Universität Bielefeld

Essays on Globalization and Economic Policy

Proefschrift voorgedragen tot het behalen van de graad van Doctor in de Economische Wetenschappen door

Dissertation zur Erlangung des Grades eines Doktor der Wirtschaftswissenschaften (Dr. rer. pol.) vorgelegt von

Toni Glaser

Faculteit Economie en Bedrijfswetenschappen
KU Leuven

Fakultät für Wirtschaftswissenschaften
Universität Bielefeld

March 26, 2015

Nummer 482 2015

Supervisor:	Prof. Gerald Willmann, PhD
Co-supervisor:	Prof. Johannes Van Biesebroeck, PhD
Doctoral Committee:	Prof. Philipp Schröder, PhD
	Liza Archanskaia, PhD
	J.-Prof. Hale Utar, PhD
Chairperson public defense:	Prof. Hylke Vandenbussche, PhD
Day of the public defense:	June 12, 2015

Acknowledgements

This thesis contains work that I started as a doctoral student at the Center for Economic Studies (CES), KU Leuven and that I continued at the Bielefeld Graduate School for Economics and Management (BiGSEM), Bielefeld University as part of the International Research Training Group EBIM (Economic Behavior and Interaction Models). I am grateful for the funding by the KU Leuven, and the scholarship that I received from the German Science Foundation (DFG) under contract GRK 1134/2.

There are many people who have supported me during this work. First and foremost, I would like to thank my advisor Gerald Willmann to convince me to carry out my research under his supervision at KU Leuven. It was very inspiring to work with him, and my work owes a great deal to his economic intuition, and to the fact that he nudged me in the right directions, when I was struggling. Also, merci to Anne and the Willmann family for the hospitality they have shown me over the years. I thank Jo Van Biesebroeck for kindly agreeing to co-supervise my thesis and providing helpful feedback on my work. This research owes a great deal to Marcus Böhme and Peter Debaere; I enjoyed working with them on Chapter 2 and 3 of this thesis. I am thankful to Philipp Schröder for inviting me to Aarhus and agreeing to be on my doctoral comittee, as well as to the other committee members Hale Utar and Liza Archanskaia, and to Hylke Vandenbussche for chairing the public defense. I would like to acknowledge Hebert Dawid for welcoming me at BiGSEM. Furthermore, I would like to thank Karla Vander Weyden, Pascale Kapers, Heidi De Vadder, Andras Avonts, Ulrike Haake and Helga Radtke for helping me to sort out the utter administrative mess that doing a doctorate can sometimes be.

My work was massively inspired by the colleagues and friends I met in Leuven, Bielefeld and Berlin over the years, and I will just single out some of them. Thanks to Luca for being his grumpy, edgy self and challenging my ideas on a regular basis, to Els for being a sister in arms, to Simon for being great at Mathematica, proofs and procrastination, to Wim, Frank and Thomas for keeping me sane through exercise, to Dirk for advice on latex and life and to Willem, Toon, Joris, Mathias, Koen, Koen, Koen (yes, all 3 of you), Roel, Lotte, Tom, Annette, Sophie, and Rien for the countless stimulating discussions. Thanks to the colleagues in Bielefeld for welcoming me amongst them, notably Phemelo and Lasha. I am grateful to Maren and the Stabi-folks for making my transition into a new working-environment as smooth as possible. Thanks to Tim and Kulli for sparking my deeper interst in economics and sharing it with me over the years. I am grateful to my family for their endless support, encouragement and understanding.

Finally, merci to Mathilde for having an open ear for my problems, a shoulder to lean on, bearing my moods, grounding me in non-academic reality and reminding me, that there is more to life than economics.

Berlin, February 2015

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1 Introduction and Summary

1.1 Motivation and Key Questions

Since the end of World War II, globalization has gained enormous momentum, leading to an ever more integrated global economy. From 1945 until the global financial crisis, international trade grew on average twice as fast as GDP. By now imports and exports account for over 27 percent of GDP in the developed countries and over 40 percent in developing countries.[1] World migration stocks and flows have also enormously evolved over the last decades. From 1960 until 2005, the share of foreign-born citizens of industrialized countries has tripled[2], and this development continues. In the first decade of the 2000s, global migrant stocks have grown more than twice as fast than in the 1990s.[3] While the recent financial crisis has decelerated this process somewhat[4], there can be no doubt that we are by now living in a world, that is far more intertwined than still a generation ago. But what are the political implications of this, and how should globalization be managed in order for it to improve global welfare?

The concept of globalization is multidimensional, and is among others concerned with the international flow of goods, capital, migrants, technology and culture. Global integration is thus a phenomenon that influences many distinct sectors at the same time. It is a process that is to a certain extent driven by political decisions, but partly policy can merely adapt to developments that are beyond its direct locus of control.
Political decisions that were still largely thought to be a sole matter of national interest just a hundred years ago will now be influenced by the growing awareness that we are living in an integrated world. National politics has more and more repercussions on global developments, while at the same time apparently unrelated events that happen thousands of miles away will also shape national policy. Decisions on minimum wages, income taxes and education policy do not only determine the welfare of the citizens that are currently living in a country, but will also have an impact on migration flows and foreign direct investment. Local production decisions have an influence on the world climate, and a carelessly handled national

[1] See UNCTAD (2014)
[2] See Docquier and Rapoport (2012)
[3] See OECD (2013b)
[4] See OECD (2013a)

debt could possibly increase financial risks in the rest of the world.

The growing need to coordinate national politics as a result of a progressing integration of the world economies is therefore apparent. Parallel to increasing economic and cultural globalization, political institutions have thus been installed that are supposed to facilitate international political exchange and manage different aspects of globalization.
At the end of World War II, the United Nations, the World Bank and the International Monetary Funds were initially founded to provide platforms that govern problems of global concern, namely peace, political and monetary stability and reconstruction of the countries that had been devastated by war.[5] By now their influence and scope have increased and many global problems are addressed by these institutions.
More organizations have followed, as the conscience grew that international coordination is necessary to manage different aspects of globalization. In several areas, such as climate change and international trade, each country on its own has incentives for non-cooperative behavior. As a consequence, forums were created that are supposed to facilitate international negotiations on topics of global concern. The General Agreement on Tariffs and Trade (GATT) and subsequently the World Trade Organization (WTO) are examples for such forums. In isolation, each country of a certain size has an incentive to set tariffs in order to shift the terms of trade in its favor. This non-coordinated behavior led to tariff-wars and inefficiently low trade-flows. The WTO offers a platform where countries can coordinate trade policy and hopefully agree on welfare improving measures.[6]
That settling on a common international agreement is not easy has been demonstrated by the ongoing struggle that is the Doha round, and the apparent impossibility to agree on a successor for the Kyoto Protocol.

Globalization has a huge potential to increase worldwide welfare, but not every country or individual may benefit from this. Under which conditions and to what extent do countries have an incentive to open their borders to greater integration? If the degree of integration is exogenously given, how will national governments adapt their national policies to respond to an increase in globalization? Will this lead to situations that are globally desirable, or should policy be coordinated internationally?

In this thesis we will address these questions which national policymakers should ask themselves, when their country faces globalization: To which degree should we open our economy and how should domestic policy react to an exogenously given degree of integration. But we also ask: When is international policy coordination

[5] A rather pessimistic assessment of how international organizations managed globalization in the 20th century see Stiglitz (2003) and Stiglitz (2007)
[6] See Staiger and Bagwell (1999).

necessary?
First, we investigate, what extent of market integration will be beneficial for a country, under different forms of globalization. Among others, we ask which degree of openness to international trade a country should choose, given the influence that this will have on the domestic production structure. If there is a trade-off between greater economic efficiency and greater risk-exposure due to globalization, then a country will refrain from completely opening its markets.
Another important aspect of globalization is international migration. We show that in this domain as well, a certain degree of openness can be beneficial to a country, even if this implies a net-loss of skilled workers in the short-run. If a greater integration of world markets changes the social and cultural norms in the domestic country, it might benefit from globalization in the long run.
Second, we analyze how other national policies will change if the degree of openness is taken as given. Even if national policymakers cannot directly influence the process of globalization, increased market integration will still have an influence on other policies, such as public expenditure. We investigate how non-coordinated national policy will adapt to globalization.
We then show that policies that aim at maximizing national welfare might not maximize global welfare, because each country will have some incentives to free-ride. In such a situation, global policy-coordination can help to improve the equilibrium outcome.

1.2 Summary of Chapter 2

The production structure of a country is clearly not independent of the degree of integration of a country. If a country engages in international trade, its economy will be more specialized than under autarky, in order to exploit its comparative advantage. In this chapter, we investigate how this globalization-induced specialization can be one justification for a protectionist trade policy.
If there is uncertainty about the terms of trade, and if some of the production factors are sector specific in the short-run, then a higher degree of specialization will increase the risk exposure of an economy. At a lower degree of specialization, the economy will be automatically hedged against adverse terms of trade shocks, and can adapt better to a situation that is different from the expected outcome. We show that if the production decisions in such an economy are made by producers who are aiming at maximizing their expected profits, the free-trade market equilibrium will not maximize expected welfare, assuming that the consumers are risk-averse. In order to benefit from the comparative advantage, the producers will allocate more resources to the export-competing sector than would be socially optimal.
We then show that in such a situation it will be beneficial to install an import tariff since this will lead to a production structure that is more diversified, thus lowering the exposure to the terms of trade risk. The trade policy thus serves as an insurance

mechanism for the risk-averse consumers.
In the second part of the paper, we extend our analysis by allowing for a source of domestic risk, and by explicitly modeling production in the foreign country. We assume that in both the domestic and foreign country agricultural output is volatile, and that terms of trade volatility is driven by these production shocks. In such a situation, openness to trade can actually reduce the aggregate risk for the domestic country, if the dominant source of uncertainty is the domestic risk. In our analysis, we investigate, which country will have an incentive to install what sort of trade policy.
We find that countries with a high comparative advantage in the manufacturing sector (as opposed to the agricultural sector) will have higher incentives to install import tariffs on the agricultural good. Furthermore, the lower the relative domestic volatility in the agricultural sector, compared to the foreign volatility, the higher the optimal tariff will be. This is the case because for such highly specialized economies, the risk of an exposure to terms of trade volatility dominates the domestic production uncertainty. The trade policy will thus be such that it creates a production structure that is more diversified than the free-trade equilibrium. If the driving force of risk is however the domestic risk, then the government of the country will install export subsidies and create an even more specialized production structure.
We conclude that the economic policy of a globalized country should be aware of the risks that it exposes itself to by opening up to international trade, and that the degree of openness should be chosen correspondingly.

1.3 Summary of Chapter 3

Globalization does not only have repercussions on the production structure, but also on the skill composition of the population of a country. Skilled migration from the countries of the global south towards the industrialized nations is one major aspect of globalization. We ask whether this migration from low- to high-wage countries is good or bad for the level of human capital in the poor countries. There is a large body of literature that investigates this question, whether migration is causing a net brain-drain which decreases the human capital, or whether the possibility to emigrate and to earn a higher skill-premium will increase the incentives to invest in education sufficiently to lead to a net brain-gain. In this chapter, we add to this literature, by introducing a migration-related intergenerational externality: aspirations.
Aspirations failure has recently been identified as one possible reason for underinvestment in human capital in developing countries.[7] Since aspirations form as a result of a person's interactions with its direct social environment, a poor individual who only knows poor people will not form the high aspirations of someone who is

[7] See Ray (2006)

constantly exposed to positive role-models. We argue that migration is one possible way to increase aspirations of the migrant, since this will confront her with different lifestyles that she will aspire to.
In the empirical part of this chapter, we use panel data from Indonesia to demonstrate that a migration experience has indeed an aspirations increasing effect. We use a fixed effects estimator and an instrumental variables approach, to demonstrate that individuals who emigrate experience an increase to their aspirations that is significantly larger than that of non-emigrants. Our estimation suggests that it is indeed the exposure to a new environment, and not the change in income that drives this boost to aspirations.
We then investigate what this empirical finding implies for the long-run influence of skilled emigration on human capital in the sending countries. We propose a theoretical model of a brain drain that takes the aspirations-increasing effect of a migration experience into account. Aspiring individuals have been observed to have a more future-oriented behavior. We thus stipulate that emigrants, as a result of their higher aspirations, are more likely to invest in the education of their left-behind children, given same abilities. There is thus a positive intergenerational spillover effect of migration on the average educational attainment.
Because the probability to emigrate increases the incentives to invest in education, but depletes the stock of skilled, there exists an optimal skilled-migration rate, which maximizes the post-migration level of human capital. We show that the optimal steady-state value of the skilled emigration rate depends positively on the aspirations effect. Higher aspirations magnify the incentive effect that the possibility to emigrate induces. Furthermore a higher steady state emigration rate increases the number of aspiring households, which further contributes to the positive effect of migration of aggregate investment in education.
A counterfactual simulation of our model suggests, that accounting for the aspirations effect has considerable effects on the optimal skilled emigration rate. Our results indicate that there are potentially more countries than previously thought which could benefit from migration, at the current migration rates.
We conclude that the degree of openness that a source country of migration chooses should take into account not only the immediate effects of migration on the stock of educated workers, but also the positive effect that openness has on the immediate and intergenerational incentives to invest in education.

1.4 Summary of Chapter 4

In the previous chapters, we asses to which extent a country will benefit from globalization, and how a country should restrict its degree of openness. In this chapter, we investigate how an exogenously given migration rate will influence education policy. The various ways in which globalization changes the content, assessment and financing of education, have been pointed out in Rizvi and Lingard (2013). We investigate how skilled emigration will change the incentives of social planners, both

in source and destination countries of migration, to publicly subsidize education. For this purpose, we develop a theoretical model of human capital formation with skilled migration and endogenous education policy.

If human capital has positive spillovers on the aggregate technology and thus the productivity of each worker, private investment in education will be lower than socially optimal. We show that in such a scenario, a social planner who aims at maximizing aggregate welfare will subsidize education, in order to achieve the socially optimal level of education. Under autarky, this is rather straightforward. Under the presence of skilled migration however, the incentives for the social planner change.

For a poor source country of migration, a non-zero migration rate implies that the country will loose some of its skilled workers to migration. We show that the optimal education subsidy for a source country is decreasing in the skilled emigration rate. This effect works through several channels.

The skilled emigrants will not contribute to the aggregate technology of the source country, thus only part of the externality that the subsidy is supposed to internalize will be appropriated by the source country. Furthermore, the emigrants will not pay any taxes after leaving, but have received education subsidies during their education. The remaining population will thus have a higher tax burden in order to finance the free education for the emigrants. This will lower their income, and thus their utility. Another reason is, that the expected skill-premium increases as a result of the possibility to emigrate to a high wage country. This results in a higher educational attainment ex-ante, thus serving as a substitute for subsidies.

We proceed by analyzing the case of a rich country that is a destination of migrants. We find that the social planner of such a country will also lower its optimal education subsidy as a result of skilled immigration, if the skill-level of the immigrants is higher than the average of the host country. This is the case, because the host country has an incentive to free-ride on the source country's freely provided skilled workers. The inflow of skilled workers decreases the need to invest in their own natives in order to achieve the desired education level.

This negative effect of skilled migration on both sending and host country can, in part or entirely, be offset by remittances. We show that, if the migrants send part of their lifetime income back home and the social planners anticipate this, their reaction to a change in the skilled migration rate will change. The social planner of the source country will be willing to invest more in the education of the potential emigrants, if she knows that part of the foreign earnings are sent back. For the host country its the opposite reasoning: Because the social planner knows that only part of the immigrants income stays in her country, she will put a lesser weight on their income, and thus raise higher taxes in order to finance public education for the natives.

Subsequently we demonstrate that the distinct behavior of both sending and host country will lead to an aggregate level of public education provision that is lower than the global optimum. As a result, the average education rate without remit-

tances in both countries is proven to be strictly lower than the social optimum. Remittances will lower the gap between the optimal global level of human capital and the equilibrium level under national education policies.
The repercussions of the negative effect of migration on public education provision are especially severe for the remaining population of the source country. As a result of the insufficient education subsidies and skilled emigration, the post migration average level of education is likely to be lower than under autarky, yet the population has to pay more taxes in order to cover the education subsidies that the skilled emigrants received. We conclude that in such a situation, the education policy of both countries has to be coordinated in order to avoid a global underprovision of public education. Either, remittance payments have to be encouraged, or the host country should commit to funding part of the source country's education, since it will benefit from this as well by host better trained immigrants.

2 Choosing between Protectionism and Free Trade in an Uncertain World[1]

2.1 Introduction

Since World War II major progress has been made in liberalizing international trade and undoing the crippling protectionism of the interbellum years. There is a broad consensus among economists that free trade is in most cases both desirable and beneficial.[2] It is thus puzzling to see that so many trade barriers persist. In particular agricultural tariffs remain high worldwide and are significantly higher than those in manufacturing.[3] Moreover, the fraction of the world's agricultural output that is traded is much lower than that of manufacturing.[4] The lack of progress in the latest WTO trade liberalization round only underscores that in spite of those facts, there is limited willingness especially on part of advanced economies to reduce protection for agriculture.[5]

In this paper we argue that under certain circumstances a country as a whole may actually benefit from some degree of protection. Because of this, there may be tacit support for protectionist policies which makes them persist in sectors such as agriculture. As we show, the combination of uncertain agricultural production, consumer risk aversion and limited inter-sectoral labor mobility may turn protectionism in the name of food security into a powerful argument backed up by higher country welfare. In sum, the explanation of protectionism that we propose can generate improvements in overall welfare because it mitigates uncertainty and risks. Agricultural trade policy is not just a response to comparative advantage and import competition. The particular trade policy stance a country takes is also a function of the domestic and or foreign shocks it is affected by. As such, a country's agricultural policy is an attempt to minimize its exposure to those shocks and, as we will show, it is informed by the respective size of the shocks and how they are correlated.

[1] This chapter is based on coauthored work with Peter Debaere and Gerald Willmann.

[2] Kemp and Wan (1972), Dixit and Norman (1980), and Dixit and Norman (1986) show that free trade is potentially Pareto superior to autarky, and that it is possible to make everybody better off under trade, using several redistributive tools. For a survey that discusses the theoretical literature on gains from trade, see Facchini and Willmann (2001). For empirical evidence see e.g. Eaton and Kortum (2002).

[3] See Paiva (2005)

[4] See Anderson and Martin (2005).

[5] For a good survey on protectionism in agriculture, see Gawande (2005).

We view our explanation as a complement to the political economy rationale for protectionism as found in the seminal work of Grossman and Helpman (1994).[6] Grossman and Helpman argue that a policymaker's objective is not to maximize the welfare of a country. Rather, protection results from a bargaining process between lobbies and the government, who tries to maximize a weighted average of campaign contributions and welfare. While there is some empirical support for Grossman and Helpman's findings, it is hard to believe that the political economy approach tells us the full story, especially w.r.t. agricultural protection. With employment shares in agriculture that are small and falling in the United States, Europe and Japan, it is increasingly difficult to attribute the reluctance to liberalize agriculture to the influence of its lobby.[7][8] The latter opens the door for an explanation that rationalizes economy-wide gains of protection beyond the involvement of the agricultural sector, and a view of trade policy as a response to changing exogenous internal or external shocks.

There is a long-standing argument that trade openness can be a form of insurance against adverse domestic shocks.[9] In the simplest case of n identical countries with linear supply and demand curves, for example, the variance of prices under free trade is one-nth of that experienced under autarky. Applied to agriculture, in case of a bad harvest, the ability to import foodstuffs is an essential form of relief.[10] In this paper, we build on this traditional argument and show how the choice between protectionism and free trade will depend on the particular shocks a country is exposed to and wants to insure itself against. We distinguish between foreign or domestic ones, and analyze how the optimal agricultural trade policy response will be an interaction between the size of the respective shocks, how these shocks are correlated and a country's comparative advantage.
We argue that free trade exposes countries to world markets that are beyond their direct control and subject to foreign shocks. This exposure may in some cases increase the aggregate volatility that countries face. Under such circumstances, a national government may wish to restrict trade on behalf of its consumers in order to be less exposed to the risks associated with higher volatility and the costs that such higher volatility entail.[11]

In order to illustrate our argument, we first focus on the small country case, which is often the benchmark case to illustrate the welfare gains that free trade realizes.

[6] See Gawande and Krishna (2003) for an overview of empirical work on the political economy of trade policy.

[7] Unless one argues, as Honma and Hayami (1986) do, that because of its shrinking share, supporting the agricultural community is increasingly less costly for the rest of society.

[8] Agribusiness campaign contributions in the US were $24.6 million during the 2012 election cycle. As a comparison, the finance and insurance sector contributed over $70 million during the same period. Source: `www.opensecrets.org/pacs/sector.php?cycle=2012&txt=F`

[9] See Winters (1987)

[10] See Burgess and Donaldson (2010) and Gráda (2009)

[11] See also Winters (1990)

In line with our objective to explain agricultural protection our small country faces exogenous terms of trade shocks that are driven by a foreign productivity shock in the agricultural sector. We show that a non-zero, non-prohibitive tariff can be welfare maximizing if two key assumptions are met: First, consumers (who care about a stable real income) are risk-averse, while firms are risk-neutral. Second, not all factors of production are perfectly mobile in the short term, so that that the economy has limited flexibility to respond to a shock. In this setting, we show that the market forces will not automatically maximize a nation's expected welfare. Risk-neutral producers want to exploit their country's comparative advantage to the fullest extent, and specialize more in the production of the export good. By contrast, risk-averse consumers prefer a more diversified production pattern. That is, they want to forego some efficiency gains from trade in order to insure against uncertainty. It is in this context that trade policy can be used to limit specialization and attain an allocation that maximizes consumers' (and hence national) welfare.

Subsequently, we turn to the more general two-large-country case, in which volatile world market prices now stem from uncertainty in both countries' agricultural outputs. That is, we explicitly model uncertainty in the home as well as in the foreign country in the form of productivity shocks in the respective agriculture sectors. The countries now face a trade-off between trade openness as insurance against domestic shocks and protection as insurance against foreign shocks. This large country case supports our argument that the particular nature of uncertainty is key for the optimal trade policy. The nature of domestic and foreign shocks as well as their correlation determines the particular type of trade policy. In particular, we show that higher foreign compared to domestic volatility of shocks to agriculture rationalizes protectionism at home, as long as the home country's comparative advantage is not affected by the shocks. Additionally, an increase in the correlation between foreign and domestic shocks will either increase or decrease the welfare-maximizing tariff rate depending on the country size and strength of the comparative advantage.

The remainder of the paper is structured as follows. In section 2, we briefly review the related literature. In section 3 we present a theoretical model for a small country that faces uncertainty about its terms of trade with the world and determine the optimal trade policy. In section 4 we extend this model to a two-country setting, in which the terms of trade form as a result of the allocation decisions and production shocks that occur in both countries. We present several numerical examples for different trade and production patterns and discuss which trade policy fits which case best. In section 5 we discuss several of the assumptions made in the paper. In section 6 we conclude.

2.2 Literature Review

Our paper is related to several strands of economic literature. There is a large literature on the optimum tariff policy which shows how large countries can use trade policy to turn terms of trade in their favor and improve their welfare.[12] The optimum tariff policy argument has been examined in the work of Staiger and Bagwell (1999) on bargaining inside the GATT and WTO, and has recently been extended to settings with firm-level heterogeneity.[13] In contrast to this literature, we are in particular interested in the insurance motive of trade policy, even for small countries, which is why we explicitly assume that even though large countries have the ability to affect international prices through trade policy, they do not exploit their market power to the fullest extent. Put differently, our argument about welfare improving agricultural trade policy is not just an extension of the optimal tariff argument and the optimal tariff rate setting ability of countries.

There are a number of papers that study how uncertainty affects the optimal pattern of production and trade without drawing any conclusions for trade policy.[14] Turnovsky (1974), for example, investigates how uncertainty about the terms of trade or the production technology changes the pattern of complete specialization in a Ricardian world. Our analysis drops the Ricardian setup and goes beyond the extreme cases of specialization reversal.

Similarly, Anderson and Riley (1976) compare the optimal allocation of resources under uncertain terms of trade. We replicate their finding that increased risk-aversion leads to a situation where less specialization is desirable and optimal production moves closer to the autarky equilibrium. In addition, we explicitly study the implications for trade policy and introduce domestic next to foreign (terms of trade) uncertainty, allowing us to explicitly consider the trade-off between insurance from openness as opposed to insurance from protection.

In a related article Eaton (1979) presents a model of a small country, in which capital is fixed in the long run, while labor is perfectly mobile. He shows that increasing uncertainty in the terms of trade can serve as a justification to transfer capital from the net-export sector to the import-competing sector. However, the author does not translate this observation into a corresponding trade policy.

Building on this work, Kucheryavyy (2015) shows that financial integration can serve as a form of insurance against productivity shocks. In a Ricardian model of international trade, the author assumes that shocks are either industry-specific, i.e. that shocks affect the worldwide production of one sector in the same way, or country-specific, i.e. all sectors in one country are affected in the same way. If shocks are industry-specific, it is shown that financial integration leads to a higher degree of specialization in all economies. If however the shocks are country-specific,

[12] Early references of this argument are Kaldor (1940) and Lerner (1944). Costinot et al. (2013) explore the interaction between optimal tariff policy and comparative advantage.

[13] See Felbermayr et al. (2013)

[14] The uncertainty we investigate does not cover the policy uncertainty studied by Handley (2011).

financial integration will lead to a greater diversification, because in such a scenario, equilibrium world prices serve as an auto-insurance against shocks.

We are, of course, not the first ones to analyze trade policy in an uncertain world. Brainard and Cooper (1970) were among the first to justify trade limitations by the need to diversify local production under terms of trade uncertainty. However, their result is partly driven by the assumption that production and trade decisions (and thus, implicitly, consumption decisions) are made under uncertainty and cannot be reoptimized when the terms of trade get revealed.
Mayer (1977) is another early reference that shows that protectionism can actually be welfare-improving. The uncertainty involves the possibility of an embargo and thus a fairly extreme reversal from free trade to autarky. In a world in which the government (as opposed to all other economic agents) can anticipate an embargo, Mayer (1977) shows how a tariff can make a country better off, since tariffs mitigate the drastic restructuring that would become necessary in the case of a forced autarky. Our analysis has Mayer's outcome as an extreme case, yet we assume rational behavior and complete information on the part of all agents.
Another paper that investigates terms of trade uncertainty as one possible motive for trade policy is Young and Anderson (1982). While they also find that, depending on the source of risk, a protectionist trade policy can be a desirable outcome, the underlying assumptions of their model are very different. Notably it is assumed that both producers and consumers will make all their decisions only once uncertainty has resolved, and policy merely choses a domestic price before knowing the terms of trade. This is in stark contrast to our model, where the different attitudes towards risk of the two groups and the resulting differences in equilibrium allocations are the main motive for policy intervention.
Closer to our approach is Cassing et al. (1986) who argue that a change in the terms of trade has different impacts on owners of different factors. The authors argue that risk-averse factor owners would advocate a tariff which stabilizes the terms of trade. We go beyond this, by showing that even if all consumers are endowed with the same factors, they would still be in favor of a tariff, if the production pattern is determined by the producers.

