2002. "Mobility and the return to education: Testing a Roy model with multiple markets." *Econometrica* 70 (6):2367–2420.

Djankov, Simeon and Bernard Hoekman. 1998. "Avenues of Technology Transfer: Foreign Investment and Productivity Change in the Czech Republic." CEPR Discussion Papers 1883, C.E.P.R. Discussion Papers.

Docquier, Frédéric and Hillel Rapoport. 2012. "Globalization, brain drain, and development." *Journal of Economic Literature* :681–730.

Durand, Jorge, William Kandel, Emilio A Parrado, and Douglas S Massey. 1996. "International migration and development in Mexican communities." *Demography* 33 (2):249–264.

Durdu, Ceyhun Bora and Serdar Sayan. 2010. "Emerging Market Business Cycles with Remittance Fluctuations." *IMF Staff Papers* 57 (2).

Eaton, Jonathan and Mark Gersovitz. 1981. "Debt with potential repudiation: Theoretical and empirical analysis." *The Review of Economic Studies* 48 (2):289–309.

Edwards, John HY. 1990. "Congestion function specification and the publicness of local public goods." *Journal of Urban Economics* 27 (1):80–96.

Faini, Riccardo. 2004. "Trade Liberalization in a Globalizing World." CEPR Discussion Papers 4665, C.E.P.R. Discussion Papers.

———. 2007. "Remittances and the Brain Drain: Do more skilled migrants remit more?" *The World Bank Economic Review* 21 (2):177–191.

Fosfuri, Andrea, Massimo Motta, and Thomas Rønde. 2001. "Foreign direct investment and spillovers through workers' mobility." *Journal of international economics* 53 (1):205–222.

Futagami, Koichi, Yuichi Morita, and Akihisa Shibata. 1993. "Dynamic analysis of an endogenous growth model with public capital." *The Scandinavian Journal of Economics* :607–625.

Galor, Oded and Joseph Zeira. 1993. "Income distribution and macroeconomics." *The review of economic studies* 60 (1):35–52.

Gassebner, Martin, Michael J. Lamla, and James Raymond Vreeland. 2013. "Extreme Bounds of Democracy." *Journal of Conflict Resolution* 57 (2):171–197.

Giuliano, Paola and Marta Ruiz-Arranz. 2009. "Remittances, financial development, and growth." *Journal of Development Economics* 90 (1):144–152.

Glomm, Gerhard and B. Ravikumar. 1994. "Public investment in infrastructure in a simple growth model." *Journal of Economic Dynamics and Control* 18 (6):1173–1187.

Gould, David M. 1994. "Immigrant links to the home country: empirical implications for US bilateral trade flows." *The Review of Economics and Statistics* :302–316.

Gould, Eric D, Victor Lavy, and M Daniele Paserman. 2009. "Does Immigration Affect the Long-Term Educational Outcomes of Natives? Quasi-Experimental Evidence." *The Economic Journal* 119 (540):1243–1269.

Gramlich, Edward M. 1994. "Infrastructure investment: A review essay." *Journal of economic literature* 32 (3):1176–1196.

Grether, Jean-Marie. 1999. "Determinants of technological diffusion in mexican manufacturing: a plant-level analysis." *World development* 27 (7):1287–1298.

Grier, Kevin B. and Gordon Tullock. 1989. "An empirical analysis of cross-national economic growth, 1951-1980." *Journal of Monetary Economics* 24 (2):259–276.

Grossman, Gene M and Elhanan Helpman. 1991. "Quality Ladders in the Theory of Growth." *Review of Economic Studies* 58 (1):43–61.

Grossman, Gene M. and Elhanan Helpman. 1993. *Innovation and Growth in the Global Economy*, *MIT Press Books*, vol. 1. The MIT Press.

Guvenen, Fatih. 2006. "Reconciling conflicting evidence on the elasticity of intertemporal substitution: A macroeconomic perspective." *Journal of Monetary Economics* 53 (7):1451–1472.

Harrison, Ann E. and Brian J. Aitken. 1999. "Do Domestic Firms Benefit from Direct Foreign Investment? Evidence from Venezuela." *American Economic Review* 89 (3):605–618.

Hatton, Timothy J. 2004. "Seeking asylum in Europe." *Economic Policy* 19 (38):6–62.

Hunt, Jennifer. 2004. "Are migrants more skilled than non-migrants? Repeat, return, and same-employer migrants." *Canadian Journal of Economics/Revue canadienne d'économique* 37 (4):830–849.