Newbery and Stiglitz (1984) show that free trade can be Pareto inferior to autarky, if there is uncertainty about production and no market for insurance. Their main argument is that under autarky, a negative shock to production will drive the price for this good up. This way, the producer is insured against bad productivity through the price mechanism. Under free trade, this insurance function of prices disappears if the shocks in the two markets are negatively correlated. The authors show that under certain assumptions, the market clearing world price is constant, and producers are therefore completely exposed to the production risk. It is shown that free trade can be Pareto inferior to free trade if producers are risk-averse.
The scope and results of this paper are very different from ours. While we investi-

gate a model with risk-averse consumers, Newbery and Stiglitz look at risk-averse producers. Furthermore, in expectation technologies of the two countries are assumed to be equal, and comparative advantages arise as a result of the realization of the production shocks. The *ex ante* production pattern of each economy is thus perfectly diversified. In our model, the comparative advantage causes *ex ante* overspecialization in one sector, which makes countries vulnerable to terms of trade fluctuations and thus necessitates policy intervention.
Another prominent example that argues that protectionism may be welfare improving is Eaton and Grossman (1985). The authors investigate trade in a setting with stochastic terms of trade and two factors of production – one is mobile, whereas the other one is indivisible and has to be allocated before the uncertainty resolves. They see trade policy as a redistributive mechanism (comparable to a tax) through which those who receive higher than expected returns after the uncertainty is resolved share some of their excess returns with those who received lower than expected returns. Our setting is quite different from Eaton and Grossman, as trade policy for us insures across different states of the world, rather than across agents. Since a shock in agriculture will have repercussions on all consumers, rather than only a small group of factor owners, our model is more directly relevant when trying to understand agriculture and how to rationalize its persistent tariffs.

In a recent article, Limão and Maggi (2013) discuss trade agreements as a remedy against uncertain trade policy. They show that, with risk-averse individuals, political instability can be one major motive to commit to trade agreements, since they make trade policy binding. Thus, even if a trade agreement does not lower the level of tariffs, but stabilizes it, it might still be beneficial to join it.[15] A less volatile trade policy will improve the expected welfare, especially if the degree of specialization is high, and the country is very open to trade. In their model, the competitive allocation will be socially efficient, even if investments are made *ex-ante*, since all agents in their model are assumed to have identical risk-preferences and resources are indivisible. The motives for trade policy are thus different from those in our model. Furthermore, in their paper, trade policy will react once the state of the world is revealed. In our paper, we sidestep the issue of trade-policy uncertainty and analyze agricultural trade policy primarily as a long-term response to different types of shocks that a country faces.

Gaisford and Ivus (2014) investigate uncertainty as a possible reason for trade policy in a model that follows Dornbusch et al. (1977). They argue that with uncertainty, small countries have a higher incentive to impose tariffs than larger countries, since they want to diversify their range of domestically produced goods. In particular, a tariff will expand the range of goods a country produces. In doing so, adverse shocks will put less pressure on a country to import those more expensive goods

[15] In an empirical paper Mansfield and Reinhardt (2008) find evidence that trade agreements can indeed lower terms of trade volatility, which suggests that part of this volatility is caused by fluctuations in national trade policy.

its consumers want but ended up not producing, even though it technically could. In their model, the degree of specialization, and consequently the need for policy intervention, is driven by the size of a country, whereas we are able to distinguish the distinct effects of size and comparative advantage.

Finally, our paper is also related to a strand of the literature that investigates how uncertainty influences allocation decisions and optimal policy, notably the work of Sandmo (1971), Rothenberg and Smith (1971), Batra and Ullah (1974), Mills (1983), van Marrewijk and van Bergeijk (1990), Hennessy (1998), and Krebs et al. (2005).

2.3 Theoretical Model for a Small Country

In this section we present the simple model that will serve as a benchmark to the more general model in section 4. We do this to gain a better understanding of how uncertainty determines whether a protectionist policy is desirable or not.
There are two sectors, manufacturing and agriculture, and two factors of production, capital and labor. We assume that the small country that we consider has a comparative advantage in producing the manufacturing good, and will export some of its production to the world market. Producers maximize their expected profit by employing capital and labor at their factor prices. We assume that output is increasing in capital and labor input, but that we have decreasing returns to scale. All producers maximize expected profit. In the aggregate, this will lead to an efficient allocation of resources in expectation.This implies expected GDP maximization. The aggregate production functions of the economy are denoted by $y_m(K_m, L_m)$ for the manufacturing sector and by $y_a(K_a, L_a)$ for the agricultural sector. The GDP of the economy can be denoted as

$$I(K_m, K_a, p) \equiv p y_m(K_m, L_m) + y_a(K_a, L_a) \tag{2.1}$$

where p is the relative price of the manufactured good. The price of the agricultural good is taken as the numeraire. The economy has the following resource constraints.

$$K = K_m + K_a, \qquad L = L_m + L_a \tag{2.2}$$

Plugging these resource constraints into (2.1), GDP can be expressed as

$$I(K_m, p) = p y_m(K_m, L_m) + y_a(K - K_m, L - L_m) \tag{2.3}$$

Capital is assumed to be mobile in the long run, but fixed in the short run. This means that the producers have to allocate capital, knowing that they cannot fully reoptimize in the short run, should the terms of trade be different from their expectations. Labor on the other hand, is perfectly mobile in the short run. Labor

will only be allocated to the sectors once the terms of trade become known. This allows producers to deviate from their expected production point, should the terms of trade turn out to differ from the expected value. The possibility to reoptimize implies a short-run and a long-run production possibility frontier, as depicted in Figure 2.1. It can be seen that a deviation from the initially expected production point implies a loss of total productivity. This is especially true, should the producers choose a highly specialized production point in the long run, as in Figure 2.2. We will see later in the paper, that consumers will want to avoid this extent of specialization.

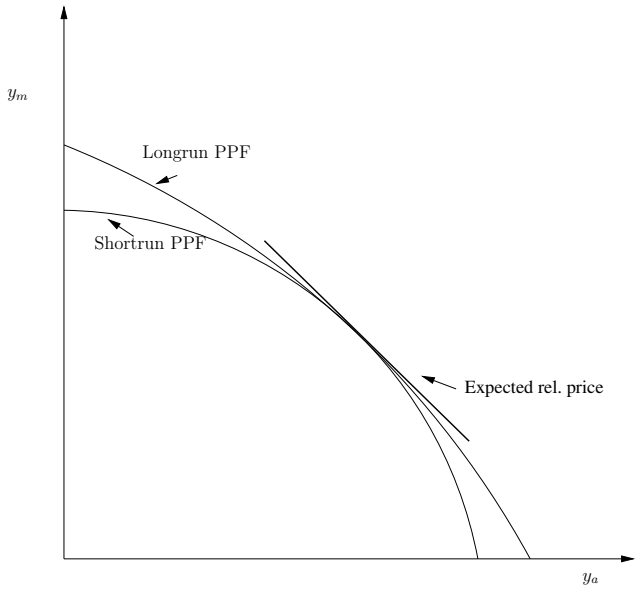


Figure 2.1: Short- and longrun PPF

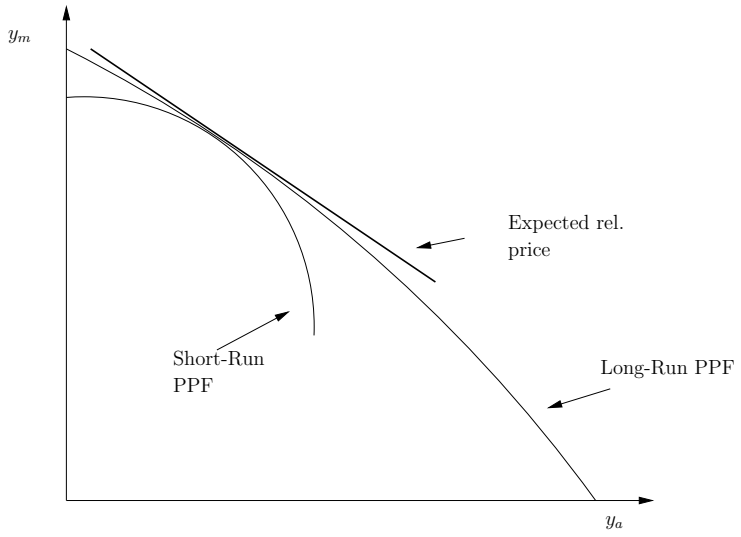


Figure 2.2: Specialized Economy

Producers anticipate that they choose labor optimally, given the actual prices and the previously allocated capital. Therefore, in expectation, labor can be expressed as a function of capital.

$$L_m^* = L_m(K_m, p) \quad \Rightarrow \quad I(K_m, L_m(K_m), p) \equiv \tilde{I}(K_m, p) \tag{2.4}$$

In this section the relative world market price is assumed to be exogenously given. It is assumed to be distributed over the closed interval $[p_l, p_h]$ according to the density function $f(p)$. The price for the agricultural good serves as the numeraire.[16] We assume that even in the worst realization of the relative world price p_l there is no reversal of the trade pattern. Thus we have that $p_l > p_a$, where p_a is the relative autarky price of the manufactured good, i. e. the net-export good. The expected GDP can thus be written in the following way

$$\mathbb{E}[\tilde{I}(K_m, p)] = \int_{p_l}^{p_h} \tilde{I}(K_m, p) f(p) dp \tag{2.5}$$

The function $\tilde{I}(K_m, p)$ has the following properties.

- $\frac{\partial \tilde{I}}{\partial p} > 0$: An increase in the relative world market price of the exported good increases GDP
- $\frac{\partial \tilde{I}}{\partial K_m} \lesseqgtr 0 \quad \frac{\partial^2 \tilde{I}}{\partial K_m^2} < 0$: there exists a maximum w.r.t. K_m
- $\frac{\partial^2 \tilde{I}}{\partial K_m \partial p} > 0$: If the price of the manufacturing good rises, the marginal return to capital in the manufacturing sector rises.

The producers' maximization behavior leads to a maximization of the expected GDP by an optimal allocation of capital. The FOC that determines the optimal capital allocation is

$$\int_{p_l}^{p_h} \frac{\partial \tilde{I}}{\partial K_m}(K_m^*) f(p) dp \stackrel{!}{=} 0 \tag{2.6}$$

We are now going to show that K_m^* is strictly larger than the allocation that risk-averse consumers would choose. From balanced trade it follows that the representative consumer's income is equal to the GDP. Therefore her income ultimately results from the choices made by the producers. Usually consumers will take income as given when maximizing their expected utility. We are interested in the question, whether their income, which is determined by the producers, maximizes their expected utility. Intuitively different risk preferences will result in different optimal allocations if there is uncertainty about the prices. We will now show that this is indeed the case in our model, if consumers are risk-averse. We let a social planner maximize the consumer's expected indirect utility by choosing an allocation that

[16] At a later stage, once we quantify the model, we will use a different normalization. For the qualitative analysis in this part, the numeraire normalization is valid and more convenient.

takes the consumer's risk preferences into account. The consumer's indirect utility function $V(I,p)$ is increasing and concave in income and decreasing in prices, if we assume that consumption of all goods is strictly positive. The social planner's maximization problem (or actually the consumer's problem) is then

$$\max_{K_m} \mathbb{E}[V(\tilde{I}(K_m),p)] = \int_{p_l}^{p_h} V(\tilde{I},p)f(p)dp \tag{2.7}$$

The consumer's FOC that corresponds to the producers' FOC is

$$\int_{p_l}^{p_h} \frac{\partial V}{\partial \tilde{I}} \frac{\partial \tilde{I}}{\partial K_m}(K_m^{c*})f(p)dp \stackrel{!}{=} 0 \tag{2.8}$$

Comparing the two FOCs, we can derive a first proposition, about the different optimal capital allocation the two groups are going to have.

Proposition 1. *In our model K_m^*, the equilibrium free-trade allocation of capital to the exporting sector (i. e. the manufacturing sector in our example) will be strictly larger than K_m^{c*}, the expected socially optimal allocation, if the consumer is risk-averse and producers are risk-neutral.*

Proof. Risk aversion implies that $\frac{\partial^2 V}{\partial \tilde{I} \partial p} < 0$.[17] Therefore, the first term in the integral is positive and decreasing in p. Since $\frac{\partial \tilde{I}}{\partial K_m}$ changes sign and is increasing in p[18], it is negative for small p and positive for larger prices. The first term thus gives a larger positive weight to the negative elements of the second term and a smaller positive weight to the positive elements. In order to clarify the argument, we are rewriting the integral as the limit of the sum of all the elements.
For the producers, we know that

$$\tilde{I}'_{K_m}(K_m^*,p_l)f(p_l) + ... + \tilde{I}'_{K_m}(K_m^*,p_h)f(p_h) = 0 \tag{2.9}$$

Since $\tilde{I}'(.)$ changes sign and is increasing in p, we know that

$$\tilde{I}'_{K_m}(K_m^*,p_l) < ... < \tilde{I}'_{K_m}(K_m^*,p_0) = 0 < ... < \tilde{I}'_{K_m}(K_m^*,p_h) \tag{2.10}$$

Since $f(p) > 0 \quad \forall p$, the distribution function does not change the sign of the terms in (2.9). If we now multiply every element in (2.9) with the corresponding marginal indirect utility, we get that

$$V'_{\tilde{I}}(K_m^*,p_l)\tilde{I}'_{K_m}(K_m^*,p_l)f(p_l) + ... + V'_{\tilde{I}}(K_m^*,p_h)\tilde{I}'_{K_m}(K_m^*,p_h)f(p_h) < 0 \tag{2.11}$$

since $V'(.)$ gives more weight to the negative elements. Therefore the derivative of the expected utility of the consumer is negative at K_m^*. It follows that the optimal K_m for the consumers has to be smaller than K_m^*. □

[17] See Appendix
[18] See Appendix

The free-trade equilibrium resource allocation is thus more specialized than the welfare-maximizing allocation. The risk-neutral producers will exploit the comparative advantage of the economy more than the producers would want them to, thereby exposing the economy more to terms of trade volatility than what would be desirable from an expected welfare point of view.
We will now show that trade policy can lead to an improvement of this situation.

2.3.1 Introduction of a Tariff

Since the producers' investment decisions do not maximize the consumer's expected utility, the question is whether there is scope for policy to improve the allocation for the consumers. Throughout the paper, we restrict our analysis of protectionist policies to tariffs.[19] We will thus investigate whether introducing tariffs can lead to an improvement, compared to the free-trade equilibrium.

Proposition 2. *With uncertainty about the terms of trade and a rigid production structure, some protection will increase expected welfare.*

$$\frac{d\mathbb{E}[V]}{dt}|_{t=0} > 0 \tag{2.12}$$

(See Appendix for proof)

Proposition 2 states that it is beneficial for a small country to install a small import tariff, if there is volatility in the terms of trade and the production structure is rigid. A tariff on the net-imported good will increase the domestic relative price of the imported good. This price increase results in a change in the resource allocation, and thus to a production point that is less specialized than the free-trade equilibrium. The economy, and therefore the risk-averse consumers, are thus less-exposed to the terms of trade volatility are a result of the introduction of a tariff. A certain amount of protectionist policies can thus be beneficial.

Proposition 3. *The optimal tariff will be strictly positive but non-prohibitive.*

$$\frac{d\mathbb{E}[V]}{dt}|_{t=\frac{p_w-p_a}{p_a}} < 0 \tag{2.13}$$

where $t \geq \frac{p_w-p_a}{p_a}$ *implies a prohibitively high tariff.*

(See Appendix for proof)

Proposition 3 states that, while a certain degree of protection is desirable, the tariff that maximizes expected welfare will never result in autarky. Such a prohibitive tariff would resolve the misallocation by taking away the terms of trade uncertainty, but it creates inefficiencies elsewhere. It can thus never be optimal to

[19] Other protectionist measures are discussed in section 5

choose autarky in order to avoid the terms of trade volatility.

In this setup, we have assumed that volatility is introduced by world trade, and that there are no domestic sources of volatility. In reality, it is more reasonable to assume, that volatility in terms of trade can have both domestic and foreign sources. If there is uncertainty about productivity at home, trade can even be an insurance against these domestic shocks. In the case of a bad domestic productivity realization in one of the sectors, access to the world market will dampen part of the shock. In the next chapter, we will therefore allow for both domestic and foreign uncertainty, and show in which cases protection is to be expected.

2.4 The Large Country Case

In the previous section we have shown that a protectionist policy will be beneficial, if trade introduces uncertainty to an otherwise non-stochastic economy. We were not suggesting what drives the change in the terms of trade, since it did not matter for our analysis. We now extend the model to two countries and add a shock to agricultural output in both countries. The market clearing price results when all allocations are determined, and after the production shocks are revealed. The case for a protectionist trade policy with both domestic and foreign shocks becomes more complex. In the previous case, the logic was straightforward. Risk-averse consumers would be in favor of trade reducing policies, since trade on the one hand brings more volatility, and on the other hand, through specialization in production, increases the exposure to that volatility. With both a domestic and a foreign source of uncertainty we will show that the optimal trade policy depends on the relative magnitude and the origin of both sources of uncertainty, and that there is a trade-off between protectionism as insurance against foreign shocks and free trade as insurance against adverse domestic shocks.

2.4.1 Consumption Side

In order to be able to perform a numerical analysis of our results, we abstract from the more general form in the previous section and assume specific functional forms. The consumers in both countries are assumed to have the same Cobb-Douglas utility function[20]

$$U = (x_m^{\alpha} x_a^{1-\alpha})^{\beta} \tag{2.14}$$

where β is a risk-aversion parameter. The lower β, the more risk-averse the consumer will be. The consumer maximizes her utility, taking the relative price p and

[20] We choose Cobb-Douglas utility, because it allows us to incorporate risk-aversion, what would not be possible if we chose e. g. quasi-linear utility. We believe that our qualitative results are not driven by this assumption.

her income I^c as given. With p being the relative price for the manufacturing good, utility maximization gives us the following demand functions.

$$d_m(I^c, p) = \frac{\alpha I^c}{p}, \quad d_a(I^c, p) = (1-\alpha) I^c p \tag{2.15}$$

This leads to the indirect utility of

$$V(I^c, p) = \left(\alpha^\alpha (1-\alpha)^{1-\alpha} I^c\right) \tag{2.16}$$

2.4.2 Price Normalization

Before we continue our analysis, we will first treat the issue of an appropriate price normalization under uncertainty. This is necessary because the numeraire normalization implicitly will lead to a different weighting of the states of the world for consumers and producers. Since we want to assure that the differences in the optimal allocations that we observe are only driven by the difference in risk aversion, we propose a normalization that is uncertainty robust.[21]
If we define $p_m/p_a = p$ as the relative price, we have to *weigh* each state of the world by $(1/p)^\alpha$ to achieve an uncertainty robust normalization.
Under the new normalization, the demand functions then become

$$d_m(I^c, p) = \frac{\alpha I^c}{p^{(1-\alpha)}}, \quad d_a(I^c, p) = (1-\alpha) I^c p^\alpha \tag{2.17}$$

2.4.3 Production Side

The producers in the home country employ capital and labor to produce manufactured and agricultural goods. We assume that capital is sector specific in the short run but perfectly mobile in the long run, whereas labor is always perfectly mobile. Producers thus will have to decide how much capital to employ in which sector, before the state of the world gets revealed. Labor can subsequently be shifted from one sector to the other, in order to react to the realization of the economic outcome.[22] The production functions for the two sectors are

$$\begin{aligned} y_{m1} &= \varphi (K_m^\gamma L_m^{1-\gamma})^\delta \\ \mathbb{E}[y_{a1}] &= \pi [s(K_a^\gamma L_a^{1-\gamma})^\delta] + (1-\pi)[(K_a^\gamma L_a^{1-\gamma})^\delta] \end{aligned} \tag{2.18}$$

φ is a productivity parameter which is used later in order to model comparative advantage. The larger φ, the bigger the relative productivity of the manufacturing

[21] See the Appendix for a discussion of the need for such a normalization and a derivation of the normalization we use.

[22] The assumption that labor is more mobile in the short-run than capital is common in the economic literature, see e.g. Neary (1978).
Labor rigidity can also have influences on the production structure, as shown in Trentinaglia De Daverio (2013). She finds that firms will install over-capacities if labor is rigid and there is demand uncertainty.

sector, compared to the agricultural sector for which productivity is normalized to one in both countries.[23]
π describes the probability that a negative production shock s will occur. We assume that $0 < \delta < 1$ which implies decreasing returns to scale. In this way, we assure that perfect specialization in one sector is not a viable option. γ is the capital share of output.
For the sake of simplicity, we set $\pi = \frac{1}{2}$ and normalize the shock such that it becomes zero in expectation.

$$\mathbb{E}[y_{a1}] = \frac{1}{2}(1+\sigma_1)(K_a^\gamma L_a^{1-\gamma})^\delta + \frac{1}{2}(1-\sigma_1)(K_a^\gamma L_a^{1-\gamma})^\delta \tag{2.19}$$

$\sigma_1 \in [0,1]$ is the shock parameter which measures volatility in the agricultural sector for the home country. We model it such that it takes the value $-\sigma_1$ or σ_1 with probability $\frac{1}{2}$. Therefore, $\mathbb{E}[\sigma_1] = 0$.
The subscript 1 identifies variables that belong to the *home* country. The production functions of the foreign country are assumed to be

$$\begin{aligned} y_{m2} &= (K_m^\gamma L_m^{1-\gamma})^\delta \\ \mathbb{E}[y_{a2}] &= \frac{1}{2}(1+\sigma_2)(K_a^\gamma L_a^{1-\gamma})^\delta + \frac{1}{2}(1-\sigma_2)(K_a^\gamma L_a^{1-\gamma})^\delta \end{aligned} \tag{2.20}$$

The correlation between the shocks in the two countries is r, where a positive r makes states more probable, where the output shock has the same sign in both countries. For a negative r, asymmetric cases with high agricultural output in one country and low output in the other become more likely to occur.

Note that, for large shocks in both countries, situations are possible, in which the effective comparative advantage can be reversed. This is the case if one country has a favorable shock in the sector where it does not have its comparative advantage, and vice versa. If the following equations are fulfilled, this will not occur.

$$\begin{aligned} \frac{\varphi}{1+\sigma_1} &> \frac{1}{1-\sigma_2} \quad \textit{for comparative advantage in manufacturing} \\ \frac{\varphi}{1-\sigma_1} &< \frac{1}{1+\sigma_2} \quad \textit{for comparative advantage in agriculture} \end{aligned} \tag{2.21}$$

In most cases, such an ex-post reversal of comparative advantage would not imply a trade reversal, because capital is allocated to the different sectors before the shock occurs. Thus, with sufficient specialization, a country will still produce more of the good for which it has an expected comparative advantage, even if, ex post, it has a

[23] We chose to use similar production functions for both sectors for mathematical convenience, and since differences in the return to capital and labor in the two sectors will not influence the intuition of our results. Note that for our purposes φ is sufficient to model productivity differences between the sectors.

disadvantage.[24]

We assume that the domestic country imposes an ad valorem tariff t on all imported goods. The social planner announces this trade policy before the producers allocate capital to the different sectors. We assume that the legislation is such that trade policy cannot be changed in the short run. Therefore the social planner has to commit to an ad-valorem tariff rate that cannot be state dependent. Since the policy is irrevocable, producers will take the announced policy as a credible threat and maximize their expected profits accordingly. The domestic producers maximize their expected profit, given the normalized world market prices and the announced trade policy t. The domestic country is assumed to have a comparative advantage in the manufacturing sector in all possible states of the world. This implies that there is no trade-reversal, and the *home* country will always be a net exporter of the manufactured good. The trade policy t that the social planner can set is then a tariff on the net imported agricultural good. The tariff will change the relative domestic price. With our uncertainty robust price normalization, the tariff changes the relative price for the manufactured good to $(p^w/(1+t))^{1-\alpha}$.
In the aggregate, the profit maximizing behavior of the producers leads to a maximization of the expected value of the total output of the domestic country, evaluated at the expected relative domestic prices. This is given by

$$\mathbb{E}[I(t,p)] = \mathbb{E}[(\frac{p^w}{1+t})^{1-\alpha} y_m + (\frac{1+t}{p^w})^{\alpha} y_a] \tag{2.22}$$

where p^w indicates the world market relative price. Setting in the production technology and resource constraints for the home country, this becomes

$$\begin{aligned} \mathbb{E}(I) =& \mathbb{E}[(\frac{p^w}{1+t})^{1-\alpha} \varphi (K_{m1}^{\gamma} L_{m1}^{1-\gamma})^{\delta} \\ &+ (\frac{1+t}{p^w})^{\alpha} ((K_1 - K_{m1})^{\gamma} (L_1 - L_{m1})^{1-\gamma})^{\delta}] \qquad i,j \in (h,l) \end{aligned} \tag{2.23}$$

where φ again measures the comparative advantage in producing the manufactured good.

We limit ourselves to a discrete version of uncertainty, where each country has either a high or low productivity in the agricultural sector. Shocks to the foreign agricultural output will also have an influence on the domestic market, since these shocks influence the world market price. A positive shock to the foreign agricultural productivity will drive the relative price of agricultural products down, thus leading to a more favorable situation for the domestic country, since we assume that it is a net exporter of the manufactured good. With two productivity outcomes in each country, this gives us four different states of the world. We can thus rewrite (2.23) as

[24] See Appendix for an illustration.

$$\mathbb{E}[I_1] =$$
$$\frac{1}{4}(1+r)I_{hh}(K_{m1}, L_{m1}, p_{hh})|_{\sigma_1>0} + \frac{1}{4}(1-r)I_{hl}(K_{m1}, L_{m1}, p_{hl})|_{\sigma_1>0} \tag{2.24}$$
$$+\frac{1}{4}(1-r)I_{lh}(K_{m1}, L_{m1}, p_{lh})|_{\sigma_1<0} + \frac{1}{4}(1+r)I_{ll}(K_{m1}, L_{m1}, p_{ll})|_{\sigma_1<0}$$

Producers maximize their expected profit by choosing capital and labor optimally. Since labor is mobile in the short run, producers can re-optimize their production point once the state of the world gets revealed. Labor is a state dependent function of the relative price of the state, the previously determined capital allocation and the trade policy. The optimal labor allocation follows in each state by maximizing within state profit. It can be written as

$$L^{t*}_{m1ij}(K_{m1}, p^w_{ij}, t) =$$
$$\frac{L_1\left((\frac{p^w_{ij}}{1+t})^{1-\alpha}\varphi K^{\delta\gamma}_{m1}\right)^{\frac{1}{1-\delta(1-\gamma)}}}{\left((\frac{p^w_{ij}}{1+t})^{1-\alpha}\varphi K^{\delta\gamma}_{m1}\right)^{\frac{1}{1-\delta(1-\gamma)}} + \left((1\pm\sigma_1)\left(\frac{1+t}{p^w_{ij}}\right)^{\alpha}(K_1 - K_{m1})^{\delta\gamma}\right)^{\frac{1}{1-\delta(1-\gamma)}}} \tag{2.25}$$
$$i, j \in (h, l)$$

The producers anticipate that they will choose labor optimally in each state of the world and can thus determine the optimal capital allocation by backwards induction. They will therefore plug the above expression for optimal labor into the long run maximization problem and choose capital accordingly.
Equation (2.24) can thus be expressed as a function that depends only on prices, capital and the trade policy.

$$\mathbb{E}[I_1(K_{m1}, L^*_{m1ij}(K_{m1}, p^w_{ij}, t), p^w_{ij}, t)] = \mathbb{E}[I_1(K_{m1}, p^w_{ij}, t)] \quad i, j \in (h, l) \tag{2.26}$$

Taking the derivative with respect to K_{m1} and setting it equal to zero gives us the first order condition for the domestic producers' problem. This is the first equation that determines the equilibrium of the economy.

$$\frac{\partial \mathbb{E}[I_1]}{\partial K_{m1}} = f_1(K^*_{m1}, p^w_{ij}, t) \stackrel{!}{=} 0 \quad i, j \in (h, l) \tag{2.27}$$

The maximization problem for the foreign producers is similar to that of the domestic producers. What changes is that $\varphi_2 = 1$, where the subscript 2 denotes country 2, and that the endowments of the foreign country might differ from those of the home country. Furthermore, we assume that there is no trade policy abroad, so that the foreign producers trade at the world market prices. The foreign production decision is indirectly influenced by the domestic trade policy, since a tariff

influences the domestic allocations and thus change the equilibrium prices.
The first order condition of the foreign country is the second equation that determines the equilibrium of the economy.

$$\frac{\partial \mathbb{E}[I_2]}{\partial K_{m2}} = f_2(K_{m2}, p_{ij}^w, t) \stackrel{!}{=} 0 \quad i,j \in (h,l) \tag{2.28}$$

2.4.4 Equilibrium Prices

What we still need in order to calculate the equilibrium is an expression for the relative world demand.
With the uncertainty-robust price normalization and the domestic tariff, the uncompensated demand functions in both countries can be calculated as

$$\begin{aligned} d_{m1}(I_1, p^w) &= \alpha I_1 (\frac{1+t}{p^w})^{1-\alpha}, \quad d_{a1}(I_1, p^w) = (1-\alpha) I_1 (\frac{p^w}{1+t})^{\alpha} \\ d_{m2}(I_2, p^w) &= \alpha I_2 (\frac{1}{p^w})^{1-\alpha}, \quad d_{a2}(I_2, p^w) = (1-\alpha) I_2 (p^w)^{\alpha} \end{aligned} \tag{2.29}$$

The relative demand in each country $d_{a1}/d_{m1} = (1-\alpha)p/\alpha(1+t)$ and $d_{a2}/d_{m2} = (1-\alpha)p/\alpha$ does not depend on the income of the representative consumer. However, since domestic prices are different from world market prices, the relative world demand in each state will depend on domestic and foreign consumer's income in the respective state .

$$\frac{d_{a1ij} + d_{a2ij}}{d_{m1ij} + d_{m2ij}} = \frac{1-\alpha}{\alpha} \frac{p_{ijt}^w}{(1+t)^{\alpha}} \frac{I_{1ijt} + I_{ijt2}(1+t)^{\alpha}}{I_{1ijt}(1+t)^{1-\alpha} + I_{2ijt}} \quad i,j \in (h,l) \tag{2.30}$$

Since the foreign country is assumed to have a tariff rate of zero, the consumer's income is equal to I_2, the output evaluated at world market prices.
This is not the case for the income of the domestic consumer, because we have to take the trade policy' s influence on the income into account. We assume that the tariff revenue is distributed directly to the consumer. The effective consumer's income I^c for any state is thus

$$\begin{aligned} &I_{1ij}^c(t,p) = \\ &(\frac{p_{ij}^w}{1+t})^{1-\alpha} y_{m1ij} + (\frac{1+t}{p_{ij}^w})^{\alpha} y_{a1ij} + \frac{t}{1+t} (\frac{1+t}{p_{ij}^w})^{\alpha} M(I_{1ij}^c, p_{ij}) \quad i,j \in (h,l) \end{aligned} \tag{2.31}$$

The last term describes the tariff proceeds, evaluated at the domestic relative price of the imported good. We see that M depends on the income of the consumers.

$$\begin{aligned} M(I_{1ij}^c, p_{ij}) &= d_{a1}(I_{1ij}^c, p) - y_{a1ij} \\ &= \frac{I_{1ij}^c (1-\alpha)(p_{ij}^w)^{\alpha}}{(1+t)^{\alpha}} - y_{a1ij} \quad i,j \in (h,l) \end{aligned} \tag{2.32}$$

Setting this into equation (2.31) and solving for I_1^c, we get

$$I_{1ij}^c(K_{m1}, p_{ij}^w, t) = \\ \frac{(1+t)^\alpha}{1+\alpha t}\left((p_{ij}^w)^{1-\alpha} y_{m1}(K_{m1}, p_{ij}^w, t) + \frac{y_{a1}(K_{m1}, p_{ij}^w, t)}{(p_{ij}^w)^\alpha}\right) \tag{2.33}$$

We can therefore write the relative demand as a function of capital allocations, prices and the tariff.

Relative world supply in all four states is determined by the allocation choices of the producers.

$$\frac{y_{a1ij} + y_{a2ij}}{y_{m1ij} + y_{m2ij}} = \\ \frac{\left((K_1 - K_{m1}^*)^\gamma (L_1 - L_{m1ij}^*)^{1-\gamma}\right)^\delta (1 \pm \sigma_1) + \left((K_2 - K_{m2}^*)^\gamma (L_2 - L_{m2ij}^*)^{1-\gamma}\right)^\delta (1 \pm \sigma_2)}{\varphi\left((K_{m1}^*)^\gamma (L_{m1ij}^*)^{1-\gamma}\right)^\delta + \left((K_{m2}^*)^\gamma (L_{m2ij}^*)^{1-\gamma}\right)^\delta} \quad i,j \in (h,l) \tag{2.34}$$

In order to calculate the market clearing relative price in each state of the world, we set relative world demand equal to relative world supply.

$$\frac{d_{a1ij}(K_{m1}^*, p_{ij}^w, t) + d_{a2ij}(K_{m2}^*, p_{ij}^w, t)}{d_{m1ij}(K_{m1}^*, p_{ij}^w, t) + d_{m2ij}(K_{m2}^*, p_{ij}^w, t)} \\ -\frac{y_{a1ij}(K_{m1}^*, p_{ij}^w, t) + y_{a2ij}(K_{m2}^*, p_{ij}^w, t)}{y_{m1ij}(K_{m1}^*, p_{ij}^w, t) + y_{m2ij}(K_{m2}^*, p_{ij}^w, t)} \stackrel{!}{=} 0 \quad i,j \in (h,l) \tag{2.35}$$

For all possible states of the world, (2.35) gives us the final four equations that, together with (2.27) and (2.28) determine the world market equilibrium.

$$\begin{aligned} f_3(K_{m1}^*, K_{m2}^*, p_{ij}^w, t) &= 0 \\ f_4(K_{m1}^*, K_{m2}^*, p_{ij}^w, t) &= 0 \\ f_5(K_{m1}^*, K_{m2}^*, p_{ij}^w, t) &= 0 \\ f_6(K_{m1}^*, K_{m2}^*, p_{ij}^w, t) &= 0 \end{aligned} \tag{2.36}$$

Solving these six equations, we receive the equilibrium values of K_{m1}^*, K_{m2}^*, and the world market relative prices for all four states of the world.

2.4.5 Free Trade Equilibrium vs. Welfare Maximizing Allocations

The equilibrium that we have characterized above describes the market outcome, given the national trade policy. We are providing some intuition for the need for policy intervention, by comparing the equilibrium capital allocation at free trade with the welfare maximizing allocation.
The allocation that maximizes the expected welfare of the domestic representative consumer and the corresponding market clearing prices can be found by replacing

$f_1(.)$ by the following. The expected indirect utility is expressed as

$$\mathbb{E}[V(I_1^c(K_m,p,t)] = (\alpha^\alpha(1-\alpha)^{1-\alpha})^\beta \mathbb{E}[\big(I_1^c(K_{m1}, L^*_{m1ij}(K_{m1},p,t),p,t)\big)^\beta] \quad (2.37)$$

The welfare maximizing capital allocation K^{c*}_{m1} then solves

$$\frac{\partial \mathbb{E}[V(I_1^c)]}{\partial K_{m1}} = f_7(K^{c*}_{m1}, p^w_{ij}, t) \stackrel{!}{=} 0 \quad i,j \in (h,l) \quad (2.38)$$

We are now going to compare K^{c*}_{m1} and K^*_{m1} at $t=0$, the free trade equilibrium.

We do not provide an analytical solution for the optimal capital allocations. Instead, in order to analyze the impact of the volatility and comparative advantage on the different optimal allocations, we perform numerical simulations, in which we vary the degree of both foreign and domestic volatility, and the magnitude of the comparative advantage.

There are two main motives why the representative consumer would want a different capital allocation than the producer. Since the consumer is risk-averse, she will favor allocations that expose her less to any sort of risk. In the small country case which we discussed in section 3, the only source of risk was the terms of trade volatility. Without domestic uncertainty, the consumer thus would always prefer an allocation that is more diversified than the free-trade equilibrium. This *diversification* motive still is one of the two reasons why consumers and producers differ in their optimal allocations. The foreign output volatility translates directly into terms of trade volatility. The higher the foreign agricultural output, the higher the relative price of the manufactured good, and vice versa.
However, with domestic uncertainty, there is another source of risk that consumers will want to avoid, the *domestic risk* which stems from the output shocks in the domestic agricultural sector. With domestic uncertainty, consumers will, *ceteris paribus*, want to produce less of the agricultural good, compared to the market equilibrium.
In the case of a country that has a comparative advantage in the manufacturing sector, these two forces are countervailing. The *diversification* motive leads to lower specialization, and thus an increase in agricultural production, whereas the *domestic risk* motive will lead to less domestic agricultural production.
Which motive dominates depends on two key variables: the extent of the comparative advantage, and thus the extent of specialization, and the relative domestic volatility, compared to the volatility abroad.

Table 2.1: $K_{m1}^{c*} - K_{m1}^{*}$ at free trade equilibrium

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
$\sigma_1 = 0$	0.00	-3.75	-17.22	-46.65
$\sigma_1 = 0.2$	0.94	-2.65	-15.48	-43.46
$\sigma_1 = 0.4$	3.73	0.59	-10.43	-34.13
$\sigma_1 = 0.6$	8.20	5.76	-2.55	-19.45
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 3$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi < (1 + \sigma_1)/(1 - \sigma_2)$.

In Table (2.1) we describe the difference in capital that is allocated to the manufacturing sector in the free trade equilibrium and the allocation that maximizes the expected welfare of the representative consumer, for various volatility scenarios, i.e. for situations in which the country has either a *volatility advantage* or *disadvatage* compared to the trading partner.
This table is representative for a country that has a strong comparative advantage in the manufacturing sector. By modeling the foreign country as owning 100 times as much of each resource as the home country, we can interpret the foreign country as the *rest of the world*, from the point of view of the domestic country.

If the value in the table is negative, this means that the market equilibrium is overspecialized, compared to the expected welfare maximizing allocation. In order to improve welfare, more capital would need to be employed in the agricultural sector. If the value is positive, the opposite will be true, and the exposure to the domestic agricultural risk would need to be lowered.
The free-trade market equilibrium for the values used in table (2.1) is such that $K_{m1}^{*} = 888.06$, implying that almost 90% of the available capital is employed in the manufacturing sector. This is clearly a highly specialized production point.

Table (2.1) analyzes the impact of different values of relative volatility on the difference between the optimal allocations of the two groups, consumers and producers. Without uncertainty, the market equilibrium at free trade will be the welfare maximizing allocation. This comes as no surprise, since there are no conflicts of interest between consumers and producers if there is no volatility.
Without domestic risk, it can be seen that the consumer will want less specialization as the foreign risk, and thereby the terms of trade volatility, increases. When

domestic volatility is the only source of risk, more capital should be employed in the agricultural sector.
When there is volatility in both foreign and domestic output, then the difference in optimal allocations depends on the relative magnitude of the shocks. With large foreign volatility, and modest domestic uncertainty, it is clear that the *diversification* motive remains much more important than the *domestic risk* motive. For a country with a large comparative advantage in manufacturing, as we have assumed, the *diversification* motive will be dominant for comparable magnitudes of foreign and domestic volatility.

Table 2.2: $K_{m1}^{c*} - K_{m1}^{*}$ at free trade equilibrium, medium φ

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
σ_1=0	0.00	-3.63	-12.91	-20.48
σ_1=0.2	6.45	3.01	-5.95	-13.93
σ_1=0.4	24.87	22.13	14.61	6.32
σ_1=0.6	52.48	51.12	47.25	41.84
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 1.5$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur.

In table (2.2), we now look at a situation in which the comparative advantage is weaker. With $\varphi = 1.5$, the extent of specialization is already a lot smaller than with our previous configuration. With the values of the parameters chosen in table (2.2), the capital that the domestic country employs in the manufacturing sector represents merely 63% of its endowment.
Still, the direction of the two effects remains the same. An increase in domestic uncertainty implies that employing more capital in the manufacturing sector, compared to the market equilibrium, will improve the expected welfare. An increase in foreign volatility on the other hand implies, that less specialization, and thus more agricultural-specific capital would be welfare improving. These findings are robust to a change in the parameters. We can then make the following proposition.

Proposition 4. *With $\varphi > \frac{1+\sigma_1}{1-\sigma_2}$, the difference between the expected welfare maximizing capital allocation and the free-trade market equilibrium capital allocation in*

the manufacturing sector, $\Delta K^*_{m1}|_{t=0} = K^{c*}_{m1} - K^*_{m1}$ *is such that*

$$\frac{\partial \Delta K^*_{m1}}{\partial \sigma_1}|_{t=0} > 0, \qquad \frac{\partial \Delta K^*_{m1}}{\partial \sigma_2}|_{t=0} < 0 \tag{2.39}$$

In words, this means that, as long as the domestic country has a stable comparative advantage in the manufacturing sector, the two motives for differences for optimal allocations between producers and consumers will be countervailing forces.[25] To evaluate which force will be dominant, we make the following proposition.

Proposition 5. *For all* φ*, we have that*

$$\frac{\partial^2 \Delta K^*_{m1}}{\partial \sigma_1 \partial \varphi}|_{t=0} < 0, \qquad \frac{\partial^2 \Delta K^*_{m1}}{\partial \sigma_2 \partial \varphi}|_{t=0} < 0 \tag{2.40}$$

A large comparative advantage will thus decrease the *domestic risk* motive, while it will reinforce the *diverisification* motive. This is intuitive. At a high comparative advantage, specialization will be high, which makes the country more vulnerable to terms of trade shocks. With a low comparative advantage, more resources are devoted to the production of agricultural goods. A domestic shock will then have a more pronounced impact.

We will now look at the case of a country that has a comparative advantage in the agricultural sector.

Table 2.3: $K^{c*}_{m1} - K^*_{m1}$ at free trade for comp. adv. in agriculture

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
σ_1=0	0.00	2.01	8.21	19.28
σ_1=0.2	6.72	8.59	14.42	24.91
σ_1=0.4	31.03	32.33	36.53	44.58
σ_1=0.6	88.17	87.84	87.33	88.19
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 0.5$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi > (1 - \sigma_1)/(1 + \sigma_2)$.

[25] In most cases, this proposition also holds for an unstable comparative advantage in the manufacturing sector, but there are exceptions.

In table (2.3), $\varphi = 0.5$, which implies that the domestic country has a comparative advantage in the agricultural sector. The parameters used for the calibration of table (2.3) result in a free-trade market equilibrium, where $11,16\%$ of the available capital is employed in the manufacturing sector. For such a country, that is specialized in the agricultural sector, we can make the following proposition.

Proposition 6. *With $\varphi < 1$, the difference between the expected welfare maximizing capital allocation and the free-trade market equilibrium capital allocation in the manufacturing sector, $\Delta K^*_{m1}|_{t=0} = K^{c*}_{m1} - K^*_{m1}$ is such that*

$$\frac{\partial \Delta K^*_{m1}}{\partial \sigma_1} > 0, \qquad \frac{\partial \Delta K^*_{m1}}{\partial \sigma_2} > 0 \tag{2.41}$$

Thus, for a country that has a comparative advantage in agriculture, no matter what the source of the risk, an increase in volatility will always imply that a production structure that is less specialized than the market equilibrium will be superior in terms of expected welfare. In other words, risk-averse consumers will want to allocate less resources to the agricultural sector, since it exposes them to two sorts of risk. The reasons for this are, that in such a case, the two forces work in the same direction. An increase in domestic agricultural volatility implies, that in order to decrease the exposure to this risk, the country should decrease domestic agricultural output. With an increase in the terms of trade volatility, the country will want to diversify. For a country with $\varphi < 1$, this means that it should produce more of the manufactured good.

2.4.6 Trade Policy

We have just shown that the market equilibrium at free trade will not maximize the expected welfare of the representative consumer. There is thus scope for policy intervention. We will show how our findings translate into trade policy. The social planner will want to maximize the expected utility of the consumers by choosing an appropriate trade policy.
Knowing the equations that determine the equilibrium, the social planner will impose a tariff t on the agricultural good, if this increases representative consumer's expected indirect utility.

$$\mathbb{E}[V(I^c_1(K_m, p, t)] = (\alpha^\alpha (1-\alpha)^{1-\alpha})^\beta \mathbb{E}[\big(I^c_1(K_{m1}, L^*_{m1ij}(K_{m1}, p, t), p, t)\big)^\beta] \tag{2.42}$$

As we have shown above, the different risk-preferences of consumers and producers lead to different optimal capital allocations for the two groups. In order to assess the influence that trade policy will have on the expected utility, the social planner thus has to take the indirect effects of the policy on the market equilibrium into

account. The maximization problem is thus

$$\frac{d\mathbb{E}[V]}{dt} = \mathbb{E}[\frac{\partial V}{\partial I_1^c}\left(\frac{\partial I_1^c}{\partial t} + \frac{\partial I_1^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t} + \frac{\partial I_1^c}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial I_1^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial p}\frac{\partial p}{\partial t}\right)] \stackrel{!}{=} 0 \quad (2.43)$$

We concentrate our analysis on the insurance motive of trade policy. It is well known that, if a country is aware of its market power, and thus its ability to influence the terms of trade, it will want to impose a tariff on imports to decrease the demand and decrease the relative world price of the imported good.[26] In order to make sure that we only capture the insurance motive of trade policy, we will assume that the social planner behaves as if she is not aware of the influence that a tariff will have on the world market price. The social planner thus behaves as if she was setting the trade policy for a small country. In practice, this means that we set $dp/dt = 0$.[27] We can therefore write (2.43) as

$$\begin{aligned}
\frac{d\mathbb{E}[V]}{dt} &= \mathbb{E}[\frac{\partial V}{\partial I_1^c}\left(\frac{\partial I_1^c}{\partial t} + \frac{\partial I_1^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t}\right)] \\
&= (1+r)\left((I_{hh}^c)^{\beta-1}\left(\frac{\partial I_{hh}^c}{\partial t} + \frac{\partial I_{hh}^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t}\right) + (I_{ll}^c)^{\beta-1}\left(\frac{\partial I_{ll}^c}{\partial t} + \frac{\partial I_{ll}^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t}\right)\right) \\
&+ (1-r)\left((I_{hl}^c)^{\beta-1}\left(\frac{\partial I_{hl}^c}{\partial t} + \frac{\partial I_{hl}^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t}\right) + (I_{lh}^c)^{\beta-1}\left(\frac{\partial I_{lh}^c}{\partial t} + \frac{\partial I_{lh}^c}{\partial K_{m1}}\frac{\partial K_{m1}}{\partial t}\right)\right) \\
&\stackrel{!}{=} 0
\end{aligned} \quad (2.44)$$

We refrain from analytically deriving the equilibrium allocations and prices as a function of t. Instead, we use the implicit function theorem and Cramer's rule on equations (2.22), (2.30) and (2.35) to derive $\frac{\partial K_{m1}^*}{\partial t}$ and thereby $\frac{d\mathbb{E}(V(I,p,t))}{dt}$.
In order to calculate $\frac{dK_m^*}{dt}$, we construct two 6×6 Jacobian matrices, each composed of the partial derivatives of $f_1(.), f_2(.), ..., f_6(.)$ with respect to the six variables that the functions depend on. For the second Jacobian we replace the derivative with respect to K_{m1}^* with the derivative w.r.t. t. This gives us the following matrices.

[26] See Feenstra (2003, chap. 7) for an elaborate discussion for terms of trade effect of a tariff as a motive for trade protection.

[27] Note that this does not mean that the terms of trade are not influenced by trade policy. In general equilibrium, the relative world prices will adapt to the tariff and the changes in allocation this implies. However $dp/dt = 0$ means that we explicitly assume that the possibility to manipulate the terms of trade in her favor are not exploited by the social planner.

$$m_1 = \begin{pmatrix} \frac{\partial f_1}{\partial K_{m1}} & \frac{\partial f_1}{\partial K_{m2}} & \frac{\partial f_1}{\partial p_{hh}} & \cdots & \frac{\partial f_1}{\partial p_{ll}} \\ \frac{\partial f_2}{\partial K_{m1}} & \frac{\partial f_2}{\partial K_{m2}} & \frac{\partial f_2}{\partial p_{hh}} & \cdots & \frac{\partial f_2}{\partial p_{ll}} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_6}{\partial K_{m1}} & \frac{\partial f_6}{\partial K_{m2}} & \frac{\partial f_6}{\partial p_{hh}} & \cdots & \frac{\partial f_6}{\partial p_{ll}} \end{pmatrix}, \quad m_2 = \begin{pmatrix} \frac{\partial f_1}{\partial t} & \frac{\partial f_1}{\partial K_{m2}} & \frac{\partial f_1}{\partial p_{hh}} & \cdots & \frac{\partial f_1}{\partial p_{ll}} \\ \frac{\partial f_2}{\partial t} & \frac{\partial f_2}{\partial K_{m2}} & \frac{\partial f_2}{\partial p_{hh}} & \cdots & \frac{\partial f_2}{\partial p_{ll}} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \frac{\partial f_6}{\partial t} & \frac{\partial f_6}{\partial K_{m2}} & \frac{\partial f_6}{\partial p_{hh}} & \cdots & \frac{\partial f_6}{\partial p_{ll}} \end{pmatrix} \tag{2.45}$$

From Cramer's rule, it then follows that

$$\frac{\partial K_{m1}}{\partial t} = -\frac{\det m_2}{\det m_1} \tag{2.46}$$

We set this into the social planner's first order condition (2.44) and are now able to evaluate the influence of a tariff on the expected utility.

2.4.7 Numerical Analysis

We will first analyze the influence of trade policy for a country that has a comparative advantage in the manufacturing sector. We set $t = 0$, in order to determine in which cases the social planner prefers protectionism over free trade. A positive derivative indicates, that the introduction of an import tariff on the agricultural good will improve the expected welfare of the consumer.

In table (2.4) we show the derivative of the expected indirect utility for different volatility levels.

Table 2.4: $\frac{d\mathbb{E}[V]}{dt}$ at free trade equilibrium

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
σ_1=0	0.00	0.02	0.09	0.23
σ_1=0.2	-0.01	0.01	0.08	0.21
σ_1=0.4	-0.01	0.00	0.05	0.17
σ_1=0.6	-0.04	-0.03	0.01	0.10
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 3$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi < (1 + \sigma_1)/(1 - \sigma_2)$.

We can see, that the influence of the introduction of a tariff on the expected welfare evolves analogous to the differences in the optimal capital allocations, presented in table (2.1). The higher the relative level of foreign volatility, the more beneficial the introduction of a tariff will be. This translates into the following proposition.

Proposition 7. *With $\varphi > \frac{1+\sigma_1}{1-\sigma_2}$, the influence of an import tariff on the agricultural good on the representative consumer's expected indirect utility is such that*

$$\frac{\partial^2 \mathbb{E}(V)}{\partial t \partial \sigma_1}|_{t=0} < 0, \qquad \frac{\partial^2 \mathbb{E}(V)}{\partial t \partial \sigma_2}|_{t=0} > 0 \tag{2.47}$$

In words, an increase in foreign volatility increases the positive impact that the introduction of a tariff has on the expected indirect utility. This is the case, because stronger foreign volatility implies riskier terms of trade. In such a case, the $diversification$ motive becomes more important, and the country should invest less in the manufacturing sector, in order to increase the expected welfare. A tariff achieves just this, since it makes the net-imported agricultural good more expensive, thereby giving incentives to produce more of it domestically.
Higher domestic volatility on the other hand, will decrease the positive impact of the tariff, and might even reverse it, if domestic volatility is the dominant source of risk. If domestic risk becomes more important, the consumer will desire to produce less of the agricultural good and more of the manufactured one, to minimize risk. In a case where this domestic motive is dominant, it might even be optimal to impose a negative tariff, which implies an export subsidy on the manufactured good.

We now investigate how a decrease in the comparative advantage changes our results.

Table 2.5: $\frac{d\mathbb{E}[V]}{dt}$ at $t = 0$ for $\varphi = 1.5$

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
σ_1=0	0.00	0.02	0.06	0.10
σ_1=0.2	-0.03	-0.01	0.03	0.07
σ_1=0.4	-0.12	-0.10	-0.07	-0.03
σ_1=0.6	-0.25	-0.24	-0.23	-0.20
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 1.5$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi < (1 + \sigma_1)/(1 - \sigma_2)$.