Islam, Nazrul. 1995. "Growth Empirics: A Panel Data Approach." *The Quarterly Journal of Economics* 110 (4):1127–70.

Jan-Sturm and Jakob de Haan. 2005. "Determinants of long-term growth: New results applying robust estimation and extreme bounds analysis." *Empirical Economics* 30 (3):597–617.

Javorcik, Beata S, Çağlar Özden, Mariana Spatareanu, and Cristina Neagu. 2011. "Migrant networks and foreign direct investment." *Journal of Development Economics* 94 (2):231–241.

Jovanovic, Boyan. 1995. "Learning and Growth." NBER Working Papers 5383, National Bureau of Economic Research, Inc.

Keller, Wolfgang. 2004. "International Technology Diffusion." *Journal of Economic Literature* 42 (3):752–782.

Keller, Wolfgang and Stephen R. Yeaple. 2009. "Multinational Enterprises, International Trade, and Productivity Growth: Firm-Level Evidence from the United States." *The Review of Economics and Statistics* 91 (4):821–831.

Kerr, William R. 2008. "Ethnic scientific communities and international technology diffusion." *The Review of Economics and Statistics* 90 (3):518–537.

Keynes, John Maynard. 1929. "The German transfer problem." *The Economic Journal* 39 (153):1–7.

Kinsler, Josh and Ronni Pavan. 2011. "Family income and higher education choices: The importance of accounting for college quality." *Journal of human capital* 5 (4):453–477.

Lach, Saul. 2007. "Immigration and prices." *Journal of Political Economy* 115 (4):548–587.

Levine, Ross and David Renelt. 1992. "A Sensitivity Analysis of Cross-Country Growth Regressions." *American Economic Review* 82 (4):942–63.

Lipsey, Robert E and Fredrik Sjöholm. 2005. "The impact of inward FDI on host countries: why such different answers?" *Does foreign direct investment promote development* :23–43.

Liu, Zheng, Pengfei Wang, and Tao Zha. 2013. "Land-price dynamics and macroeconomic fluctuations." *Econometrica* 81 (3):1147–1184.

Lodigiani, Elisabetta. 2008. "Diaspora Externalities and Technology Diffusion." *Economie Internationale* (115):43–64.

Machin, Stephen, Kjell G Salvanes, and Panu Pelkonen. 2012. "Education and mobility." *Journal of the European Economic Association* 10 (2):417–450.

Malamud, Ofer and Abigail Wozniak. 2012. "The Impact of College on Migration Evidence from the Vietnam Generation." *Journal of Human resources* 47 (4):913–950.

Mandelman, Federico S. 2013. "Monetary and exchange rate policy under remittance fluctuations." *Journal of Development Economics* 102:128–147.

Mandelman, Federico S and Andrei Zlate. 2012. "Immigration, remittances and business cycles." *Journal of Monetary Economics* 59 (2):196–213.

Mankiw, N Gregory and Michael D Whinston. 1986. "Free entry and social inefficiency." *The RAND Journal of Economics* :48–58.

McCulloch, Rachel and Janet L. Yellen. 1977. "Factor mobility, regional development, and the distribution of income." *The Journal of Political Economy* :79–96.

Mendoza, Enrique G. 1991. "Real business cycles in a small open economy." *The American Economic Review* :797–818.

Meza, Felipe and Erwan Quintin. 2007. "Factor utilization and the real impact of financial crises." *The BE Journal of Macroeconomics* 7 (1).

Miles, Thomas J and Adam B Cox. 2014. "Does Immigration Enforcement Reduce Crime? Evidence from Secure Communities." *Journal of Law and Economics* 57 (4):937–973.

Mundaca, B Gabriela. 2009. "Remittances, financial market development, and economic growth: the case of Latin America and the Caribbean." *Review of Development Economics* 13 (2):288–303.

Nelson, Richard R. and Edmund S. Phelps. 1966. "Investment in humans, technological diffusion, and economic growth." *The American Economic Review* 56 (1/2):69–75.

Neumeyer, Pablo A and Fabrizio Perri. 2005. "Business cycles in emerging economies: the role of interest rates." *Journal of monetary Economics* 52 (2):345–380.

Niimi, Yoko, Caglar Ozden, and Maurice Schiff. 2010. "Remittances and the Brain Drain: Skilled Migrants Do Remit Less." *Annales d'Economie et de Statistique* (97-98):123–141.