Table (2.5) shows the influence of a tariff for the same values used in table (2.2). We can see that the diversification motive is relatively less important for a country that has only a moderate comparative advantage in manufacturing. This result is robust, and can be stated as follows.

Proposition 8. *For all $\varphi > 1$, we have that*

$$\frac{\partial^2 \frac{\partial \mathbb{E}(V)}{\partial t}}{\partial \sigma_1 \partial \varphi}|_{t=0} > 0, \qquad \frac{\partial^2 \frac{\partial \mathbb{E}(V)}{\partial t}}{\partial \sigma_2 \partial \varphi}|_{t=0} > 0 \tag{2.48}$$

This implies that, the stronger the comparative advantage in the manufacturing sector, the more trade policy is driven by the *diversification* motive. The *domestic risk* motive becomes more important, as the comparative advantage decreases.
There are two related reasons for this. First, a higher comparative advantage implies a higher specialization of the economy, which makes it particularly vulnerable to terms of trade shocks. Second, the influence of a bad domestic harvest will not have a big impact on domestic GDP if only a small fraction of the value of national output comes from agriculture. For these reasons, we should expect that countries with a high comparative advantage in manufacturing will impose higher tariffs on agricultural goods.

We now look at the case of a country that is a net exporter of the agricultural good.

Table 2.6: $\frac{d\mathbb{E}[V]}{dt}$ at $t = 0$ for $\varphi = 0.5$

Volatility	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
σ_1=0	0.00	-0.01	-0.04	-0.08
σ_1=0.2	-0.03	-0.04	-0.06	-0.11
σ_1=0.4	-0.13	-0.13	-0.15	-0.18
σ_1=0.6	-0.35	-0.35	-0.35	-0.35
$r = 0$	$K_1 = 1000$	$K_2 = 100,000$	$\delta = 0.6$	$\alpha = 0.4$
$\varphi = 1.5$	$L_1 = 1000$	$L_2 = 100,000$	$\gamma = 0.6$	$\beta = 0.2$

Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi > (1 - \sigma_1)/(1 + \sigma_2)$.

We can immediately see that, as in table (2.3), an increase in both sources of volatility will influence trade policy in the same direction. This translates into the following proposition.

Proposition 9. *With $\varphi < 1$, the influence of volatility on the impact of the tariff on the expected indirect utility is such that*

$$\frac{\partial^2 \mathbb{E}(V)}{\partial t \partial \sigma_1}|_{t=0} < 0, \qquad \frac{\partial^2 \mathbb{E}(V)}{\partial t \partial \sigma_2}|_{t=0} < 0 \tag{2.49}$$

A net-exporter of agricultural products will want to install a trade policy instrument that decreases the domestic relative price of the agricultural good, instead of increasing it as a tariff would. We thus interpret a negative derivative as the wish to install an import tariff on the manufactured good. With such a tariff, the producers would allocate less capital to the agricultural sector which makes the country less vulnerable to both sources of risk.
First, by decreasing the degree of specialization, the country will become less exposed to terms of trade shocks. Second, it will also be less exposed to the domestic agricultural risk, if it produces more of the manufactured good.

We will now investigate the influence of the risk structure on the level of the optimal tariff. Table (2.7) shows the derivative of the expected indirect utility with respect to a tariff for different tariff levels. For a positive derivative, this implies that a further increase of the tariff will improve the expected utility. We see that the derivative gets smaller as the tariff grows, and that the optimal tariff is increasing in the foreign risk. Table (2.8) shows the same as table (2.7), but now for a situation with a positive amount of domestic volatility.
For comparable levels of foreign volatility, the optimal tariff is strictly lower when

Table 2.7: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different values of t

t	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
0	0.00	0.02	0.09	0.23
0.01	-0.04	-0.02	0.04	0.18
0.015	-0.06	-0.05	0.02	0.16
0.02	-0.08	-0.07	-0.00	0.13
$r = 0$	$\varphi = 3$	$K_2 = 100,000$	$L_2 = 100,000$	$\alpha = 0.4$
$\sigma_1 = 0$	$\delta = 0.6$	$\gamma = 0.6$	$\beta = 0.2$	

Note: Numbers printed in red denote situations where more diversification improves expected welfare.

Table 2.8: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different values of t, $\sigma_1 = 0.2$

t	$\sigma_2 = 0$	$\sigma_2 = 0.2$	$\sigma_2 = 0.4$	$\sigma_2 = 0.6$
0	-0.02	0.00	0.05	0.17
0.01	-0.06	-0.05	0.01	0.12
0.015	-0.08	-0.07	-0.01	0.10
0.02	-0.10	-0.09	-0.04	0.07
$r = 0$	$\varphi = 3$	$K_2 = 100,000$	$L_2 = 100,000$	$\alpha = 0.4$
$\sigma_1 = 0.4$	$\delta = 0.6$	$\gamma = 0.6$	$\beta = 0.2$	

Note: Numbers printed on light-gray background denote situations where diversification is favorable to consumers. Numbers printed in white denote situations in which comparative advantage reversals can occur, $\varphi < (1 + \sigma_1)/(1 - \sigma_2)$

there is a positive amount of domestic uncertainty. This is the case, because a higher tariff reduces the exposure to the terms of trade volatility, but increases the exposure to the domestic risk. The optimal trade policy will thus take into account the two sources of risk to which domestic income is exposed and "insure" against the more dominant source. In the case of a country with a moderate amount of domestic risk, compared to the rest of the world, and a high comparative advantage in the manufacturing sector, the optimal policy will therefore be a tariff on the agricultural good, whereas it will be an export subsidy if the domestic risk dominates.

Other parameters that influence the optimal trade policy are the amount of risk-aversion, short-term rigidity, size and the correlation of shocks.[28]
An increase in β, which implies a decrease in the risk-aversion of the representative consumer, will favor a trade policy that is closer to free trade. This result is easily understandable since the difference in risk-preferences of producers and the consumer is the driving motive for policy intervention in our model. Without risk-averse consumers, the market equilibrium will attain the welfare maximizing allocation, thereby making trade policy obsolete.
A decrease in γ, the share of capital in the production function, will have a similar effect. With a higher capital share, the production function is more rigid in the short-run, since capital is sector specific once the state of the world is revealed. The impact of an adverse terms of trade or productivity realization is thus higher if the share of capital in the production function is large.
A relative increase of the size of the domestic country, modeled by an increase of the domestic resource endowment, will make the *diversification* motive of trade policy less important. The reason for this is, that the pass-through of a foreign shock to the terms of trade is less direct if the rest of the world is smaller, compared to the home country.[29]
The influence of correlation on the optimal trade policy is very ambiguous and depends on the comparative advantage and the relative magnitude of foreign and domestic shocks.
Let us first consider the case of a country that has a comparative advantage in the manufacturing sector. An increase of r implies that the symmetric states hh and ll become more likely. In the state hh, the relative world market price for the manufactured good will be high, but so is the domestic agricultural productivity. It

[28] For numerical examples of the influence of the different parameters on trade policy, see tables (2..9)-(2..13) in the Appendix.

[29] Gaisford and Ivus (2014) find a similar result. In a Ricardian model with a continuum of goods, smaller countries will impose higher tariffs, since they have larger diversification incentives. In their model, small countries are more specialized than large countries, since they only produce a small range of goods. While the result is similar, the reasoning driving it is different. Note that in our model, the degree of specialization does not depend on the size, but only on the comparative advantage of a country. The only influence of a country's relative size is the pass-through of foreign shocks on the terms of trade. Furthermore, once we drop the assumption that the social planner ignores the terms of trade effect, the impact of size on trade policy will be reversed, with larger countries imposing higher tariffs.

thus depends on the relative magnitude of the shocks, whether or not it would be better to produce more of the agricultural good. The opposite holds for the state ll. These symmetric cases are thus somewhat "auto-insured". The asymmetric cases however are not. In hl it will increase GDP to allocate more capital to the agricultural sector, whereas in lh it would be unambiguously better to produce more of the manufactured good. Since the consumer is risk-averse, she will put more weight on the worse state of the world, and policy should follow accordingly. However, without knowing the size of foreign and domestic shocks, we cannot clearly say, which state is worse, hl or lh. Thus, for a net-exporter of manufactured goods, we cannot clearly state how trade policy will react to a change in correlation.
For a country that has a comparative advantage in the agricultural sector, the influence of an increase in r is easier to asses. Here, the state with the lowest income will be lh, since this implies a low price of the net-exported good, combined with a bad productivity realization. In this state, it would be better unambiguously better to produce more of the manufactured good. This worst state becomes more likely when the correlation becomes negative. A decrease in r will hence imply a stronger deviation from free-trade, where the social planner will impose a tariff on the import of manufactured goods. Since the symmetric cases are again "auto-insured", the asymmetric cases are dominant. A decrease in the correlation will thus lead to a more interventionist trade policy.

2.5 Discussion

In this section we discuss possible extensions and implications of some of the assumptions made in this paper.

2.5.1 Different risk aversion for agricultural good

We have implicitly assumed that the risk aversion of the consumers is with respect to fluctuations in their real income. The result that consumers in industrialized economies generally prefer an equilibrium allocation that is less specialized in manufacturing is thus only driven by the effect of agricultural volatility on real income. It might be argued that risk aversion might be different for different consumption goods. The consumption of some goods is a necessity, whereas the consumption of other goods is not required for survival. Typically, one would assume that risk aversion should thus be higher for agricultural products.
We could include this in our model by using a Stone-Geary utility function, with a subsistence level for agricultural consumption. In such a setting, consumers could only get a positive utility from consuming other goods once their basic consumption of agricultural goods is satisfied. Intuitively, including such a parameter in our model should reinforce our result that countries which have a comparative advantage in manufacturing should protect their agricultural sector. With a higher

risk-aversion for agricultural goods, consumers will not only want to avoid to be exposed to fluctuations in real income, but will want to assure that their food consumption is stable. If a country has a *volatility advantage* in the production of the agricultural good, it will then be welfare maximizing to produce more of the agricultural good, compared to the market equilibrium, in order to avoid both income and consumption fluctuations.

2.5.2 Different Policy Instruments

Throughout this paper, we have restricted the set of policy instruments to tariffs. The purpose of our analysis was to point out, that protectionist policies can be welfare improving in a situation with volatility. We do not claim that tariffs are the best way to achieve this welfare improvement. Other instruments like production or export subsidies, quotas or non-tariff barriers to trade, such as technical norms might also achieve this result. Especially in the agricultural sector, non-tariff barriers to trade and domestic support play a very important role. For example, more than 40% of the EU's budget is spent on agricultural policies.[30]
Previous work on optimal trade policy under uncertainty has already discussed the question, which policy instrument a small country should ideally choose e.g. Young and Anderson (1982) and Eaton and Grossman (1985). In general, the answer depends on the specific form of uncertainty. Ad-valorem tariffs tend to be preferable over quotas and production subsidies. Thus, the policy instrument that we chose for our model seems to be potentially efficient.

2.5.3 Different Sources of Volatility

Our analysis limits volatility to production shocks to the agricultural sector. The uncertainty about the terms of trade is entirely driven by this production volatility. For the sake of the argument, we normalized production uncertainty in the manufacturing sector to zero. While it is a well known fact that agricultural output is more volatile than output in the manufacturing sector, it should be expected that there is indeed some volatility in the manufacturing sector.[31] If this volatility is different for different countries, there will be an additional dimension of *comparative volatility advantage*. While one country can have an *absolute volatility advantage* in the production of both goods, it will necessarily have a *comparative volatility disadvantage* in one of the two goods. The insurance motive for trade policy will then depend on whether or not a country has a *comparative volatility advantage* in the same sector where it has its comparative advantage or not. Intuitively, a country will want to diversify its production, if it specializes in the production of

[30] See Swinnen et al. (2012)

[31] Ngouana (2013) finds that output volatility is substantially higher in agriculture than in manufacturing. Still, the volatility in manufacturing is found to be significant and roughly twice as high as in the service sector.

the good of which it has a *comparative volatility disadvantage*.
Another worthwhile extension of this ideas is to see how the results change once one extends the model to more than two sectors. Trade policy will then be a complex function of comparative advantages and the risk structure of the world economy.
It would also be very interesting to extend the model to more than two countries to compare optimal bilateral trade policy for different trading partners. The conclusions that we can draw from our two-country model suggests that tariffs on agricultural products will be higher if the volatility level of the trading partner is higher. Indeed, this might be one explanation for why over the last decades tariffs imposed by developed countries on agricultural products from developing countries have increased, while they have shrunk for EU countries.[32]
As an additional source of volatility, as already investigated by Limão and Maggi (2013), one might want to investigate how, in addition to shocks to production, political volatility in the countries one is trading with might become a reason for domestic trade policy. If the uncertainty about the terms of trade is not only driven by the production shocks but also by the trade policy of the rest of the world, one would expect that countries are more protectionist if their trading partners have an unstable political environment.

2.6 Conclusion

Protectionism is still a prevalent phenomenon. Especially in certain sectors, notably in agriculture, political obstacles to trade remain substantial. The Doha negotiations, for instance, have underscored the difficulty of making progress in terms of liberalizing agricultural trade. In this paper we shed new light on trade policy by arguing that, in the presence of uncertainty, trade protection may actually improve a country's welfare, which is why there might be tacit support in many countries for protectionist measures, especially in agriculture.

In our analysis, trade policy is not solely a matter of the particulars of a country's comparative advantage, or of the power of its interest groups. In a setting with uncertainty due to domestic and international shocks, and with heterogeneous risk-preferences across consumers and firms, we show that competitive equilibria need not be socially optimal. In such a world, trade policy has a welfare-improving role to play, as it allows countries to reduce their exposure to domestic or terms of trade shocks. The particular stance that countries take will depend on the respective size and correlation of those shocks, and on their interaction with the countries' comparative advantage.

If — for clarity of exposition and in order to establish a reference point — we abstract from domestic shocks, then volatile terms of trade are the main (or only)

[32]Paiva (2005) finds that from 1990 to 2002, tariffs imposed by developed countries on agricultural exports of the least developed countries have increased from 3.3 percent to 6.6 percent. Over the same period, the tariffs that developed countries imposed on the agricultural exports of EU countries declined from 7.9 percent to 4.6 percent.

source of uncertainty. The analysis of this case is relatively straightforward. We can show that risk-averse consumers will unambiguously prefer a more diversified production pattern over the sectoral structure chosen by risk-neutral firms. A non-prohibitive tariff on agricultural imports can thus be used to increase consumers' — and hence society's — welfare, as it changes the market equilibrium towards a less specialized production point, and by reducing trade exposure reduces the uncertainty that consumers are avers to.

Allowing for both domestic as well as foreign shocks, our main analysis offers a novel perspective on trade policy that sees it as a direct function of the shocks (domestic and foreign) that a country is exposed to. In spite of the additional complexity, we are able to predict by relying on numerical analysis, what trade policy to expect from a country under different circumstances. Regardless of the dominant source of risk, net-exporters of agricultural products will enact policies that help them diversify their production pattern, since specialization in agriculture exposes them to both sources of risk, foreign as well as domestic shocks. By contrast, for countries with a comparative advantage in the manufacturing sector, the ideal policy depends on the dominant source of risk. If the comparative advantage in manufacturing is sufficiently large, and the relative domestic risk is low, the country will use tariffs on agricultural imports or other policies that will artificially increase the size of the local agricultural sector.

The insurance motive of trade policy is thus driven by two forces: It depends on a country's comparative advantage, and simultaneously on the *volatility advantage* of the country. If a country has a clear *volatility advantage* in the agricultural sector, meaning that domestic production shocks are smaller than in the foreign country, but at the same time a comparative advantage in the manufacturing good, it will specialize less in manufacturing than in an scenario without volatility. The *volatility advantage* of the country implies that it will be welfare improving to forego some of the comparative advantage and diversify production, thereby exploiting some of its *volatility advantage*.

In sum, our analysis of trade policy opens the door for empirical studies of agricultural trade policy as a reaction to a variety of shocks that countries face domestically or internationally, while explicitly taking into account the size of these shocks and their (international) correlation.

Appendix

2..1 Proof for $\frac{\partial^2 V}{\partial I \partial p} < 0$

With homothetic preferences, we can write $V(I,p)$ as $V = g(I)h(p)$. We know that $\frac{\partial V}{\partial I} = g'(I)h(p) > 0$. Taking the cross-derivative w.r.t. p we get

$$\frac{\partial^2 V}{\partial I \partial p} = g'(I)h'(p) \tag{2.50}$$

From Roy's Identity, we know that $-x_m = \frac{\frac{\partial V}{\partial p}}{\frac{\partial V}{\partial I}}$. Therefore, if consumption is strictly positive, we have that $\frac{\partial V}{\partial p} < 0 \Rightarrow h'(p) < 0$. Thus

$$g'(I)h'(p) < 0 \tag{2.51}$$

Q.E.D.

2..2 Proof for $\frac{\partial^2 I}{\partial K_i \partial p}(K_i^*) > 0$

$$I(K_i^*) = py_m(K_m^*) + y_a(K_m^*) \tag{2.52}$$

Since this is an optimal value function, we can use the enveloppe theorem to get

$$\frac{\partial I(K_m)}{\partial p} = y_m(K_m^*) \tag{2.53}$$

taking the derivative of this w.r.t. K_m gives

$$\frac{\partial^2 I(K_m)}{\partial p \partial K_m} = \frac{\partial y_a(K_m^*)}{\partial K_m} = \frac{\partial^2 I(K_m)}{\partial K_m \partial p} > 0 \tag{2.54}$$

Q.E.D.

2..3 Proof of Proposition 2

First we proof that the introduction of a tariff is beneficial

Proof. We take the derivative of the expected indirect utility w.r.t. to t.

$$\frac{d\mathbb{E}[V(.)]}{dt} = \mathbb{E}[\frac{\partial V}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial t} + \frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial K_m}\frac{\partial K_m^*}{\partial p}\frac{\partial p}{\partial t}]$$

Since K_m^* is fixed in the short run, we can draw it out of the expectation

$$\begin{aligned}
&= \mathbb{E}[\frac{\partial V}{\partial p}\frac{\partial p}{\partial t} + \frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial t} + \frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial p}\frac{\partial p}{\partial t}] + \frac{\partial K_m^*}{\partial p}\frac{\partial p}{\partial t}\mathbb{E}[\frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial K_m}] \\
&= \mathbb{E}[\frac{\partial V}{\partial \tilde{I}}\left(-d_m\frac{\partial p}{\partial t} + \frac{\partial \tilde{I}}{\partial t} + \frac{\partial \tilde{I}}{\partial p}\frac{\partial p}{\partial t}\right)] + \frac{\partial K_m^*}{\partial p}\frac{\partial p}{\partial t}\mathbb{E}[\frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial K_m}]
\end{aligned} \tag{2.55}$$

where d_m describes the domestic consumption of the industrial good. The last line follows from Roy's Identity.
A tariff decreases the relative price of the industrial good, by increasing the absolute price of the import good. The domestic price of the agricultural good still serves as the numeraire. Tariff revenue is redistributed to the consumer as a lump-sum transfer. The GDP after the introduction of the tariff is then written as

$$\tilde{I}|_t \equiv p(t)y_m + y_a + \frac{t}{1+t}M \tag{2.56}$$

where t is the tariff and M is the net import of the agricultural good. $\frac{t}{1+t}M$ describes the tariff revenue, evaluated at world market prices. A tariff changes the relative domestic price such that

$$p(t) = \frac{p_w}{1+t}, \qquad \frac{\partial p}{\partial t} = -\frac{p_w}{(1+t)^2} \tag{2.57}$$

Using $M = d_a - ya$, we can rewrite (2.56) as

$$\tilde{I}|_t = p(t)y_m + y_a + \frac{t}{1+t}(d_a - y_a) \tag{2.58}$$

We now take the partial derivative of (2.58) w.r.t. t.

$$\frac{\partial \tilde{I}|t}{\partial t} = \frac{1}{(1+t)^2}M + \frac{t}{1+t}\frac{\partial d_a}{\partial t} \tag{2.59}$$

Using the envelope theorem, we know that $\frac{\partial \tilde{I}|_t}{\partial p} = y_m + \frac{t}{1+t}\frac{\partial d_a}{\partial p}$. Using this, (2.57) and (2.59), equation (2.55) can be rewritten as

$$\begin{aligned}
\frac{dE[V(.)]}{dt} =& \mathbb{E}[\frac{\partial V}{\partial \tilde{I}|_t}\left(\frac{1}{(1+t)^2}(M - p_w X) - \frac{tp_w}{(1+t)^3}\frac{\partial d_a}{\partial p}\right)] \\
&- \frac{\partial K_m^*}{\partial p}\mathbb{E}[\frac{p_w}{(1+t)^2}\frac{\partial V}{\partial \tilde{I}|_t}\frac{\partial \tilde{I}|_t}{\partial K_m}]
\end{aligned} \tag{2.60}$$

where X is the net export of the industrial good. The balanced trade condition for the economy is

$$M - p(t)X \equiv 0 \tag{2.61}$$

With $p(t)|_{t=0} = p_w$ and $p(t) < p_w$ if $t > 0$, $M - p_w X$ must be negative for positive tariffs.
With p being the relative price of the industrial good, it follows that $\frac{\partial d_a}{\partial p} > 0$ for homothetic preferences. Thus, the first term of (2.60) is negative for positive t.
We have shown in Proposition 1 that the equilibrium capital allocation is too extreme for the consumers, if there is uncertainty concerning the terms of trade. Thus $E[\frac{\partial V}{\partial \tilde{I}|_t}\frac{\partial \tilde{I}|_t}{\partial K_m}] < 0$. We also know that $\frac{dK_m^*}{dp} > 0$.[33] Therefore we have

$$\begin{aligned}\frac{dE[V(.)]}{dt} =& \underbrace{\mathbb{E}[\frac{\partial V}{\partial \tilde{I}|_t}\left(\frac{1}{(1+t)^2}(M - p_w X) - \frac{tp_w}{(1+t)^3}\frac{\partial d_a}{\partial p}\right)]}_{\leq 0} \\ & - \underbrace{\frac{\partial K_m^*}{\partial p}}_{<0}\underbrace{\mathbb{E}[\frac{p_w}{(1+t)^2}\frac{\partial V}{\partial \tilde{I}|_t}\frac{\partial \tilde{I}|_t}{\partial K_m}]}_{\leq 0} \lesseqgtr 0\end{aligned} \tag{2.62}$$

Now we are going to show, that the introduction of a tariff has a beneficial effect for the consumers. In order to do so, we evaluate equation (2.62) at $t = 0$.

$$\frac{d\mathbb{E}[V(.)]}{dt}|_{t=0} = \underbrace{\mathbb{E}[\frac{\partial V}{\partial \tilde{I}}\frac{\partial \tilde{I}}{\partial K_m}]}_{<0 \quad for \quad K_m = K_m^*}\underbrace{\frac{\partial K_m^*}{\partial t}}_{<0} > 0 \tag{2.63}$$

We can thus conclude that some protection is superior to free trade.

□

2..4 Proof for $\frac{\partial K_m^*}{\partial p} > 0$

Proof. From the GDP maximization we have that

$$p\frac{\partial y_m}{\partial K_m} + \frac{\partial y_a}{\partial K_i} \stackrel{!}{=} 0 \tag{2.64}$$

taking the total derivative and using the enveloppe theorem, we get

$$\begin{aligned}&\frac{\partial y_m}{\partial K_m}dp + \left(p\frac{\partial^2 y_m}{\partial K_m^2} + \frac{\partial^2 y_a}{\partial K_m^2}\right)dK_m = o \\ \Rightarrow &\frac{dK_m^*}{dp} = \frac{-\frac{\partial y_m}{\partial K_m}}{p\frac{\partial^2 y_m}{\partial K_m^2} + \frac{\partial^2 y_a}{\partial K_m^2}} > 0\end{aligned} \tag{2.65}$$

With decreasing returns to scale, the denumerator is negative. □

[33] See A.4.

2..5 Proof of Proposition 3

Proof. A prohibitive tariff is such that $p = \frac{p_w}{(1+t)}$ equals the autarky price.

$$\frac{p_w}{(1+t)} = p_a \quad \Rightarrow \quad t = \frac{p_w - p_a}{p_a} \tag{2.66}$$

Under autarky, we do not have uncertainty about the terms of trade. The producers' FOC is thus

$$\frac{\partial \tilde{I}}{\partial K_m} \stackrel{!}{=} 0 \tag{2.67}$$

and the consumer's FOC becomes

$$\frac{\partial V}{\partial \tilde{I}} \frac{\partial \tilde{I}}{\partial K_m} \stackrel{!}{=} 0 \tag{2.68}$$

which leads to the same optimal K_m^*. Thus, the second term in (2.62) becomes zero. Equation (2.62)changes to

$$\frac{d\mathbb{E}[V(.)]}{dt}|_{t=\frac{p_w-p_a}{p_a}} = \mathbb{E}[\frac{\partial V}{\partial \tilde{I}|_t} \left(\frac{p_a^2}{p_w^2} \underbrace{(M - p_w X)}_{<0} - (p_w - p_a) \frac{p_a^2}{p_w^2} \underbrace{\frac{\partial d_a}{\partial p}}_{>0} \right)] < 0 \tag{2.69}$$

□

2..6 Uncertainty-Robust Price Normalization

Flemming et al. (1977) state that, if price uncertainty is not modeled as a geometric mean preserving spread, comparative static results will depend on the choice of the numeraire. Since we want to investigate how trade policy should react to situations where price uncertainty follows from asymmetric production shocks in several countries of different size, our form of price uncertainty cannot fulfill this requirement.

As Dierker and Grodal (1999) explain in their work, different price normalizations under uncertainty implicitly imply a different weighing of the states of the world. They argue that there is no wrong or right way to normalize, but there are ways that make more sense than others. Since we need to quantify how different shocks will influence the optimal allocations of the two different groups, we need to choose a normalization that leads to the same weights for both groups.

The problem with using the numeraire normalization is that the high relative price of the manufactured good in the *good* state of the world makes the producers put a large emphasis on this state of the world. This problem does not arise for the consumers (since they effectively care not about prices, but about actual consumption), which biases our comparison of the optimal allocations of both groups. The numeraire price normalization would thus, in addition to different risk preferences,

be effectively one driving factor for the difference in the optimal allocations, since it leads to a different weighting of states by different agents.

In order to assure that the differences between consumers and producers are only driven by differences in attitudes towards risk, we will thus choose a normalization that leads explicitly to the same weights for both groups.
We define an appropriate normalization as one, where producers and consumers give the same weight to the different states. Under such a normalization, a risk neutral producer will choose the same allocation as a social planner that wants to maximize the consumer's expected welfare.
The expected indirect utility of the representative consumer, without price normalization, can be expressed as

$$\mathbb{E}(V(I^c,p)) = \mathbb{E}[\left(\alpha^\alpha(1-\alpha)^{1-\alpha}(\frac{1}{p_m})^\alpha(\frac{1}{p_a})^{1-\alpha}I^c)\right)^\beta] \tag{2.70}$$

If the consumer is risk neutral, the expected indirect utility becomes

$$\mathbb{E}(V(I^c,p)) = \alpha^\alpha(1-\alpha)^{1-\alpha}\mathbb{E}[(\frac{1}{p_m})^\alpha(\frac{1}{p_a})^{1-\alpha}I^c] \tag{2.71}$$

Producer's profit maximizing behavior leads to GDP maximization. Therefore, a normalization that will result in the same optimal allocations for both groups is one for which the following holds.

$$\mathbb{E}(V(I^c,p)) = \alpha^\alpha(1-\alpha)^{1-\alpha}\mathbb{E}[I^c] \tag{2.72}$$

Under this normalization, the social planner will choose the allocation that maximizes expected GDP in order to maximize expected welfare. Thus, our normalization has to be such that

$$(\frac{1}{p_m})^\alpha(\frac{1}{p_a})^{1-\alpha} = 1 \quad \Leftrightarrow \quad p_m^\alpha p_a^{1-\alpha} = 1 \tag{2.73}$$

If we define $p_m/p_a = p$ as the relative price, we have to *weigh* each state of the world by $(1/p)^\alpha$ to get the desired normalization. Consider an example. With our old normalization we had that

$$I = py_m + y_a \tag{2.74}$$

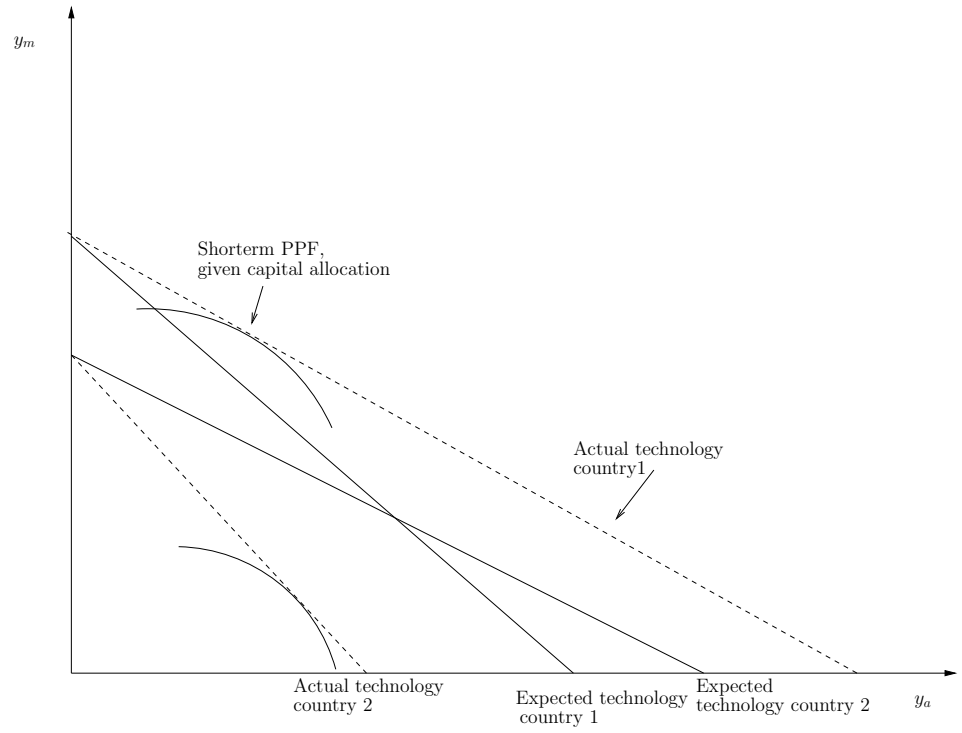
Now this changes to

$$I = p^{1-\alpha}y_m + (\frac{1}{p})^\alpha y_a \tag{2.75}$$

The relative price remains unchanged, but this normalization fulfills our requirements.

2..7 Comparative Advantage Reversal

Figure 2..3: Expected and actual comparative advantage



In figure (2..3) we show a situation in which the expected comparative advantage of the domestic country is in the manufacturing sector, whereas the actual comparative advantage after the production shocks in the agricultural sector have occurred is reversed (dotted lines).
Despite this, for equal prices in both countries, the domestic country will still produce relatively more of the manufactured good than the foreign country, because of the initial capital allocation. In the short run, each country can only choose a production point that is on the short-term PPF, the locus of which is determined by the capital allocation.
Since the preferences in both countries are assumed to be equal, the fact that the output of country 2 is relatively more specialized than in agriculture than country 1 implies that country 1 still is a net exporter of the manufacturing good, despite the comparative advantage reversal.

2..8 Influence of Rigidity on Trade Policy

In table (2..9) we investigate the effect that the amount of short term flexibility has on the optimal trade policy. We see that, as the share of capital in production decreases (i.e. γ) optimal trade policy moves closer to free trade. The insurance motive becomes weaker if the relative importance of labor in production increases.

Table 2..9: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different levels of rigidity

t	$\gamma = 1/7$	$\gamma = 2/7$	$\gamma = 4/7$	$\gamma = 6/7$
0	0.03	0.05	0.08	0.10
0.01	-0.02	0.01	0.04	0.06
0.015	-0.04	-0.02	0.02	0.04
0.02	-0.06	-0.04	-0.01	0.01
$r = 0$	$\varphi = 3$	$K_2 = 100,000$	$L_2 = 100,000$	$\alpha = 0.4$
$\sigma_1 = 0$	$\sigma_2 = 0.4$	$\delta = 0.6$	$\beta = 0.2$	

Note: Numbers printed on light-gray background denote situations where diversification improves expected welfare.

Since labor is perfectly mobile in the short run, a higher relative productivity of labor allows the producers to react to output and price shocks to a larger extent.

2..9 Influence of Risk Aversion on Trade Policy

Table 2..10: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different levels of risk aversion

t	$\beta = 1/7$	$\beta = 2/7$	$\beta = 4/7$	$\beta = 6/7$
0	0.07	0.12	0.31	0.46
0.01	0.03	0.05	0.01	-0.82
0.015	0.02	0.01	-0.14	-1.45
0.02	0	-0.02	-0.28	-2.08
$r = 0$	$\varphi = 3$	$K_2 = 100,000$	$L_2 = 100,000$	$\alpha = 0.4$
$\sigma_1 = 0$	$\sigma_2 = 0.4$	$\delta = 0.6$	$\gamma = 0.6$	

Note: Numbers printed on light-gray background denote situations where more diversification improves expected welfare.

In table(2..10) we investigate the influence of risk-aversion on the resulting trade-policy. We can see that, even though a higher β leads to a bigger reaction to to deviations from the desired equilibrium in both directions, it will unambiguously lead to a trade policy that is closer to free trade. As β becomes smaller, the consumers will have more incentives to demand "insurance" against the risks of the free-trade equilibrium. We can thus conclude that trade policy will be more interventionist, when the difference in risk-preferences between consumers and producers is more pronounced.

2..10 Influence of Relative Country Size on Trade Policy

Table 2..11: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different endowment levels

t	$K_1, L_1 = 100$	$K_1, L_1 = 1000$	$K_1, L_1 = 10,000$	$K_1, L_1 = 50,000$
0	0.03	0.03	0.01	-0.02
0.01	0	-0.01	-0.05	-0.09
0.015	-0.02	-0.03	-0.08	-0.12
0.02	-0.04	-0.06	-0.10	-0.16
$r = 0$	$\varphi = 3$	$\beta = 0.2$	$\alpha = 0.4$	
$\sigma_1 = 0.3$	$\sigma_2 = 0.3$	$\delta = 0.6$	$\gamma = 0.6$	

Note: Numbers printed on light-gray background denote situations where more diversification improves expected welfare.

Table (2..11) depicts a situation with equal levels of volatility in both countries, where the *diversification* and the *domestic risk* motive for trade policy are more or less balanced in the small-country case. As the size (i.e. endowment) of the domestic country increases, the *domestic risk* motive for trade policy becomes relatively more important, leading to a situation in which trade policy should favor the production of the net-exported good. This is the case, because the influence of the foreign shock on the terms of trade becomes less direct, if the market power (i.e. its relative size) of the foreign country becomes smaller. The pass through of the domestic shock is then a lot more direct than that of the foreign shock, which makes the *diversification* motive for trade policy less important.

2..11 Influence of Risk-Correlation on Trade Policy

Table (2..12) depicts the influence of a change in the correlation between foreign and domestic shocks on the trade policy of a country that has a strong comparative advantage in the manufacturing sector. As stated before, correlation does not play a very big role in such a case, because the optimal trade policy is rather similar for symmetric and asymmetric cases. This changes for countries that have a comparative advantage in the agricultural sector.

Table (2..13) shows how correlation influences the trade policy of a net exporter of the agricultural good. We depict the change in utility to the introduction of a negative tariff on the agricultural good, which corresponds to a positive tariff on the manufactured good. Here, the influence of correlation is much stronger. Negative correlation makes the asymmetric states more likely. Since in these states, the spread between incomes is very high (*lh* is the worst outcome, whereas *hl* is the best) and the optimal reaction in the worst state is clearly to produce more of

Table 2..12: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different correlations, $\varphi = 3$

t	$r = -0.8$	$r = -0.2$	$r = 0.2$	$r = 0.8$
0	0.05	0.04	0.02	0.01
0.01	0.01	-0.01	-0.02	-0.03
0.015	-0.01	-0.03	-0.04	-0.06
0.02	-0.04	-0.05	-0.06	-0.08
$\varphi = 3$	$\beta = 0.2$	$\alpha = 0.4$	$K_1 = 1000$	$L_1 = 1000$
$\sigma_1 = 0.3$	$\sigma_2 = 0.3$	$\delta = 0.6$	$\gamma = 0.6$	

Note: Numbers printed on light-gray background denote situations where more diversification improves expected welfare.

Table 2..13: $\frac{\partial \mathbb{E}[V]}{\partial t}$ for different correlations, $\varphi = 0.5$

t	$r = -0.8$	$r = -0.2$	$r = 0.2$	$r = 0.8$
0	-0.15	-0.10	-0.07	-0.02
-0.01	-0.11	-0.07	-0.03	0.02
-0.02	-0.08	-0.03	0.01	0.06
-0.03	-0.04	0.01	0.04	0.10
$\varphi = 3$	$\beta = 0.2$	$\alpha = 0.4$	$K_1 = 1000$	$L_1 = 1000$
$\sigma_1 = 0.3$	$\sigma_2 = 0.3$	$\delta = 0.6$	$\gamma = 0.6$	

Note: Numbers printed in dark-gray on light-gray background denote situations where a more liberal trade policy improves expected welfare.

the manufactured good, a negative correlation implies that the country will want to impose a stronger tariff on manufactured goods, when correlation is low.

3 Migration Experience, Aspirations and the Brain Drain: Theory and Empirical Evidence[1]

3.1 Introduction

The question of whether or not emigration of skilled citizens is a curse or a blessing for developing countries has been of great concern in the recent past. Whereas previous contributions like Bhagwati and Hamada (1974) identified the brain drain as one of the primary reasons for poverty and lacking growth in countries of the global south, more recent articles show that the picture is not as bleak as previously imagined.[2] Various studies such as Mountford (1997), Beine et al. (2001) and Stark (2004) have made the argument that the possibility to migrate to a richer country, where one can earn considerably higher wages, given the necessary skills, will serve as an incentive to invest in education. With this additional stimulus, it can be shown that emigration can actually increase the average skill level of the remaining population.

In this article, we demonstrate that the influence which emigration has on the inhabitants of the sending country goes beyond a change in the expected skill premium. We find that in addition to economic incentives, aspirations increase considerably as a result of emigration. Our research aims at establishing a connection between the literature on aspirations formation and the more recent brain drain models. The concept of aspirations is currently attracting a growing interest in the economic literature. They are defined as a quality of individuals who pursue a certain goal with conviction. This capacity is usually thought to form as a result of interactions with one's immediate social environment.[3] However, in an environment that is strongly segregated, the poor might not develop sufficient aspirations, because they lack positive role models. Several articles identify such an *aspirations failure* as one possible reason for underinvestment in education in developing countries. Ray (2006), Dalton et al. (2011) and Bernard et al. (2011) all stress the importance of raising aspirations in order to fight persisting poverty. While the importance of aspirations is thus acknowledged, there is discontent on how to raise them. We claim that one possible channel to overcome *aspirations failure* is

[1] This chapter is based on coauthored work, see Böhme and Glaser (2014)
[2] For an extensive survey of the literature see Commander et al. (2004)
[3] See Appadurai (2004)

migration.

We show that aspirations increase as a result of emigration, and that this effect reduces the net brain drain. Since emigration exposes the migrant to a new social environment and increases the sample of potential role models, it is intuitive that aspirations should rise as a result of a migration experience.[4]
In the empirical part we use panel data from Indonesia to show that a migration experience has a beneficial effect on the aspirations of individuals. Our identification strategy allows us to interpret this increase in aspirations as a causal treatment effect. The aspirations of migrants are found to increase considerably more than that of non-migrants.
This finding motivates the second part of this paper in which we present a theoretical model of human capital formation and migration that explicitly accounts for the aspirations increasing effect of migration. We establish that it is not only inherent ability, but also psychosocial capacities that shape an individual's education decision. As demonstrated by Beaman et al. (2012), raising aspirations goes hand in hand with a rise in educational investment of parents and time devoted to education of their children.

All the existing brain drain literature that we are aware of assumes that individuals differ in their ability, and that this exogenously given one-dimensional variable is the only source of heterogeneity. We add to this by introducing an intergenerational externality on the household level to a theoretical model of a brain drain. In our model, it is no longer only the aggregate probability to emigrate that determines the education decision of an individual, but also the household's migration history. As shown in the empirical part, the psychosocial capacities of an individual are typically not inherent, but evolve as a result of experience and social interactions. A migration experience will therefore lead to a revision of the migrant's prior aspirations. The subsequent rise in aspirations lowers the perceived intertemporal discount rate for the migrant and thus increase the aggregate investment in education.
We find that introducing aspirations as a variable that increases the weight that someone places on future earnings increases the positive influence that migration has on skill formation. There are two reasons for this. First, the higher aspirations magnify the original incentive effect of migration. The expected skill premium that a higher migration rate implies will be larger for aspiring individuals, since they value future earnings more than non-aspiring people. Second, a higher steady state migration rate means that it is more likely to have a parent who has a migration experience. Thereby, a higher migration rate will increase the average aspirations level in the society, and hence, the average investment in education. Taken together,

[4] Czaika and Vothknecht (2012) find that migrants are in general more aspiring at the time they choose to leave their home, and that migration serves as a tool to fulfill their aspirations. We exploit the panel structure of our data to control for this effect.

these two effects lead to a higher optimal migration rate for every country. Furthermore, they increase the autarky equivalent migration rate. Below this benchmark, allowing for migration will lead to a higher average skill-level than under autarky. This implies that the *aspirations effect* increases the range of migration rates for which a country will have a net brain-gain. Our results suggest that omitting the intergenerational household effect of emigration in empirical studies on the effect of skilled migration on the skill level of sending countries will overstate the negative effect of emigration. Beine et al. (2008) study which countries win and loose from emigration. We show that, depending on the size of the aspirations effect, some countries that were found to be net losers of emigration could potentially be winners.

The remainder of this paper is structured as follows. In section 2 we give a short overview about aspirations and their influence on economic behavior. In section 3 we give empirical evidence on the influence that a migration experience has on aspirations. In section 4 we present a theoretical model that investigates the implications of aspirations for the brain drain. In section 5 we use our empirical estimates to simulate the quantitative importance of aspirations in our brain drain model. In section 6 we conclude.

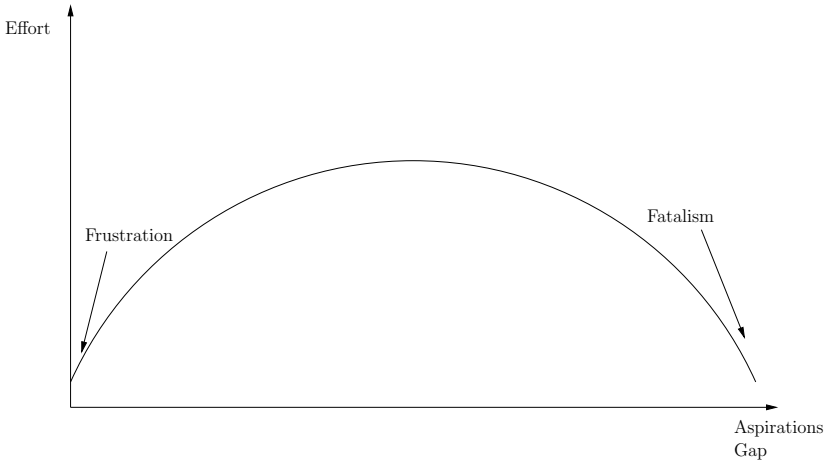
3.2 The Aspirations Concept

An aspiring individual is someone who has a certain goal or dream that she is pursuing with conviction. The notion of aspirations as a social capacity is still rather new to economics. Appadurai (2004) argues that aspirations do not form in a void, but that the contact and interaction with our peers is essential for the formation of aspirations. An individual will aspire to a level of wealth, education or social norms that she is confronted with in her immediate environment. The more diverse this social environment, the more likely it is that someone will find a desirable and attainable goal to aspire to. Appadurai points out that in cultures of absolute poverty, individuals will lack this *capacity to aspire*. The point he is making is that if all the peers of a poor individual are equally bad off, than she will not form the capacity to imagine herself better off.

Ray (2006) develops this idea further and investigates the economic implications of such a *culture of poverty* in which the poor will accept their destiny. He develops the concept of an *aspirations window*, which is composed of the people that influence an individual's aspirations. Usually these are the closest peers, such as family members, friends and even neighbors. If this window is solely composed of other economically and socially disadvantaged people, an individual will be unaspiring because of her unawareness of the possibility of social and economic ascension. Ray (2006) proposes that someone who is aspiring towards a better, attainable life will put a certain amount of effort into the realization of this goal, whereas someone who

is unaspiring will not. It is important that the *aspirations gap*, the distance between where an individual sees herself currently and the goal she is aspiring to, must be of a reasonable size, in order to affect her behavior. A gap that is too small, as in poor or segregated societies, will lead to frustration, since there is no goal worth pursuing. A gap that is larger than what is reasonably attainable is also unlikely to affect an individual's behavior, since she will get fatalistic at the prospect of never being able to attain her goal. Figure 3.1 illustrates this relationship.

Figure 3.1: Aspirations gap and corresponding effort; inspired by Ray (2006)



Ray (2006) further argues that this *aspirations failure* in poor societies can be the cause for a self-sustaining poverty trap. The poor will not save or invest in education, because the improvement in their lives that this could bring about is not considered as an option. Bernard et al. (2011) state that aspirations in themselves are future-oriented, meaning that they are not about the satisfaction of immediate needs, but rather about the achievement of a long-term goal. Furthermore, they are seen as motivators. If an individual is aspiring to a certain goal, she is willing to spend time and money on the realization of this goal. In poor societies, the aggregate lack of aspirations will then lead to a behavior that is not concerned with the pursuit of a better life, but the fulfillment of instant needs, and can thus for example be associated with a lack of human capital, which in turn will be detrimental to growth. There is strong empirical and experimental evidence that a lack of aspirations will indeed lead to a less future oriented behavior. See for example Wilson and Boldizar (1990), Schoon and Parsons (2002), Page et al. (2007), and Bernard et al. (2011) .

Several authors have recently proposed models which formalize how *aspirations failure* arise and how they influence skill acquisition. In Mookherjee et al. (2010), parental aspirations form with respect to the economic status of their neighbors. They show that in such a setting, segregated societies can arise, where some neigh-

borhoods invest much more in education than others. In Dalton et al. (2011) aspirations are shaped by one's past successes and failures. Since the poor face greater downside risk, they will be less likely to put effort into the pursuit of a goal than the rich. This results in a situation where the poor achieve less than the rich, which confirms their initial behavior and lowers their aspirations. This will then lead to self-sustaining poverty traps, where poor individuals exert less effort because of their acquired low aspirations. The authors argue that policy needs to tackle the belief and aspirations formation of the poor to be successful in fighting persisting poverty.

The points made by Ray (2006), Mookherjee et al. (2010) and Dalton et al. (2011) have been taken up by a number of recent empirical studies who aim at finding ways to increase aspirations of the poor. Exposing poor individuals to successful role models from a similar social background is such a mechanism that is found to have the desired effect. Macours and Vakis (2008) find that the responsiveness to an asset transfer program would increase if the test subjects were exposed to a female leader that also participated in that program. They argue that the proximity to the female leaders increases the aspirations of the test subjects, which in turn increases their investment and human skill accumulation.
Another analysis looking at the importance of role models has been undertaken by Chiapa et al. (2012). The authors studied participants in a Mexican anti-poverty program and reported higher educational aspirations for children that came into personal contact with professional medical staff such as doctors and nurses. This suggests that the children include this highly-trained personnel in their aspirations window.

A different approach that can be found in the literature is the enrollment of individuals in interventions that are designed to raise their self-efficacy. Krishnan and Krutikova (2010) evaluate a program that was specifically designed to foster the psychosocial skills of disadvantaged children in the slums of Bombay. In the course of the program, participating children are enrolled in activities that are meant to boost their non-cognitive abilities. The study finds that aspirations, as well as self-efficacy and self-esteem, grow significantly as a result of the intervention. Similarly, Wydick et al. (2013) investigate the effects of international child-sponsorship programs on the schooling outcomes and job-prospects of the sponsored individuals. They find that the long-term enrollment and participation in such a program has a significantly positive effect on children's aspirations, by exposing them to an encouraging and optimistic environment. It is then shown that this increase in aspirations improves their educational attainment.

Beaman et al. (2012) find that a law that was introduced in India, which randomly assigned female leaders to several village councils, resulted in a significant increase in educational aspirations of parents for their daughters in the treated vil-

lages. The treatment leads to a 25% reduction in the gender gap in aspirations of the parents. The effect is even bigger for the adolescents themselves, with a 32% reduction in the gender gap. At the same time it was found that this increase in aspirations is paralleled by an increase in educational attainment of girls.
Bernard et al. (2014) run a randomized experiment, in which they show a motivational video to inhabitants of poor villages in Ethiopia. This video shows success stories of previously poor individuals, who have all managed to greatly improve their lives by showing perseverance, reliability and determination. They find that subjects that saw the video experience a significantly higher increase in their aspirations, compared to a control group that watches a placebo video. Six months after the video intervention, they find that actual behavior has also changed for the test subjects. Their children's school enrollment and savings behavior has increased significantly. Furthermore, there seem to be spillover effects on other villagers that haven't seen the video, but have heard about it from their peers.

This literature shows that increasing aspirations is vital in order to help the poor to overcome their condition. We identify an additional channel through which *aspirations failure* can be overcome: migration. It has been pointed out in several articles, that migration influences cultural values and norms, both of migrants themselves and of their family in the source country.[5] There are two main reasons why migration is likely to have a positive influence on the migrant's aspirations. First, migration allows an individual to broaden her horizon and to meet new people. This is equivalent to a widening of the *aspirations window*. The more people an individual knows, the more likely she is to know someone who has a lifestyle that she considers worth aspiring to. Migration thus serves as an increase in the sample of potential role models. Second, migrants usually move to a destination that is wealthier than their place of origin and often differs substantially in culture and norms. This means that the migrant will be surrounded by individuals who have a lifestyle that is different from and probably more luxurious than the one of her domestic peers. The migrant will then aspire to these new social and economic norms that she discovers while being abroad. In the following section we show empirical evidence that migration increases the aspirations of migrants.

[5]Spilimbergo (2009) demonstrates that democratic values are adopted by migrants and then promoted in their home countries upon their return. Beine et al. (2013) show that birthrates of source countries will adapt as a result of migration flows to destinations with different fertility norms. Interestingly, this adaption does not require return migration, which suggests that strong cultural links between the migrants and their home country persist. Migration is also found to have an impact on political aspirations. Lodigiani and Salomone (2012) find that political participation of women in sending countries increases as a result of migration streams to countries that have a greater female political empowerment.

3.3 Empirical Foundation

In this part, we demonstrate that migration has a sizable effect on the aspirations of migrants. The empirical literature on this subject remains scarce and does not provide any suggestions with respect to the magnitude or overall importance of the aspirations effect of a migration experience. The main problem is the limited data availability since only few datasets include questions on aspirations and migration at the same time. Using data from Mexico, Kandel and Kao (2001) find that the extent of migration in a student's household has a negative effect on students' aspirations but increases educational attainment. Böhme (2012) finds a beneficial effect of migration on the parental aspirations for Moldavian households. Both studies use cross-sectional data, which makes it difficult to clearly identify the effect of a migration experience on aspirations.[6]
For our estimation, we use panel data from the Indonesian Family Live Survey (IFLS). This survey constitutes an exception, since it includes questions on aspirations and tracks individuals over time. Czaika and Vothknecht (2014) use the IFLS and discover a significant correlation between migration and the aspirations gap. Their analysis offers interesting insights but does not fully exploit the potential of the dataset. We extend their analysis by focusing on the problem of endogeneity to come closer to a causal interpretation of the association between migration and aspirations. Making full use of the panel structure of the data we overcome time invariant unobservable characteristics of individuals by emphasizing the importance of fixed effects and difference in difference estimations. Our results suggest that the migration experience of an individual is positively associated with an upward shift in aspirations. This empirical exercise and the resulting coefficients allow us to quantitatively estimate the influence that migration has on the aspirations of an individual.

3.3.1 Data and Descriptive Statistics

The IFLS is a panel household survey that is representative of around 80% of the Indonesian population.[7] Since the questions that are relevant in order to measure aspirations have only been introduced recently to the survey, we limit our analysis to the third and fourth wave (compiled in 2000 and 2007). The survey keeps track of the internal migration of all household members aged 15 years or more. There are only few recorded incidents of international migration. However, this should not pose a problem since internal migration does expose the migrant to a new socioeconomic environment as does international migration. The intensity of the effect will most likely depend on the sociocultural difference between origin and destination. In both cases the migrant will revise her own goals and ambitions. It is reasonable to assume that the sociocultural gap will be even larger for international migration.