Ohlin, Bertil. 1929. "Transfer difficulties, real and imagined." *Economic Journal* 39:172–178.

O'Neil, Kevin. 2003. "Brain Drain and Gain: The Case of Taiwan." Migration information source, Migration Policy Institute, Washington, DC.

Ousey, Graham C and Charis E Kubrin. 2009. "Exploring the connection between immigration and violent crime rates in US cities, 1980–2000." *Social problems* 56 (3):447–473.

Park, Jungsoo. 2004. "International student flows and R&D spillovers." *Economics Letters* 82 (3):315–320.

Paserman, M Daniele. 2013. "Do high-skill immigrants raise productivity? Evidence from Israeli manufacturing firms, 1990-1999." *IZA Journal of Migration* 2 (1):1–31.

Ratha, Dilip and Sanket Mohapatra. 2007. "Increasing the macroeconomic impact of remittances on development." *World Bank* .

Ratha, Dilip and William Shaw. 2007. *South-South migration and remittances*. 102. World Bank Publications.

Rivera-Batiz, Luis A and Paul M Romer. 1991. "Economic Integration and Endogenous Growth." *The Quarterly Journal of Economics* 106 (2):531–55.

Romer, Paul M. 1990. "Endogenous Technological Change." *Journal of Political Economy* 98 (5):S71–102.

Rotte, Ralph, Michael Vogler, and Klaus F Zimmermann. 1997. "South-North Refugee Migration: Lessons for Development Cooperation." *Review of Development Economics* 1 (1):99–115.

Sá, Filipa. 2015. "Immigration and House Prices in the UK." *The Economic Journal* 125 (587):1393–1424.

Sáenz, María R. 2007. "Framing the Debate: Use of Family Remittances for Housing Finance." Tech. rep., V Mimeo, Habitat for Humanity International.

Sala-i Martin, Xavier. 1997. "I Just Ran Two Million Regressions." *American Economic Review* 87 (2):178–83.

Santacreu, Ana Maria. 2014. "Innovation, Diffusion, and Trade: Theory and Measurement." Working Papers 2014-42, Federal Reserve Bank of St. Louis.

Schmitt-Grohé, Stephanie and Martın Uribe. 2003. "Closing small open economy models." *Journal of international Economics* 61 (1):163–185.

Serageldin, M and E Guerra. 2008. "Migration, remittances, and investment in Sub-Saharan Africa." Tech. rep., V Mimeo, Institute for International Urban Development.

Stowell, Jacob I, Steven F Messner, Kelly F McGeever, and Lawrence E Raffalovich. 2009. "Immigration and the recent violent crime drop in the united states: a pooled, cross-sectional time-series analysis of metropolitan areas*." *Criminology* 47 (3):889–928.

Treyger, Elina, Aaron Chalfin, and Charles Loeffler. 2014. "Immigration Enforcement, Policing, and Crime." *Criminology & Public Policy* 13 (2):285–322.

Turnovsky, Stephen J. 1996. "Optimal tax, debt, and expenditure policies in a growing economy." *Journal of Public economics* 60 (1):21–44.

———. 1997a. "Fiscal policy in a growing economy with public capital." *Macroeconomic Dynamics* 1 (03):615–639.

———. 1997b. *International macroeconomic dynamics*. MIT Press.

Turnovsky, Stephen J. and Walter H. Fisher. 1995. "The composition of government expenditure and its consequences for macroeconomic performance." *Journal of Economic Dynamics and Control* 19 (4):747–786.

Turunen-Red, Arja H and Alan D Woodland. 1988. "On the multilateral transfer problem: existence of Pareto improving international transfers." *Journal of International Economics* 25 (3-4):249–269.

Van Wincoop, Eric. 1993. "Structural adjustment and the construction sector." *European Economic Review* 37 (1):177–201.

Woodruff, Christopher and Rene Zenteno. 2007. "Migration networks and microenterprises in Mexico." *Journal of development economics* 82 (2):509–528.

Yang, Dean. 2008. "International migration, remittances and household investment: Evidence from philippine migrants' exchange rate shocks." *The Economic Journal* 118 (528):591–630.

———. 2011. "Migrant remittances." *The Journal of Economic Perspectives* 25 (3):129–151.

Young, Alwyn. 1995. "The Tyranny of Numbers: Confronting the Statistical Realities of the East Asian Growth Experience." *The Quarterly Journal of Economics* 110 (3):641–680.