[6] As shown by Czaika and Vothknecht (2014), the aspirations of migrants are already likely to be different from those of non-migrants prior to migrations.

[7] See Strauss et al. (2009)

Therefore, if we find that internal migration has a significant effect on aspirations, the relation should also hold for international migration and might even be stronger.

The survey captures the migration experience in the last observation period of individuals, only if they had lived in a different village for more than 6 months. In order to be able to identify the impact of migration we also narrowed our analysis down to individuals who did not migrate before 2000. This provides us with a sample of 12,092 individuals present in each wave who where between 15 and 80 years old in 2000 (table 3.1). Although there are only few instances where this is relevant, we decided to keep only migrants who moved for reasons related to labor or education, i.e. we exclude marriage induced migration and whole household migration. Based on these adjustments, the national migration prevalence in our sub-sample stands at around 16 % in 2007. Migrants are on average 33 years old compared to non-migrant who were on average 45 years old (not reported in table 3.1). About one in five migrants has a higher education degree and 95% of them can write Indonesian. This is quite different from non-migrants where only 78% of all individuals can read and only 7% hold a higher education degree.

Aspirations can be measured in several ways, since the concept can be cultural or socio-economic. A question concerning the desired years of schooling for an individual's offspring is a type of aspirations measure, as is the commitment to a certain saving behavior.[8] The IFLS provides us with a set of questions that allow us to construct a measure for the economic aspirations gap. Participants were asked to assess their subjective current economic well-being, relative to the rest of society, on a 6 step ladder.

> *Please imagine a six-step ladder where on the bottom (the first step), stand the poorest people, and on the highest step (the sixth step), stand the richest people.*
> *On which step are you today ?*

They were also asked where on this ladder they see themselves in the near future.

> *On which step do you expect to be in one/five years from now?*

This forward looking evaluation of the respondents' future is equivalent with what is generally considered as aspirations. The simple difference between the forward looking evaluation and the assessment of her current situation is the aspirations gap our analysis focuses on.[9]

table 3.1 shows the average current well-being, aspirations and aspirations gap for all individuals in both years. In 2007 migrants had a higher aspirations gap

[8] See Copestake and Camfield (2010) for a discussion of the multidimensional nature of aspirations gaps and different strategies of measuring them.

[9] We also used ratios of aspirations and current situation assessment of individuals as a measure for the aspirations gap and came largely to the same qualitative conclusions.

Table 3.1: Descriptive statistics for both waves

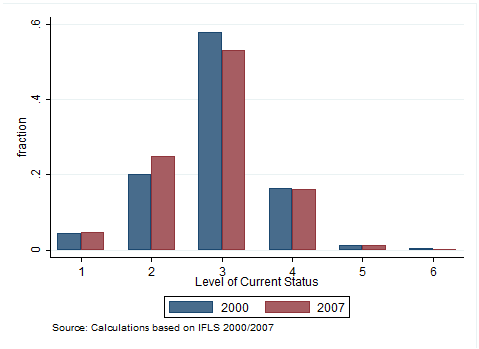
	2000		2007	
	Mean	Std Dev.	Mean	Std Dev.
Individual characteristics				
Age	35.43	14.54	42.75	14.49
Gender (male=1)	0.45	0.50	0.45	0.50
Married (yes=1)	0.67	0.47	0.76	0.42
Household head (yes=1)	0.32	0.46	0.44	0.50
Education & household size				
No education	0.12	0.32	0.11	0.32
Years of education	7.62	3.92	7.82	4.04
Household size	7.57	3.6	7.96	3.42
Migration and aspirations				
Migration prevalence	-	-	0.16	0.37
Current wellbeing	2.91	0.78	2.85	0.80
Aspirations	3.24	0.91	3.47	1
Aspirations gap	0.34	0.61	0.62	0.75
Observations	12,092		12,092	

(0.79) than non-migrants (0.59). This is not driven by the assessment of current well-being which is 2.91 and 2.84 for migrants and non-migrants respectively (not reported).

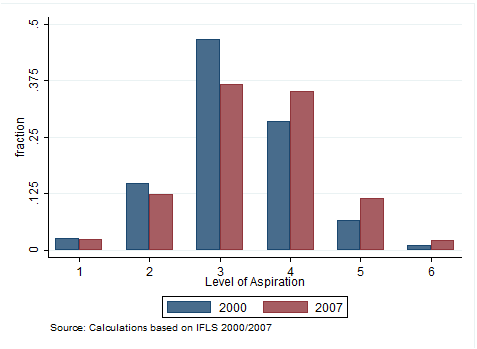
It must be noted that between 2000 and 2007 a small adjustment of the aspirations question was undertaken. The authors of the IFLS changed the time horizon of the aspirations from one year to five years. This modification of the question is unfortunate for comparisons in the level of the aspirations gap. It can be seen that there is an increase in the mean aspirations gap for both groups from 2000 to 2007 for which the change in the time horizon is a probable explanation. The change in the question does not affect the distribution of the evaluation of the current economic well-being of individuals (see graph 3.2a) but does shift the distribution as expected in the forward looking evaluation (see graph 3.2b). For our purposes this does not pose a problem, since the fixed effects estimation that we perform measures the difference in the change in the aspirations gap, not the level. The adjustment of the question would only be problematic if migrants understood the question differently than non-migrants, i.e. they processed the changed horizon of the question systematically different. There is no reason to believe that such a

Figure 3.1: Distributions

(a) Distribution of current well-being



(b) Distribution of aspirations



systematic bias exists.

3.3.2 Estimation Approach

We explore the influence of migration on aspirations both at the individual as well as at the household level. Our standard estimation equation looks as follows:

$$A_{ijt} = \alpha + \beta_1 M_{ijt} + \beta_2 C_{ijt} + \varepsilon_{ijt} \tag{3.1}$$

where A_{ijt} is the aspirations gap of individual i, in household j at time t. M_{ijt} is a binary migration indicator and C_{ijt} is a vector of observable individual characteristics such as age, gender and education but also the assessment of the current well-being. We include the latter to control for possible level effects. We first approach the data with simple OLS to explore the basic relationship between aspirations and migration. The central problem in this setup is the endogeneity of migration. More precisely, unobserved characteristics of the individual might be driving both her aspirations gap as well as her decision to emigrate. We have the big advantage to be able to control for unobserved fixed characteristics by using fixed effects estimation based on the two waves of the IFLS. The fixed effects estimation helps us to come closer to a causal interpretation of the relation between migration and aspirations. This is important since the correlation between migration and aspirations could go in both directions. More aspiring individuals are forward looking and are ready to act in order to shape their own future. Migration is one way to achieve this. Therefore, migrants are likely to have higher aspirations at the time they decide to emigrate. To be able to isolate the effects of migration we limit our analysis to households that had no migrants before 2000.

In the fixed effects setup the identification of the effect of migration on aspirations is based on the inter-temporal variation of both the aspirations gap and the migration behavior of individuals. Equation (3.1) is therefore reduced to:

$$\Delta A_{ij} = b + \Delta M_{ij} + \Delta e_{ij} \tag{3.2}$$

This approach controls for both effects that are common to all groups between the two periods and time invariant individual characteristics. It therefore addresses the unobserved characteristics of individuals that could affect both the decision to migrate and the change in aspirations which is the main concern of identification. It is reasonable to expect that in the context of Indonesia the distribution of households with specific characteristics is partly exogenous. This is due to the government initiated Transmigration program that has been in place in Indonesia since 1902.[10] One of the main goals of the program was to populate uninhabited regions of Indonesia and to counterbalance the increasing urbanization. Within the Transmigration program that moved more than a quarter of a million people per year, a random element can be found. The program provided free farm land and housing in the periphery of Indonesia, as well as free transport and free food and fertilizer for the first year. But most importantly, the free farm land was allocated by lot.[11] This implies that the productivity and quality of farmland was independent of the families' characteristics. Households might have opted into the Transmigration program without knowing the economic benefit this decision would provide. Consequently some households could be considered randomly distributed.

This particularity of Indonesia can however not entirely remove the doubt about the causal effect of migration on aspirations since there is still a chance that unobservable variable factors influence both the dependent and the independent variable at the same time. We therefore also employ an instrumented variable strategy and propensity score matching to evaluate our fixed effects results. The instruments we use to identify the effect of migration on aspirations are the gender distribution and birth order of siblings within households. Our identifying assumption is that geographic mobility will strongly depend on the composition of households but the gender composition of siblings and the position in the birth order should not have significant effects on the change in aspirations. Rainer and Siedler (2009), for example, document that due to intergenerational responsibilities at least one adult child will remain geographically close to take care of the elderly. The same pattern has been documented by Abramitzky et al. (2013). They also point out that birth order could be an extremely important factor for individual migration. We build the birth order based on the first period of observation (2000). It is therefore time invariant and will drop in the fixed effects estimation. However, the share of male siblings in the household that have reached working age (+15) varies over time. We keep the effect of being the first born by interacting the share of male siblings and the first born dummy. Hence our identification will run through the change of the share of male siblings in the household and its interaction with the first born

[10] See Hugo (2006)
[11] See Kebschull (1986)

dummy for each individual. The validity of our instruments rests on the exclusion restriction that siblings do not differ systematically with regard to their propensity to migrate except with respect to their quasi-random birth order.

The first stage of our instrumented fixed effects estimation shows clearly that an increase in the share of male siblings reaching working age is having a negative impact on the likelihood to migrate. However being the firstborn changes the picture entirely. The oldest sibling is significantly more likely to migrate due to an increase in the share of male siblings. All covariates included in the estimation predict migration in the first-stage as found in other studies. For example, we observe an increased probability to migrate of individuals in larger households and of individuals with a higher education. With respect to the statistical strength of the instruments we conduct various tests. First, the first stage F-Test is slightly below the critical value of 19.93 for a 10% bias but above the value of 11.59 for a 15% bias of the instrumented estimator as proposed by Stock and Yogo (2005). This suggests that our instruments are reasonably strong.

Another common approach to evaluate the unconfoundedness of the two comparison groups is propensity score matching. Although we are controlling for a number of covariates in all estimations this does not ensure that the linearity assumption of the comparison is satisfied. More precisely, if migration depends strongly on the covariates and if the average value of the covariates is quite different between the two groups, we should not compare migrants and non-migrants. To address this issue we follow Heckman et al. (1998) and build a comparable synthetic control group based on a nonparametrically derived propensity score estimate.

3.3.3 Results

In table 3.2 we present the benchmark regression results. The standard OLS displayed in rows one and two shows positive but only borderline significant coefficients for the migration dummy. The coefficient size roughly reflects the findings reported by Czaika and Vothknecht (2014). This suggests that in the cross-section there is a significantly positive correlation between the aspirations gap and migration. Looking at the included covariates we observe that the aspirations gap decreases with age and that gender does not seem to play a significant role. We also observe that married individuals display a significantly more positive outlook than unmarried individuals, and that education and skills represented by the years of education and the ability to read are positively correlated with the aspirations gap.

In a second step we look at between effects, random effects, and finally fixed effects regressions, exploiting the full potential of the panel dataset at hand. A Hausman Test suggests a systematic bias in the random effects model and leads to the conclusion that the fixed effects model is suited best to answer our research

question. It is interesting to observe that only marital status and education seem to have a statistically significant impact on the aspirations gap independently of the econometric specification. The last row of table 3.2 contains our preferred estimation specification. It is clearly observable that a migration experience has a considerable (and highly significant) effect on the aspirations gap. If the average migrant had chosen not to migrate prior to 2007, her aspirations gap would have been 0.086 units lower. Under the assumption of parallel trends the aspiration gap is roughly 12% higher than it would have been in the absence of migration. Hence, the effect is also economically significant.

Table 3.2: *Benchmark regressions aspirations gap*

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	BE	RE	FE	FE
Variables	2007	2007			(no trend)	(with trend)
Migration	0.0322	0.0381*	0.0541**	0.0811***	0.0850***	0.0863***
Current Wellbeing	-0.2062***	-0.2182***	-0.1541***	-0.1894***	-0.2352***	-0.2348***
Age	-0.0094***	-0.0084***	-0.0059***	-0.0059***	0.0338***	-0.0097
Gender (male=1)	0.0109	0.0150	-0.0301	-0.0267	/	/
Married (yes=1)	0.0266	0.0357*	0.0309*	0.0546***	0.0923***	0.0958***
HH Head (yes=1)	-0.0731***	-0.0665***	-0.0474**	-0.0264*	0.0063	0.0076
Years of Education	0.0202***	0.0239***	0.0187***	0.0200***	0.0161***	0.0158***
Reads Indonesian	0.0491**	0.0604***	0.0426**	0.0481***	0.0617*	0.0619*
HH Size	0.0018	0.0026	0.0017	0.0027**	0.0150**	0.0154**
Province fixed effects	No	Yes	Yes	Yes	/	/
Observations	12,092	12,092	24,184	24,184	24,184	24,184
R-squared	0.11	0.14	0.13	/	0.15	0.15
Number of individuals	/	/	12,092	12,092	12,092	12,092

Notes: Authors calculation based IFLS3 and IFLS4;
Dependent variable is aspirations gap. Includes interaction between Married and Gender.

Robust standard errors in parentheses; $^{***}p < 0.01$,** $p < 0.05$,* $p < 0.1$; Standard errors clustered at the household level.

One might argue that the change in aspirations that a migration experience induces is simply driven by a migration induced increase in income. To address such concerns about the importance of changes in income vis-a-vis the exposure to a new environment, we also included income and a wealth index based on a principal component analysis (PCA). The results in columns 1 and 2 of table 3.3 show only a slight decrease of the strength of the migration effect. As a second robustness check we split the sample into households with a more than median increase and less than median increase in income between 2000 and 2007. The results displayed in columns 3 and 4 do not change the picture. Both these robustness checks suggest that income is not the driver of the observed effects.[12]
We also evaluated the assumption of common trends by using random assignment of the migration status to non-migrants. Using this randomly assigned dummy we should not observe an effect that is different from zero if our difference in difference estimates are unbiased. Obviously for this estimation true migrants were excluded, which reduces the sample size. We report the result of these tests in column 5 of table 3.3 . Independent of the stratification used for the random assignment we find no effect that suggests any problems with the assumption of parallel trends.

Table 3.3: *Fixed Effects – Robustness Tests*

	(1)	(2)	(3)	(4)	(5)
	Including wealth (PCA)	Including log income	Low change in Income	High change in income	Random placebo assignment
Migration	0.0715***	0.0829***	0.0903**	0.0793**	0.0011
Observations	23,971	23,971	11,766	11,994	20,330

Note: Authors calculation based IFLS3 and IFLS4. Estimation setup is the same as in the benchmark; Regressions include all controls reported in the baseline estimates shown in table 2; Standard errors clustered at the household level;
Robust standard errors in parentheses; $^{***}p < 0.01,^{**}p < 0.05,^{*}p < 0.1$.

In order to control whether the aspirations effect differs by origin, we ran all estimations separately for migrants from rural and urban areas. Assuming that economically more dynamic destinations attract more migrants, individuals will typically leave for urban destinations. For migrants from rural areas, migration thus implies a greater change in their cultural and social environment. Migrants

[12] A similar concern might be, that migration can be seen as an investment, and that migrants have higher aspirations simply because they expect this investment to pay off. However, in our data we only capture temporary migration.

from urban areas are less likely to experience a severe change in their cultural and social environment if they move. According to our theory, the drastic change in cultural norms that the rural-born migrants experience should result in a stronger revision of their prior aspirations, and thus in a higher increase of their aspirations gap. Our estimations show that this is indeed the case. The fixed effects estimate displayed in columns 1 and 2 of table 3.4 increases drastically for the rural sample and remains statistically highly signifcant whereas urban migrants do not seem to experience this effect.

Table 3.4: *Fixed Effects – Urban and Rural Origin*

	(1)	(2)
	Rural	Urban
Migration	0.1365***	0.0551
Observations	13,102	11,082

Note: Authors calculation based IFLS3 and IFLS4. Estimation setup is the same as in the benchmark; Regressions include all controls reported in the baseline estimates shown in table 2; Standard errors clustered at the household level; Robust standard errors in parentheses; $^{***}p < 0.01,^{**} p < 0.05,^{*} p < 0.1$.

In table 3.5 we address the concern of variable unobserved variables that drive the observed effect of migration on the aspirations gap. As outlined before we use the share of male siblings in the household and the interaction of this share with the first born status for each individual. As reported in column 1 of table 3.5 the change in the composition of siblings in the household is not able to predict the subsequent migration behavior of individuals. However when interacting the change in the composition of siblings with birth order we find that this combination of variables serves as a good instrumental variable to predict subsequent migration. The results in column 2 repeat the previous finding that migration seems to have a strong causal impact in the aspirations window of individuals. The large size of the instrumented coefficient stems from the fact that the subpopulation which reacts to the exogenous stimulus of our instrument is rather limited: the effect is driven by individuals heading the birth order of the household.

Based on the procedure proposed by Heckman et al. (1998) we also implement a nonparametric propensity score estimation. This method uses the observed characteristics to match members of both the treatment and control group, i.e. migrants and non-migrants, based on a nonparametrically generated weight. These characteristics include current economic well-being, age, gender, martial status, education

and ability to read as well as the position of the individual in the household and the household size. We exclude individuals that have propensity scores outside of the region of common support. The result of this approach is reported in columns 3 and 4 of table 3.5. It corroborates the effects suggested by our benchmark regressions even though the effect is slightly higher with 0.121.

Table 3.5: *Fixed Effects - Alternative Approaches*

	(1)	(2)
	IV (Firstborn interacted with ratio of male sibblings)	Propensity score‡ (Kernel)
Migration (Instrumented)	1.2822**	.125***
CDF	14.033	/
Observations	24,184	24,184

Note: Authors calculation based IFLS3 and IFLS4. Regressions include all controls reported in the baseline estimates shown in table 2. Standard errors in parentheses; $^{***}p < 0.01$,$^{**}p < 0.05$,$^{*}p < 0.1$;. ‡ Standard errors for the treatment effect and regression treatment effect are computed using a bootstrap with 50 replications; CDF are Cragg-Donald test statistic of the first stage.

To assess the spillover effect of migration of an individual on all other household members we also conducted the analysis at the household level. For this purpose we only kept individuals who did not migrate but lived in a migration household. The uninstrumented fixed effects estimation results of this exercise show that it is primarily young household members whose aspirations are positively affected by migration. For migrant household members that are 25 years of age or younger the aspirations gap increases by 0.1029 between between 2000 and 2007 compared to individuals who do not live in migrant households. Although mostly positive this effect is not statistically significant for other age cohorts. Still, this suggests that even if the education decision wasn't taken by the head of the household, as we assume in our model, but by the children themselves, an aspirations effect would probably still lead to an increase in the average skill rate.

3.4 Theoretical Framework

The findings of the previous section motivate our theoretical model. Consider a small open economy where each household consists of a parent and her child. This economy represents a poor country, where aspirations are initially low and intertem-

poral discounting is high.[13] Each individual lives for two periods. In the first period, *youth*, an individual will opt for education if her parent decides that she should do so. In the second period, *adulthood*, all youths become parents of one child and make the education decision for the child. At birth, each individual is endowed with one efficiency unit of labor, and can invest in education in order to increase its labor force to $h > 1$ units. Individuals differ in their ability, which is inversely related to their perceived cost for education c_i. This perceived cost can be interpreted as the time that is needed in order to achieve a high-school diploma. The more time a child needs to spend on her education in order to achieve a degree, the less time she can spend on work.

c_i follows the cumulative distribution function $F(c_i)$ and the density function $f(c_i)$ and is defined on $\mathbb{R}_+$. We assume that a child's inherent ability, and therefore the perceived education cost, is independently distributed of her parent's ability.[14] If an individual pursues education, she earns $w_t - c_i$ in the first period of her life. In the second period, her effective units of labor will have increased to h and her income will change accordingly to $w_t h$. Unskilled individuals will earn w_t in both periods.

We assume, as in Cunha and Heckman (2007), that parents make the education decisions for their offspring out of altruistic motives. They are assumed to perfectly know the ability of their children, and can therefore judge the cost and benefits of education for their children. We assume that a parent's aim is to maximize the expected discounted lifetime earnings of her child, net of the perceived education cost. If a parent decides that her child should pursue education, this can be seen as an investment of the parent, because during *youth* children only contribute $w_t - c_i$ to the household's income. The higher the perceived cost, the lower is the effective income in the first period. Without migration, a parent invests in her child's education if

$$w_t - c_i + (1 - \delta) h w_{t+1} \geq w_t + (1 - \delta) w_{t+1} \tag{3.3}$$

In this setting without migration, the perceived cost benchmark for which parents will just invest in education is then

$$c_i \leq \tilde{c}_t = (1 - \delta) w_{t+1} (h - 1) \tag{3.4}$$

where δ is the perceived intertemporal discount rate for non-aspiring parents.

We include intertemporal discounting in our model, because the perceived dis-

[13] The basic setup of this model is inspired by Beine et al. (2008).

[14] This assumption will become important in the course of our analysis, because the parent's ability will indirectly influence the child's education investment through the probability that the parent is aspiring. High-ability parents are more likely to be educated and thus to have a migration experience, since migration is more likely to be possible for the skilled.

count rate is closely related to aspirations and poverty. The fact that the poor are exposed to a considerably higher amount of risk in their day-to-day lives than the wealthy has gained considerable interest in the recent economic literature. The lack of insurance or savings as well as the insufficient funds to purchase weather resistant crops can be reasons for this. Banerjee and Duflo (2007) and Banerjee and Duflo (2011) give several striking examples that illustrate the considerable risk-exposure of the poor. Vargas Hill (2009) argues that this high perceived amount of risk of the poor will have a considerable effect on their production decisions. The author shows that poorer households with low risk-preferences are less likely to invest in cash-crops, such as coffee, even if their expected long-run return is higher than that of traditional crops. As argued earlier, individuals in poor societies are also likely to have low aspirations. The lack of aspirations manifests itself in a disregard for long run goals and a higher valuation for the fulfillment of imminent needs.
For these two reasons, future expected earnings should be heavily discounted in our model. At a high δ, investments in education become less attractive, because skilled workers earn higher wages only in the second period of their lives, whereas the initial perceived education costs c_i have to be paid in the first period. The next step is to extend the model and allow for migration.

3.4.1 Migration and Aspirations

We now assume that in the second period of their lives, after becoming a parent, skilled workers can emigrate to a higher wage destination with an exogenous probability.[15] Foreign wages w_t^* are assumed to be significantly higher than domestic wages, $w_t^* > w_t$. We assume that there are no costs associated with emigration. However, an inclusion of the costs does not alter our results qualitatively. Since foreign wages are significantly higher, an individual will emigrate with certainty if she gets the opportunity to do so. Migration is thus not a choice variable, but can be seen as a random shock to the income of the individual.

As argued in Docquier and Marfouk (2000) and Beine et al. (2008), educated individuals are more likely to emigrate. We adopt this assumption and normalize the probability that an unskilled individual emigrates to $\underline{p} = 0$. The emigration probability for skilled individuals is denoted by p and is the same for all the educated. This is a reasonable assumption in our model, where only one education regime exists. In a world where more than one education level can be achieved, it would be likely that the emigration probability is increasing in the skill level. Our assumption also implicitly indicates that the ability level is unobservable for the visa authority, and that education therefore is the only variable that influences the

[15] We assume that migrants will leave their offspring behind. This might seem strange, given our simplifying assumption of one parent per child, but in reality, children have two parents. Often, the head of the household emigrates to earn money for the family, while the rest of the family stays behind. The education decisions will still be carried out by the head of the household, even if she is abroad.

authority's choice.
A parent will then decide to invest in her child's education, if the expected discounted lifetime earnings of the child, including education costs, are higher if it is skilled.

$$w_t - c_i + (1-\delta)\left((1-p_{t+1})hw_{t+1} + p_{t+1}hw^*_{t+1}\right) \geq w_t + (1-\delta)w_{t+1} \tag{3.5}$$

The perceived costs to education for a child have to be below a benchmark value $\tilde{c}$, otherwise the parent will not invest in the education of her offspring.

$$c_i \leq \tilde{c}_t = (1-\delta)\left(w_{t+1}(h-1) + p_{t+1}h(w^*_{t+1} - w_{t+1})\right) \tag{3.6}$$

It can be seen that $\tilde{c}_t$ is increasing in h. The higher the increase in effective work units as a result of education, the more attractive it becomes to invest in skills. Furthermore, $\tilde{c}_t$ is also increasing in p_{t+1}. Since wages are higher abroad, and migration is only possible for the skilled, a higher migration probability increases the expected skill premium, and leads to a higher education-cost benchmark.

In the previous brain drain models, the only source of heterogeneity were differences in the inherent individual ability and budget constraints. We introduce aspirations as an additional source of heterogeneity. We have shown in the empirical section, that migration increases the aspirations of the migrants. Thus, if a parent has emigrated, she is said to have a migration experience and her aspirations will increase by γ, compared to a non-migrant. Aspirations are seen as an externality to migration. When parents choose whether or not their child should go to school, they are aware that this will result in an increase in her expected income and her emigration probability. However, they do not consider that emigration will alter the mindset of their offspring.[16]
As mentioned before, empirical and experimental evidence[17] suggests that increased aspirations will lead to higher educational attainments. For example Beaman et al. (2012) show that educational attainment increases as parent's and children's aspirations rise.
There are at least three possible ways of introducing aspirations to our model, such that the skill rate of children from aspiring households are higher. First, one could think of an aspirations-induced change of preferences.[18] Second, children of aspiring parents can be assumed to have systematically lower perceived costs for

[16] It is common in the literature to assume that individuals do not anticipate how their actions will change their aspirations and beliefs. See e.g. Mookherjee et al. (2010), Dalton et al. (2011) and Genicot and Ray (2014).

[17] See Page et al. (2007)

[18] In such a setting, individuals might experience a disutility from not attaining the level of consumption of their peers. This could be modeled by using a Stone-Geary utility function, where aspirations measure the subsistence level of consumption.

education.[19] Third, aspirations could lead to a higher valuation of future earnings, lowering the inter-temporal discount rate.
For our model, we choose the last option, because it has been pointed out in the literature that aspiring individuals have a more future-oriented behavior and are willing to spend time and money in the pursuit of their goals. They believe themselves capable of altering their own destiny, which distinguishes them from other poor individuals who have an *aspirations failure*. Some recent studies such as Wilson and Boldizar (1990) and Bernard et al. (2011) provide empirical evidence that aspirations are fundamental for future-oriented behavior.

The way in which we incorporate this in our model is straightforward. Aspiring individuals will have a lower perceived discount rate, whereas parents who do not have a migration experience are non-aspiring, and will therefore put a high discount rate δ on possible future earnings. The aspiring parent will thus be more future oriented, and puts a larger weight on the second period earnings of her child. It becomes more important for the parent that her child will have a better life when it is grown up. Migration thus creates an intergenerational externality, since it influences the future of the child through the increased aspirations of her parent.
The aspiring parent will invest in the education of her child, if the following holds.

$$w_t - c_i + (1-\delta)(1+\gamma)\left((1-p_{t+1})hw_{t+1} + p_{t+1}hw^*_{t+1}\right) \geq w_t + (1-\delta)(1+\gamma)w_{t+1} \quad (3.7)$$

The higher aspirations γ lead to a change in the perceived cost benchmark.

$$c_i \leq \tilde{c}_{t,\gamma} = (1-\delta)(1+\gamma)\left(w_{t+1}(h-1) + p_{t+1}h(w^*_{t+1} - w_{t+1})\right) = (1+\gamma)\tilde{c}_t \quad (3.8)$$

This benchmark is strictly higher than for non aspiring households. Migrants will thus also invest in education if their children are less able than what would be required for non-migrant families.
What implications does this have for the brain-drain? We assume that a fraction π of the population has a parent who has a migration experience and is therefore aspiring. Imposing that there are no binding budget constraints, which implies that every individual who chooses education over work can do so, the aggregate pre-migration education rate in the economy in period t can then be calculated as

$$H_{a,t} = (1-\pi_t)F(\tilde{c}) + \pi_t F((1+\gamma)\tilde{c}) \quad (3.9)$$

The probability that one's parent has a migration experience depends on the probability that this parent is educated herself, $H_{a,t-1}$, and the current migration rate for skilled individuals p_t. This probability is then calculated as $\pi_t = H_{a,t-1}p_t$.

[19] In Appendix A, we show that this can be modeled such that it results in the same outcome as a change in the discount rate.

In order to asses the influence that migration has on the brain drain in the long run, we want to investigate how a change in the exogenous migration probability will influence the steady state education rate.[20] In the steady state, wages, the migration probability and education rates remain constant over time. The steady state education rate is then

$$\begin{aligned} H_a^{ss} &= (1-\pi^{ss})F(\tilde{c}) + \pi^{ss}F((1+\gamma)\tilde{c}) \\ &= F(\tilde{c}) + \pi^{ss}(F((1+\gamma)\tilde{c}) - F(\tilde{c})) \\ &= F(\tilde{c}) + H_a^{ss}p^{ss}(F((1+\gamma)\tilde{c}) - F(\tilde{c})) \\ H_a^{ss} &= \frac{F(\tilde{c})}{1-p^{ss}(F((1+\gamma)\tilde{c}) - F(\tilde{c}))} \end{aligned} \tag{3.10}$$

Remembering that $\tilde{c}$ depends positively on p, it is clear that H_a^{ss} depends positively on p^{ss}. There are two reasons for this conclusion. First, the possibility to emigrate will increase the expected skill-premium, because skilled work earns considerably higher wages abroad. This is the classical argument for a brain gain, the *incentive effect*, as it has often been identified in the literature. The second channel that drives this positive relationship between the steady state migration rate and investment in education is the *aspirations effect*. If the steady state emigration rate is high, the possibility to have a parent that has a migration experience is higher, and therefore it is more likely that the parent will be aspiring. This effect is visible in the denominator. The bigger the aspirations effect γ, the higher the positive influence of the emigration rate on education will be.

However, we are not only interested in the incentive effect that migration has on education. Our ultimate aim is to asses whether migration will increase or decrease the *post-migration skill ratio*. This rate is calculated as

$$H_{p,t} = \frac{(1-p_t)H_{a,t-1}}{1-p_t H_{a,t-1}} \tag{3.11}$$

which, in the steady state becomes

$$\begin{aligned} H_p^{ss} &= \frac{(1-p^{ss})H_a^{ss}}{1-p^{ss}H_a^{ss}} \\ &= \frac{(1-p^{ss})F(\tilde{c})}{1-p^{ss}F((1+\gamma)\tilde{c})} \end{aligned} \tag{3.12}$$

It is evident that this average post-migration skill level is strictly increasing in the

[20] See Appendix B for proof of existence of a steady state.

aspirations effect.

$$\frac{\partial H_p^{ss}}{\partial \gamma} = \frac{(1-p^{ss})p^{ss}\tilde{c}f\big((1+\gamma)\tilde{c}\big)F(\tilde{c})}{\Big(1-p^{ss}F\big((1+\gamma)\tilde{c}\big)\Big)^2} \tag{3.13}$$

Even though the possibility to migrate increases the incentives to invest in education, it also depletes the stock of skilled workers. The subsequent question then becomes under which circumstances skilled emigration leads to a brain drain, and what the role of aspirations in this context is. We will focus on the steady state only.[21] In order to determine whether migration will lead to a net brain drain or gain, and thus whether migration is good or bad for a country, we have to investigate the influence that migration has on this post-migration skill rate.[22] Taking the derivative of (3.12) with respect to p, we get

$$\begin{aligned}\frac{\partial H_p}{\partial p} = & \\ & \frac{-F(\tilde{c})\big(1-F((1+\gamma)\tilde{c})\big)}{\big(1-pF((1+\gamma)\tilde{c})\big)^2} \\ & + \frac{(1-p)\frac{\partial \tilde{c}}{\partial p}\Big(f(\tilde{c})+p\big((1+\gamma)F(\tilde{c})f((1+\gamma)\tilde{c})-F((1+\gamma)\tilde{c})f(\tilde{c})\big)\Big)}{\big(1-pF((1+\gamma)\tilde{c})\big)^2}\end{aligned} \tag{3.14}$$

It can easily be shown that the first term is negative, whereas the second term is unambiguously positive. As argued in Beine et al. (2008), the possibility for a beneficial brain drain exists if the derivative above is positive for $p = 0$. That means that a transition from a state of autarky to very restricted emigration would increase the post-migration skill level. In this case, there will be a positive emigration rate, which results in the same average post-migration skill-level as autarky. As a first part of our analysis, we focus on the effect that an intergenerational *aspirations effect* has on this autarky-equivalent emigration rate.

Proposition 10. *If the aspirations effect increases the weight that aspiring individuals put on the future and assuming that $c_i \sim U(0,1)$, the aspirations effect increases the autarky-equivalent migration rate and thus the range for which migration is considered to be better than autarky.*

$$H_{p,\gamma}(p_{0|\gamma=0}) > H_p(0) \tag{3.15}$$

where $p_{0|\gamma=0}$ is the autarky-equivalent emigration rate without aspirations effect, for

[21] From now on we drop the superscript *ss* in our analysis. All variables of interest are now assumed to be in steady state.

[22] We assume that due to productivity spillovers of education and *aspirations failure*, the education rate in the economy is lower than optimal. Therefore, an increase in the education rate will be described as being "better"for the economy.

which the autarky skill-ratio equals the ex-post emigration skill-ratio.

Proof. With $c_i \sim U(0,1)$ and a model without aspirations, the emigration rate for which the skill ratio is identical under autarky and migration fulfills

$$\frac{(1-p_{0|\gamma=0})H_a(p_{0|\gamma=0})}{1-p_{0|\gamma=0}H_a(p_{0|\gamma=0})} = (1-\delta)w(h-1) \tag{3.16}$$

where the RHS is the education rate under autarky. We can then calculate $p_{0|\gamma=0}$ as

$$p_{0|\gamma=0} = \frac{h(w^*-w) - w(h-1)(1-(1-\delta)w(h-1))}{h(w^*-w)(1-(1-\delta)w(h-1))} \tag{3.17}$$

We want to show that at this emigration rate, the skill ratio in the economy will be higher than under autarky, if we account for the aspirations effect.

$$\begin{gathered} H_{p,\gamma}(p_{0|\gamma=0}) > H_p(0) \\ \frac{(1-p_{0|\gamma=0})(1-\delta)(w(h-1)+p_{0|\gamma=0}h(w^*-w))}{1-p_{0|\gamma=0}(1-\delta)(1+\gamma)(w(h-1)+p_{0|\gamma=0}h(w^*-w))} > (1-\delta)w(h-1) \end{gathered} \tag{3.18}$$

Setting in (3.17) for $p_{0|\gamma=0}$ and rewriting[23], we obtain

$$\gamma h(w^*-w)\frac{(1-\delta)w(h-1)}{1-(1-\delta)w(h-1)} > 0 \tag{3.19}$$

which is fulfilled by the assumption that $h > 1$ and that $c_i \sim U(0,1)$[24]. □

If a country has an effective skilled migration rate that is below the autarky-equivalent, it will benefit from migration. Proposition 10 states that accounting for the *aspirations effect* increases the range of the migration rate, for which a country can be seen as such a net-winner of migration. The bigger γ, the bigger the magnitude of this effect. Hence, accounting for the aspirations effect when quantifying which country has a net brain drain or gain will potentially[25] increase the number of net winners. If a positive autarky-equivalent emigration rate exists, there must also be an optimal emigration level, which maximizes the average skill level.

We now proceed by showing that this optimal migration rate, which maximizes the post-migration skill ratio, is also increasing in aspirations. We will first calculate the first-order condition to determine the optimal skilled emigration rate. Then we will use the implicit function theorem on the first order condition to show that the

[23] See Appendix C.

[24] $(1-\delta)w(h-1)$ is the autarky education cost benchmark for which investments in education will be made. It has to be smaller than one if $c_i \sim U(0,1)$.

[25] With a continuum of countries, it would definitely increase the number of net-winners at the margin. Since in reality there is a discrete number of countries, it depends on the actual size of the aspirations effect, whether or not it will shift some net-looser countries on the net-winner side.

optimal skilled emigration rate is increasing in aspirations.

We set equation (3.14) equal to zero and define this first order condition as a function of the migration rate and the aspirations effect.

$$\begin{aligned}
&\frac{\partial H_p}{\partial p} \equiv \eta(p^*, \gamma) \\
&= -F(\tilde{c})(1 - F((1+\gamma)\tilde{c}) \\
&\quad + (1-p^*)\frac{\partial \tilde{c}}{\partial p}\Big(f(\tilde{c}) + p^*\big((1+\gamma)F(\tilde{c})f((1+\gamma)\tilde{c}) - F((1+\gamma)\tilde{c})f(\tilde{c})\big)\Big) \\
&\stackrel{!}{=} 0
\end{aligned} \tag{3.20}$$

where p^* is the optimal migration rate.

As argued earlier, the first term of (3.20) is negative, whereas the second is positive. For small enough migration rates and sufficiently large differences between foreign and domestic wages, $\partial\tilde{c}/\partial p$ will be large enough to ensure a net brain gain. If an optimal migration rate exists, that is if $\partial\eta/\partial p < 0$, then we can show that the optimal skilled migration rate is increasing in aspirations by showing that $\partial\eta/\partial\gamma > 0$.

Proposition 11. *Assuming that $c_i \sim U(0,1)$, the optimal skilled migration rate is increasing in the aspirations effect.*

$$\frac{\partial p^*}{\partial \gamma} > 0 \tag{3.21}$$

where p^* is the migration rate that maximizes the post-emigration skill-ratio.

Proof. From the implicit function theorem, we know that $\partial p^*/\partial\gamma = -\frac{\partial\eta/\partial\gamma}{\partial\eta/\partial p}$. $\partial\eta/\partial p < 0$ is a necessary condition for p^* to be a local maximum. It is thus sufficient to show that $\partial\eta/\partial\gamma > 0$.

$$\begin{aligned}
\frac{\partial \eta}{\partial \gamma} &= F(\tilde{c})f\big((1+\gamma)\tilde{c}\big)\tilde{c} \\
&\quad + (1-p^*)p^*\frac{\partial \tilde{c}}{\partial p}\left(f\big((1+\gamma)\tilde{c}\big)\big(F(\tilde{c}) - f(\tilde{c})\tilde{c}\big) + f'\big((1+\gamma)\tilde{c}\big)F(\tilde{c})(1+\gamma)\tilde{c}\right)
\end{aligned} \tag{3.22}$$

For $c_i \sim U(0,1)$ the expression simplifies with $F(\tilde{c}) = \tilde{c}$ and $f(\tilde{c})$, $f((1+\gamma)\tilde{c}) = 1$. For uniformly distributed perceived education costs, the equation above thus changes to

$$\frac{\partial \eta}{\partial \gamma} = \tilde{c}^2 > 0 \tag{3.23}$$

□

Proposition 11 states that for uniformly distributed perceived education costs, the optimal migration rate will be increasing in the *aspirations effect*. The higher the impact of a migration experience on the increase in aspirations γ, the higher the optimal level of emigration.

The *aspirations effect* works through two distinct channels. First, the negative effect of emigration is weakened because a higher steady state migration rate increases the probability that one's parent has a migration experience. This implies that more people will have aspiring parents if migration is higher, which means that a higher fraction of the population has a higher education cost benchmark. Second, aspirations magnify the incentive effect of the skilled emigration rate. A higher skilled emigration rate means that the expected returns of education are higher. This effect is stronger for aspiring individuals, because, compared to the non-aspiring, they give a higher weight to expected future earnings. This means that the higher aspirations are, the bigger the impact of the *incentive effect* will be, and the more pronounced the positive impact of migration on the aggregate educational investment.

3.4.2 Robustness of Theoretical Results

The proofs we have conducted above required the assumption that the perceived education costs follow a uniform distribution. We made this assumption, because it is very common in the brain drain literature. For example, Beine et al. (2008) and Mountford (1997) have used uniform distributions in their models. Is it realistic to assume that perceived costs are uniformly distributed? Most data suggests that intelligence quotient testscores, as a proxy for unobservable inherent ability, seem to follow a normal distribution.[26] Even if we do not know exactly how different intelligence quotients translate into different magnitudes of perceived education costs, this finding suggests that perceived costs could also be approximated by a normal distribution, rather than by a uniform distribution.

Would our findings concerning the aspirations effect still be valid under an alternative ability distribution? Rewriting (3.22), we see that the aspirations effect will increase the optimal skilled migration rate, if

$$\frac{\tilde{c}}{(1-p^*)p^*\frac{\partial\tilde{c}}{\partial p}} + \frac{f'\big((1+\gamma)\tilde{c}\big)}{f\big((1+\gamma)\tilde{c}\big)}(1+\gamma)\tilde{c} \geq \frac{f(\tilde{c})\tilde{c} - F(\tilde{c})}{F(\tilde{c})} \tag{3.24}$$

This equation will be fulfilled under some requirements on the distribution function. First, the variance around the benchmark education cost $\tilde{c}$ must be sufficiently high, such that $\big(f(\tilde{c})\tilde{c} - F(\tilde{c})\big)/F(\tilde{c})$ does not become to big. With a strong concentration around $\tilde{c}$ the density would otherwise be too high. The aspirations effect thus works better if there is a large variety of different abilities in the society. Sec-

[26] See e.g. Shaywitz et al. (1992)

ond, $f'\big((1+\gamma)\tilde{c}\big)$ should be positive or at least not strongly negative. The density of people with higher perceived costs should thus be higher than that of people with low costs. The aspirations effect works on those who would otherwise not choose to invest in education. If the density is increasing, more people will change their education decision as a result of an increase in aspirations.[27] Third, if p^* is small or close to one the aspirations effect gets stronger. This implies that the aspirations effect will be larger for countries that have otherwise a small *incentive effect*.

3.5 Counterfactual Simulation

We perform a numerical simulation, assuming a uniform distribution for the perceived education cost, for different magnitudes of the aspirations effect to get an idea of the quantitative implications. The graphs are based on the theoretical model presented in the previous section. The empirical results from section 3 were used to calibrate the model. Since the fixed effects estimator represents our preferred estimation, we take the FE point estimate of the aspirations gap as a benchmark value for the aspirations effect.

The fixed effects approach which produces our preferred estimator implies that migration increased the aspirations gap by 0.0848 units. In other words, the aspirations gap of an individual from the migrant group would be roughly 12% lower in 2007, had he not migrated. This effect represents the γ of our theoretical model. We use this as a lower bound to calibrate our counterfactual simulation. Since our survey mainly covers interregional migration, it might be that the migration experience of an actual international migration has a more important impact on aspirations than what we measured. We thus also run the simulation for an *aspirations effect* that is 50% stronger ($\gamma = 0.183$), in order to compare the implications of a possible higher impact of international migration.

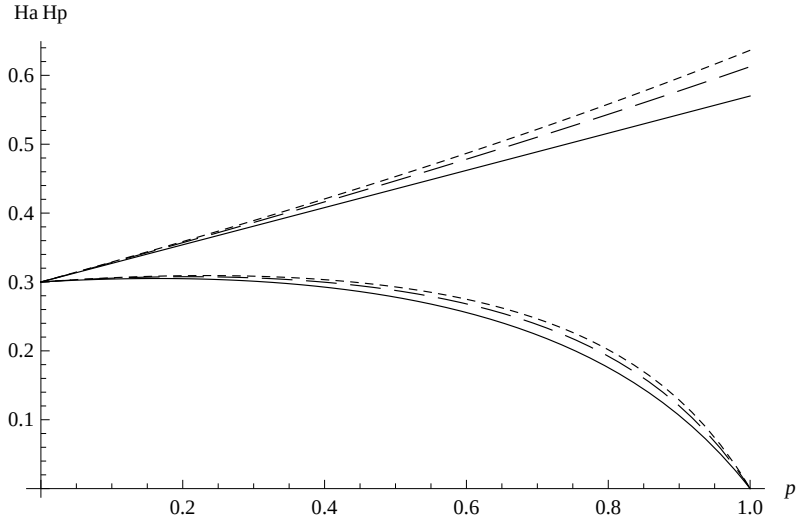
Figure 3.1 depicts the pre- and post-emigration proportion of skilled individuals. As expected, a higher aspirations effect results in more investment in education, which in turn increases the post-emigration human capital. Figure 3.2 shows the derivative of the post-emigration skill rate with respect to the emigration rate. The intersection of the graphs with the x-axis identifies the optimal emigration rate, which maximizes the *ex-post* skill proportion. It can be seen that an aspirations effect of 0.122, as we find it in the data, increases the optimal emigration rate considerably, in this example from 16% to 20%. Using a more optimistic estimate for the aspirations effect of 0.183, the optimal migration rate increases to 22.5%.[28]

As we have seen in the empirical part, aspirations are a somewhat blurry concept

[27] With $H_a < 0.5$, this will be fulfilled for the normal distribution. See graph in Appendix D.

[28] We have used a rather cautious guess for the intertemporal discount rate, setting $\delta = 0.4$. This was done so that we do not get overly optimistic results. Decreasing δ to 0.3 almost doubles the *aspirations effect* in our simulation. See Appendix E for an illustration.

Figure 3.1: Effect of aspirations on the pre and post-emigration skill proportion



Note: The following values were used for the simulation. $h = 1.5$, $\delta = 0.4$, $w = 1$, $w^* = 1.3$

$\gamma_1 = 0$ (———), $\gamma_2 = 0.122$ (- - -), $\gamma_3 = 0.183$ (·····)

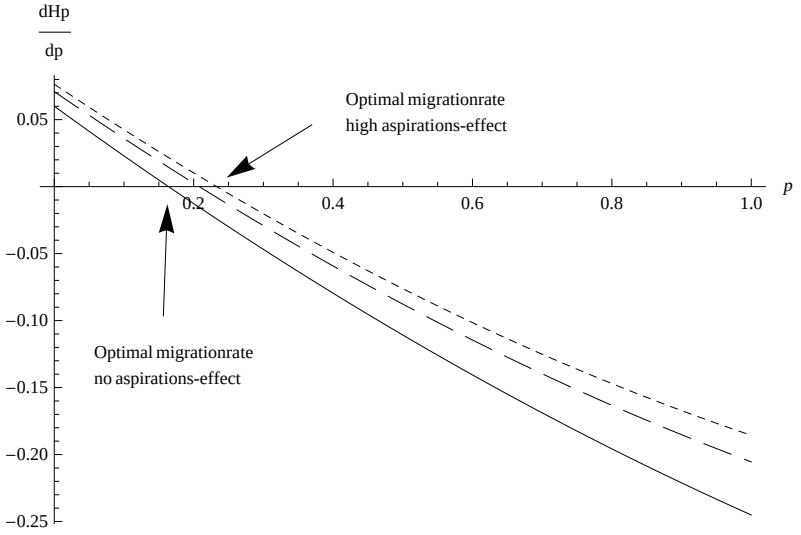
that is hard to quantify. Furthermore, the survey did not provide us with an estimator for the actual influence of aspirations on education decisions. The examples above are therefore only meant to clarify the possible implications that aspirations could have for the brain drain. However, the results suggest that the effect is sizable even for small aspirations increases due to a migration experience.

3.6 Conclusion and Discussion

This article finds evidence that migration changes the goals which individuals aim to achieve and argues that this should lead to a more optimistic view concerning the impact of skilled emigration on the level of human capital in the countries of origin.

It has been argued that *aspirations failure* in segregated societies is one reason for persisting poverty in the global south. The importance of finding ways to increase aspirations of the poor has been stressed by much of the recent literature, especially because a lack of investment in human capital is often associated with low levels of aspirations. In this paper we suggest that migration is one possible way of overcoming this *aspirations failure* and thereby increasing educational attainment. We have provided empirical evidence that shows that migration changes an individual's attitude towards the future by exposing her to a new environment. We find that aspirations of emigrants increase significantly more than that of non-migrants. Having lived and worked in a different location for a while changes the goals and

Figure 3.2: Effect of aspirations on optimal emigration rate



Note: The following values were used for the simulation. $h = 1.5, \quad \delta = 0.4, \quad w = 1, \quad w^* = 1.3$

$\gamma_1 = 0$ (———), $\gamma_2 = 0.122$ (- - -), $\gamma_3 = 0.183$ (·····)

values that an individual aspires to.

Since parents who are aspiring are generally found to invest more in the education of their offspring, we interpret this aspirations increase as an intergenerational externality of a migration experience. The brain drain literature of the recent past has been arguing that a small amount of emigration might actually be beneficial for the sending country, since it increases the incentives to invest in education. However, this literature has only focused on the incentive effect of the aggregate emigration probability.

In this paper, we argue that it is not only the migration probability, but also the migration history of a household that determine the education decisions in the source country. Assuming that aspirations lead to a more forward looking behavior, we propose a theoretical model which suggests that an aspirations effect will magnify the positive impact of emigration on the incentives to invest in education. Our model shows that accounting for this aspirations effect increases the autarky-equivalent skilled emigration rate, which leads to the same level of human capital as zero emigration. This implies that the range of emigration rates, for which emigration is beneficial to the aggregate skill level of an economy depends positively on the aspirations effect. As a consequence, the optimal skilled emigration rate is found to be increasing in aspirations.

The counterfactual simulation of the model suggests that neglecting aspirations leads to a sizable underestimation of the beneficial effect of migration in the country of origin.

These insights about the relationship between aspirations and the brain drain provide a promising starting point for further research. First and foremost, more panel data on the relationship between migration, aspirations and education is needed in order to quantify the actual impact of the *aspirations effect* on the overall brain drain. Since aspirations are still a somewhat blurry concept that can be measured in several dimensions, it is important to develop reliable survey questions to measure aspirations such that they can be compared quantitatively across cultures and across time. Panel data that allows us to observe both aspirations and educational attainment over time will allow us to make quantitative predictions about the influence of aspirations on education, and thus on the brain drain.
Second, studies which calculate the net brain drain for different countries should incorporate the *aspirations effect*. This would help to gain knowledge about how the brain drain develops in the long run if the intergenerational linkages discussed in this study are taken into account.

Assessing the influence of skilled emigration on the countries of origin is a complex issue. There are many well-known feedback and network effects which have an ambiguous influence on the sending countries. Aspects such as remittances, diasporas, return migration and education incentives can make it difficult to evaluate the overall net-effect of migration on the poorest countries. Our research suggests that the overall picture is more optimistic than previously assumed. Policymakers in the destination countries who are concerned about the impact of skilled emigration on the source countries should take all these aspects into account. In the long run, it might be beneficial to the human capital in the sending countries, if there is a (well communicated) possibility to emigrate to the first world. Skill-dependent immigration rates should be set accordingly by the host countries.

Appendix

3.A Equivalence of Different Aspirations Interpretations

We claim that assuming that aspirations decrease the perceived costs of education is equivalent to interpreting it as a decrease in the perceived discount rate. Our interpretation of aspirations is thus not a critical requirement for its validity.

Proof. If coming from an aspiring household decreases the perceived education costs, a parent will invest in her child's education if.

$$w_t - \frac{c_i}{1+\gamma} + (1-\delta)\left((1-p_{t+1})hw_{t+1} + p_{t+1}hw^*_{t+1}\right) \geq w_t + (1-\delta)w_{t+1} \quad (3.25)$$

This then leads to the following benchmark perceived cost.

$$c_i \leq \tilde{c}_{t,\gamma} = (1-\delta)(1+\gamma)\left(w_{t+1}(h-1) + p_{t+1}h(w^*_{t+1} - w_{t+1})\right) = (1+\gamma)\tilde{c}_t \quad (3.26)$$

which is the same as equation (3.8). □

3.B Existence of Steady State

Proof. In the very first period when going from autarky to migration, we have that π=0. Thus

$$H_{a,0} = F(\tilde{c}) \quad (3.27)$$

In the second period, $\pi_1 = pF(\tilde{c})$ of the households will have a migration experience, leading to

$$H_{a,1} = (1 - pF(\tilde{c}))F(\tilde{c}) + pF(\tilde{c})F(\tilde{c}(1+\gamma)) > H_{a,0} \quad (3.28)$$

For small π, it is thus the case that $H_{a,t}$ is increasing in $H_{a,t-1}$.
Assuming the extreme scenario where in period 0 every household has a migration experience, we have that

$$H_{a,0} = F(\tilde{c}(1+\gamma)) \quad (3.29)$$

then, in the next period, we will have that

$$\begin{aligned} H_{a,1} =& (1 - pF(\tilde{c}(1+\gamma)))F(\tilde{c}) + pF(\tilde{c}(1+\gamma))F(\tilde{c}(1+\gamma)) \\ =& F(\tilde{c}) + pF(\tilde{c}(1+\gamma))\big(F(\tilde{c}(1+\gamma)) - F(\tilde{c})\big) \end{aligned} \quad (3.30)$$

In this case, it can be verified that $H_{a,1} < H_{a,0}$ by taking the difference.

$$H_{a,1} - H_{a,0} = \big(F(\tilde{c}) - F(\tilde{c}(1+\gamma))\big)\big(1 - pF(\tilde{c}(1+\gamma)\big) < 0 \quad p \in (0,1) \tag{3.31}$$

Thus, for high values of π, $H_{a,t}$ is decreasing in $H_{a,t-1}$. There must therefore exist at least one steady state. □

3.C Rewriting Equation (3.18)

We rewrite equation (3.18) by multiplying with the denominator of the left hand side. We then get

$$\begin{aligned}&(1-p_{0|\gamma=0})(1-\delta)\left(w(h-1)+p_{0|\gamma=0}h(w^*-w)\right) > \\ &(1-\delta)w(h-1) - p_{0|\gamma=0}(1-\delta)^2(1+\gamma)w(h-1)\left(w(h-1)+p_{0|\gamma=0}h(w^*-w)\right)\end{aligned} \tag{3.32}$$

We now subtract $(1-\delta)w(h-1)$ and divide both sides by $p_{0|\gamma=0}$ and $(1-\delta)$. This simplifies the equation to

$$\begin{aligned}&(1-p_{0|\gamma=0})h(w^*-w) - w(h-1) > \\ &-(1-\delta)(1+\gamma)w(h-1)\left(w(h-1)+p_{0|\gamma=0}h(w^*-w)\right)\end{aligned} \tag{3.33}$$

which can be written as

$$h(w^*-w) - \big(p_{0|\gamma=0}h(w^*-w) + w(h-1)\big)\big(1-(1-\delta)(1+\gamma)w(h-1)\big) > 0 \tag{3.34}$$

Setting in (3.17), some terms cancel out, and we obtain equation (3.19).

3.D Normally Distributed Education Costs

With a normal distribution, the density is increasing in $\tilde{c}$ as long as $H_a < 0.5$. Therefore, ceteris paribus, the aspirations effect is likely to be greater in situations where only a minority of the non-aspiring population would invest in the education of their children.

3.E Counterfactual Simulation with Low Delta

Figure (3.E.1) shows an example for a counterfactual simulation where we decreased δ to 0.3. There are two main effects of this.

- The optimal migration rate increases considerably for all levels of aspirations. When not accounting for the aspirations effect, the optimal migration rate is now 22% compared to 16% for $\delta = 0.4$. This is intuitive, because a lower discounting implies weighing future income more. The low discount rate thus

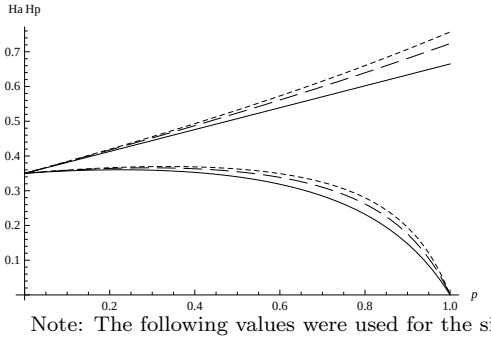
Figure 3.D.1: Normally distributed perceived education costs

leads to a magnification of the *incentive effect* of the possibility to emigrate on the education decision.

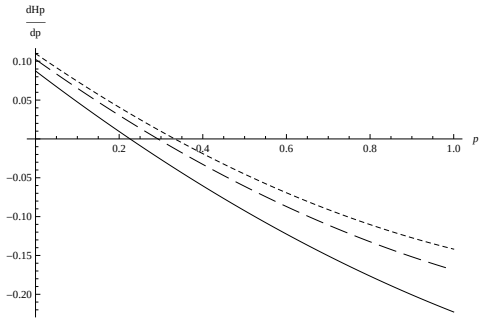
- The *aspirations effect* becomes larger and the gaps between a moderate and a high aspirations effect increase. For a γ of 0.122 as we find it in our estimation, the optimal migration rate increases to 29% and for $\gamma = 0.183$ to 33%. This is due to the multiplicative form of aspirations that we assume. If the initial discount rate is low, the increase in the weighting of future earnings that aspirations imply, is magnified.

Figure 3.E.1: Counterfactual for lower discount rate

(a) Effect of aspirations on the pre and post-emigration skill proportion



(b) Optimal emigration rates



Note: The following values were used for the simulation. $h = 1.5$, $\delta = 0.3$, $w = 1$, $w^* = 1.3$

$\gamma_1 = 0$ (———), $\gamma_2 = 0.122$ (– – –), $\gamma_3 = 0.183$ (·····)

4 Education subsidies in a globalized world: Endogenous policy as a source of brain drain

4.1 Introduction

One major aspect of economic policy that determines a country's innovation potential is education policy. With positive productivity spillovers of human capital, the privately optimal level of education will typically not account for positive externalities and thus be inefficiently low. The government of a closed economy will then have an incentive to subsidize education in order to internalize these spillovers. We now ask, which influence does the possibility of (skilled) migration have on such national education policy? If its benefits can only be partly captured by one country, but become freely available for another, will governments still have enough incentives to subsidize education?
It is clear that with increasing globalization, the incentives to invest in human capital, both private and public, will change. Gradstein and Justman (1995) develop the claim that, if foreign direct investment flows are determined by the relative skill differences between countries, each national government will have an inefficiently high level of public education expenditure, in order to attract foreign funds. But what if it is skilled labor instead of capital, that is internationally mobile?

In this paper, we argue that the incentives for national policymakers to invest in public education decrease as a result of skilled international migration. If national governments anticipate skilled migration flows, they will adapt their education policy accordingly. The purpose of subsidizing education is to internalize its positive externalities and to achieve a level of human capital that is optimal for a country. We argue that the country of origin will have less incentives to invest in education if it anticipates that some of its educated citizens will migrate, and thus take their human capital with them. At the same time, the destination country anticipates that they can free-ride on the human capital of skilled immigrants, and consequently lower their public education expenditure as well. We demonstrate that this behavior of national governments leads to an equilibrium, where the aggregate level of education subsidies and, consequently, human capital is lower than under globally optimal policies. We argue that remittances might be one way to solve this problem.

A big part of the brain-drain literature has argued, that one way to overcome

the underinvestment in education can be to open the country for emigration to higher-wage destinations. This will increase the expected skill premium for education, and therefore lead to a higher private incentive to accumulate human capital. The brain drain literature however typically neglects the interplay between emigration and national education policy. If education is not only determined through a private decision, but partly or entirely publicly provided, then emigration will have an effect that goes beyond the private incentive effect. With skilled emigration, not all the recipients of education subsidies will choose to work at home, which decreases the positive impact of the education externality induced by the subsidy. Thus, while the possibility to work abroad will increase the incentives to privately invest in education, it decreases the incentives for public education provision. It has already been recognized that these two mechanisms are linked. Stark and Wang (2002) show that the optimal level of education for a society can both be achieved by either using education subsidies or by allowing for a certain, positive amount of emigration. Along similar lines, Docquier et al. (2008) show that there is a trade-off between the two instruments, and that emigration can be seen as a substitute for subsidies.

We are adding to this literature, by not only focusing on the optimal policy for a poor, sending country, but also on the influence that skilled migration flows have on the policy in the high-wage destination of migrants, the host country. We propose a model of skilled migration with an exogenous migration rate in an asymmetric world, i.e. where income is considerably higher in one country. Migration then only flows from the country of origin to the host country. We first analyze how emigration affects the education policy of the sending country. For this country, emigration makes it harder to appropriate the positive education effect of a subsidy, since part of the skilled population leaves the country. At the same time, the remaining population has to pay higher taxes in order to finance the public education that the emigrants have received. As a consequence, the optimal education subsidy for the country of origin is decreasing in the skilled emigration rate. Subsequently we analyze the influence of migration on the host country's policy. With skilled immigrants contributing to the aggregate level of its human capital, immigration is decreasing the necessity for public education in the host country. Here also, the optimal subsidy is decreasing in the migration rate.
Through migration, education policy has international spillover effects on aggregate productivity. This however is neglected by the national social planners. In equilibrium, the national education policies are thus lower than what would be globally optimal. We show that this results in a level of human capital that is lower than under a globally optimal education policy. We argue that one way to partly resolve the negative effect of migration on education subsidies and to internalize their international spillovers are remittances. If social planners anticipate that some of the migrant's income will be sent back to the country of origin, this creates incentives to increase education subsidies in both countries. For the country of origin

remittances lower the negative effect of skilled migration on the optimal education subsidy, because remittances are increasing in the emigrant's income, and thus in their level of education. The social planner of the host country on the other hand will care less about the income of the immigrants if they send part of it back home. The planner will then have an incentive to increase taxes in order to finance higher education subsidies for the natives.
To our knowledge, this is the first paper that explicitly explores this underprovision problem in the setting of a brain-drain model between first and third world, and assesses the impact on the policy of both countries.

The remainder of this paper is structured as follows. In section 2 we discuss the literature on human capital investment and growth to give a better understanding for the necessity of education subsidies. We then review the literature on brain-drain and labor mobility, and show how our work connects both strands. In section 3 we present a theoretical model of education subsidies and brain-drain, both from the point of view of a sending and a host country. We then investigate how remittances influence the education policies and compare the optimal national policies to the global optimum. Section 4 concludes and discusses policy implications of our findings.

4.2 Literature Review

The literature review is structured as follows. First, we are going to present work that shows that human capital is important for growth, but that due to externalities the aggregate private investment in education will be lower than socially optimal. In the presence of spillovers, education should thus be partly subsidized.
Second, we review the brain-drain/brain-gain literature, which is concerned with the effect of skilled emigration on the poor source countries in the developing world. This literature takes investment in education as a private decision and shows that the possibility to emigrate to a high-wage destination will increase the incentive to invest in education. It thereby shows that skilled migration can serve as a substitute for public education subsidies, by providing a higher expected skill premium. In these models, migration is typically restricted by a fixed migration quota. Since wage differences between first and third world are substantial, workers are assumed to always prefer emigrating over staying, if they are allowed to leave their country. The migration choice is thus not explicitly modeled, an the probability of migration is an exogenous variable which individuals take as given when making their education decision.
Third, we present literature on public education under labor mobility. This literature is concerned with the problem that local authorities might underinvest in education, if skilled workers are mobile and can apply their skills elsewhere. Typically, these models investigate symmetric regions, which engage in a Nash game

with other regions, taking the foreign education investment as given. The main reason for underinvestment in these models is free-riding and tax competition between states. Countries will lower their investment in public education, if lower taxes will make them more attractive for high-skilled immigrants. In these models, typically migration will not be restricted by quotas, but there is uncertainty about the transferability of the acquired skills. The motivation for migration depends on the wage differences and the migration costs.

4.2.1 Evidence for Education Spillovers and Growth Effects of Education

As has already been pointed out by Lucas (1988), the spillovers of human capital on the entire economy might be large enough to explain long run differences between the income of rich and poor countries. There is ample evidence which shows that aggregate education expenditure, both private and public, has a significant influence on growth and technological innovation. However, there is also evidence that the social return of human-capital investment is higher than the private return. This implies that the equilibrium private investment in education will be lower than the socially optimal level, which justifies education subsidies.[1]
Acemoglu and Angrist (2001) find that aggregate secondary schooling has significantly positive externalities on average wages. This effect becomes smaller when aggregate schooling is instrumented by compulsory schooling laws, but stays significant.
Moretti (2004a) finds evidence that higher rates of postsecondary education create local spillovers on wages of both low- and high-skilled workers. The author demonstrates that a change in the average rate of college graduates at a location strongly increases the average wages of high-school dropouts and high school graduates. The effect on college graduates' average wages is lower, but also significant. Since low- and high-skilled labor are complements, the stronger effect on the average wages of low-skilled workers follows economic intuition.
Along similar lines, Moretti (2004b) shows that it is not only wages that change as a result of a higher average rate of college graduates, but that these go along with increases in productivity of plants. Controlling for the human capital that each firm employs, firms in regions that have a strong increase in the average college graduate rate experience a stronger increase in productivity than firms in other regions.
The findings of these articles suggest that it should be beneficial to subsidize education in order to internalize some of the externalities.

There is indeed evidence that public education expenditure is growth enhancing. Aghion et al. (2009) show that investment in different types of education, high-brow and low-brow, have different implications for growth, depending on the initial

[1] Another justification for education subsidies can be redistributional considerations, as shown in Trostel (1996) and Bovenberg and Jacobs (2005). Other forms of externalities, besides technology spillovers, that are associated with human capital formation are presented in Hall (2006).

technology level of a state. In the presence of skilled migration, regions that are close to the technological frontier should invest more in high-brow education than they would do under autarky. Low-tech states on the other hand, should invest in low-brow education, in order to minimize the brain drain to the other state. The authors present empirical evidence for their claims, using data on education expenditure for the US. While an investment in higher education increases growth significantly for states that are close to the technological frontier, the impact of investment in low-brow education on growth is non-significant. For low-tech states investment in higher education is found to decrease growth, due to the brain-drain that this investment induces. Investment in mid-level education has a significantly positive impact on growth, whereas investment in low-brow education does not considerably contribute to growth.
Their results are related to our findings: In the aggregate, public education provision has a significant impact on growth. However, under the presence of skilled migration a brain-drain makes it difficult for the low-wage locations to appropriate the returns on their investment. In our model, this is one of the reasons that we identify for an underprovision of public education in open developing countries.
In a related article, Stone et al. (2010) show how regions can capture returns to education expenditures when labor is mobile. They find that expenditures in public infrastructure and education are complements, and that isolated expenditures in either of these will have negative effects on growth. However, the complementarity between them is high enough to create spillovers, such that coordinated investments in both will have a significantly positive effect on growth. The authors thus suggest that creating a favorable environment for the educated may be one way to capture the returns to investments in human capital.

4.2.2 Migration as a Substitute for Subsidies

This part of the literature is concerned with the impact of high-skilled emigration on developing countries. In these models, migration streams flow typically in one direction and potential earnings in the destination country are considerably higher than in the source country. The possibility to emigrate for high-skilled workers is then found to increase the private incentives to invest in education, thereby reducing the necessity to subsidize education.
Mountford (1997) is mainly concerned with the effect that a brain drain has on the average skill level of a sending country. Most importantly, he models present productivity as a function of the average human capital of the previous period. There is therefore a growth externality to the private education decisions of the previous generation on the present level of output. Workers take the technology as exogenously given when making their education decision. Mountford shows that there will be at least one steady state level of technology. He argues that a higher level of human capital can be achieved if the country opens up to allow for skilled

emigration. The higher expected skill premium that probabilistic migration induces increases private incentives to invest in education. If the emigration probability is not too high, a brain-drain will increase the long-term income of the remaining population, if the difference in domestic and foreign skill premiums is sufficiently high. Subsidies are not explicitly discussed, but it is clear that, since individuals do not take the influence of their own human capital on the next generation's technology into account, the no-migration level of education will be inefficiently low.

Stark and Wang (2002) show that both migration and education subsidies can be a way to attain a socially desirable education rate. In their model, the equilibrium autarky level of human capital is too low under private education provision. This is the case because individuals do not consider the positive externality of their education choice on the aggregate productivity. It is subsequently demonstrated that education subsidies can help to achieve the socially desirable human capital level. The authors proceed by showing that allowing for a certain level of skilled emigration to a high wage destination can also lead to an average post-migration human capital level, that is optimal, if the differences between foreign and domestic wages are sufficiently large. In conclusion, it is shown that migration can be an alternative to subsidies. However, the authors do not explicitly calculate the optimal subsidy as a function of the migration rate.

Docquier and Rapoport (2007) argue that, if the government of the source country of migration pays education subsidies, then skilled emigration represents a net fiscal loss. The authors state that this implies that the government will have to respond by either lowering the subsidy or raising taxes for the remaining population. An explicit influence of the migration rate on the optimal subsidy is not calculated. Docquier et al. (2008) explicitly show that migration can serve as a substitute for education subsidies, from the point of view of a poor, sending country. The authors present an overlapping generations model where education creates intergenerational spillover effects on income and the return to education. All agents are homogeneous in their abilities and can emigrate to a high-wage country at a certain probability, where their expected skill premium is substantially higher. In such a scenario, a situation without migration and public education subsidies constitutes a first-best solution, if there are no distortion effects related to the subsidy. When migration is possible, the optimal education subsidy is shown to be decreasing in the migration rate. This result is caused by two channels. First, migration reduces the social return to education subsidies, since the beneficial education externalities cannot be captured for migrants. Second, the migration probability stimulates private investment in education, which decreases the necessity of subsidies to achieve the optimal education level. In the empirical part of the paper, the authors find a negative relationship between migration rate and subsidies. It is then concluded, that the beneficial brain-gain effect found in previous literature is likely to be overstated, since the endogeneity of education subsidies is typically not taken into account.

This article is closely related to our work. However, we go beyond the scope of Docquier et al. (2008) by extending our analysis on the impact of migration on education policy in the host and in the source country. Furthermore, we assume a model with different levels of skill and ability, which allows us to identify the effects of migration on the different groups.

Bertoli and Brücker (2011) present a model of a brain-drain from a *low* to a *high* income destination with selective immigration policies. In their model, the probability to be admitted to the high income destination depends linearly on the level of schooling of each individual. They find that, if the social planner maximizes the expected welfare of all the native citizens, even the potential emigrants, the optimal education subsidy will be decreasing in the slope parameter of the migration probability.

In summary, the findings of this part of the literature suggest that migration might be beneficial for the population of the poor source country and that the optimal education subsidy will be lower, if emigration is possible.

4.2.3 Local Education Provision and Labor Mobility

This part of the literature shows that labor mobility lowers incentives for regional governments to invest in publicly provided education. In these models, migration streams flow in both directions, which gives incentives to free-ride on foreign education, both because only a fraction of domestically educated workers remains at home and because immigrants provide freely available skilled-labor.
Justman and Thisse (1997) propose a model in which the amount of education is entirely determined by the authorities of each region. There are two symmetric regions between which skilled workers can migrate. The social planners will invest in education in order to maximize the profit of the local landowners, which depends on a fixed amount of land and skilled labor. After education is completed, a fraction of the skilled workers migrates from one region to the other and vice versa, such that the total fraction of skilled labor that flows out of one jurisdiction equals that of the other region. Each region thus loses part of its own skilled workforce, but receives skilled migrants. This lowers the incentive to invest in local education, since part of the investment is lost, and part of the skilled labor arrives for free. The model represents thus a Nash game between the two regions, where each region takes the other region's education investment as given. Justman and Thisse (1997) show that a higher skilled migration rate will lead to a lower investment in education. While this main finding is similar to ours, the model is very different, since it cannot capture the incentive effect that the possibility to emigrate has on workers. Furthermore, the authors do not motivate the migration decision of the skilled workers, but just assume that a certain fraction will leave, for whatever reason.

This shortcoming is addressed in Justman and Thisse (2000), where the probability of migration depends on the wage differences between the regions and the location specific amenities. They show that if skilled labor is state provided and mobile, there will be an underprovision of education if the decision is made by the local authorities, instead of a centralized authority. This shortfall in education increases as the monetary motives for migration increase. The result is reverted if the local authorities do not care about local output but about the output of the native population. Then there will be an overprovision of education. As in Justman and Thisse (1997), education decisions are made by the authorities, which implies that the migration probability will not have a positive incentive effect on the education decision of the individuals.
In both papers, migration streams between countries are balanced in equilibrium, which distinguishes them from our work. Furthermore, both models assume that public education provision is necessary, without giving an explicit justification for this, like e.g. externalities. It is simply assumed that there is no private investment in education.

Wildasin (2000) investigates several implications of labor-market integration on the investment in human capital, both public and private, when skilled labor is sector specific and mobile. He finds that, when unskilled workers are immobile and skilled workers value mobility, because it decreases their unemployment risk, public education provision will increase inequalities. With perfect mobility of skilled labor, symmetric jurisdictions will engage in a tax competition that drives taxes on skilled labor to zero. Public education will then be entirely financed by taxes on the unskilled. With labor mobility, the equilibrium level of education subsidies is found to be lower than in the case of non-integrated labor-markets, because higher subsidies decrease welfare by increasing inequality.
Poutvaara and Kanniainen (2000) show that it may be in the interest of *low*-ability workers to subsidize the education of *high*-ability individuals, if the externalities to human-capital are strong enough. However, if skilled individuals are mobile, this result will become infeasible since the skilled will leave the country if emigration increases their potential earnings. If domestic income is higher, the result is also unfeasible because the *low*-ability workers will free-ride, anticipating high skilled immigration from abroad. In equilibrium there will be an underinvestment in education.
Poutvaara (2008) investigates the public and private provision of two types of education in a federal state composed of two separate entities. One skill is country-specific, the other is internationally applicable, but working abroad implies losing a fraction of one's workforce. Wages in both regions are stochastic. Workers who have acquired the transferable skill will migrate to a different location if they can earn more abroad. Individuals will take this into account when choosing their level of education. Each individual has a comparative advantage in one of the skills. Under a public education regime, the government decides who will be trained in which

skill, depending on individuals' comparative advantages. The social planner chooses its education policy with the intention of maximizing a welfare function, composed of the weighted welfare of native stayers, native emigrants and foreign-born immigrants. It is found that, if a local government puts less weight on native emigrants' welfare than that of the stayers, there will be an underprovision of internationally applicable education, compared to the solution that a federal government would choose. This shortfall becomes more important as the international applicability of the transferable skill increases. Poutvaara (2008) then proceeds by showing that financing education through a graduate tax will lead to an equilibrium where each national government will invest more in the internationally applicable skill, compared to a situation with an income tax. A graduate tax allows governments to tax the individuals it has educated, even if they work abroad. This will increase their incentives to invest in internationally mobile students, because emigration will not lead to a shortfall in the tax-base.
The intuition behind the shortfall in a provision of internationally transferable skills is closely related to one of the five mechanisms that we identify in this paper. We show that public education expenditure is lower when the risk to loose some of the initial investment through migration rises. Poutvaara (2008) shows that, if there are two possible education regimes, governments will invest more in region specific skills in order to be sure that their investment stays. The scope of the paper however differs from ours. In Poutvaara (2008), regions are symmetric in their wages and productivity. There is therefore no systematic migration from one region to the other, as in our model. Furthermore, migration is unrestricted for those who acquired the internationally applicable education and they can freely choose whether to move or not. Another main difference is that the model is not concerned with the aggregate amount of education, but the composition of skills of its labor-force. In our model the government provides education subsidies in order to increase the productivity spillovers of education.

In an article that is in between the brain-drain and the labor-mobility literature, Haupt and Janeba (2009) show that a government who cares about maximizing the transfer that it pays to the unskilled part of the population, will decrease education subsidies when skilled migration becomes less costly. In their model, the government extracts taxes from the skilled and redistributes it to the unskilled. The skilled will emigrate if the tax burden becomes too high, in order to avoid exploitation. If migration costs are low, the skilled will be able to make a more credible threat to emigrate and thus stop paying taxes. Since the government invests in human capital in order to extract taxes from them, the investment becomes less attractive, if taxation becomes more constrained due to migration possibilities. Lower migration costs thus lead to less public investment in education.

Egger et al. (2012) investigate the incentives for governments to engage in fiscal competition in order to attract highly-skilled workers. In their model, the brain-

drain is an endogenous outcome of education policy, where the national social planners decide to invest less in education in order to have a lower tax burden and higher skilled wages which makes them more attractive for skilled immigrants. They assume that there are no exogenously given migration quotas, but that individuals can freely choose their destination, if they have previously invested in education. Governments provide a homogeneous education regime which is financed by an income tax. Once they have acquired their education, skilled individuals will leave their home if they can attain a higher utility abroad. Individuals are heterogeneous in their perceived migration cost. This assures that there are no equilibria where all the skilled workers leave one destination. The probability to migrate does not have an influence on the education choice of an individual.
The main results are that national governments of symmetric countries will engage in a tax race to the bottom in order to attract skilled workers. This will lead to an inefficiently low level of public education provision. It is subsequently shown that cooperation between governments will be hard to achieve and that such an equilibrium will be biased against migration. The main reason why we do not observe such a tax competition in our model, is that we assume highly asymmetric countries with substantial wage differences. This insures that migration streams will strictly flow in one direction.
In a related article Demange et al. (2014) predict that governments will lower their income taxes if skilled labor is mobile in order to attract high-skilled workers. In their model, education is financed through a mixture of fees and taxes. They focus on the influence that labor and student mobility has on the optimal financing scheme for education. They conclude that education provision will be increasingly financed by fees, rather than taxes, if migrants can choose their destination freely. This will lead to an underprovision of public education. If students as well are mobile, the result may shift back again, as countries will want to be attractive for high-skilled students as well.

Another article that focuses on student mobility is Mechtenberg and Strausz (2008). In a setting with two symmetric countries and endogenous migration decisions, it is shown that there are two forces that determine the effect of higher student mobility on education expenditure. Countries will want to attract the best students by offering high-quality education, if there is a high probability that they will stay after having completed their studies. On the other hand, they have an incentive to free-ride if the return rate of students is high. This will allow a country to enjoy the benefits of the higher-education provided by a third country without having to invest in education itself.
Lange (2009) also finds that the stay rate of foreign educated students is a key variable in the determination of the effect of increased student mobility on education expenditure. Other related research which finds that the free-riding problem which student mobility causes will decrease public education expenditures are Büttner and Schwager (2004), Gérard (2007), and Krieger and Lange (2010).

In one of the few empirical analyses of the relationship between globalization and education expenditures, Baskaran and Hessami (2010) find that an increase in globalization causes a shift from expenditure on primary education to tertiary education. This is explained by the fact that globalization tends to increase the wages for skilled labor, while it decreases the wages for unskilled workers.[2]
Other empirical papers on the impact of different forms of globalization on education spending, that find mixed results, are Avelino et al. (2005), Dreher et al. (2008), and Busemeyer (2009). Since these papers typically do not measure globalization by skilled migration rates, but rather by trade liberalization, the implications of their findings might not be directly applicable to our context.

4.3 A Theoretical Model of Education Subsidies and Migration

We now develop a model whose basic setup is similar to Stark and Wang (2002). We show how international migration and remittances can influence in education subsidies, both in sending and host countries. We focus on the case where the social planners of both the source and destination countries take the actual migration rate as given. They will thus adapt their education policy, in order to respond to changes in international migration.

4.3.1 Setup Sending Country

Consider the citizens of a poor country. We call this the sending or source country, because migrants will choose to leave this country for a high wage destination. Variables concerning the sending country are denoted by subscript 1. Each individual lives for two periods. When an individual is young, she can invest in education. When grown up, individuals work and produce output, which differs with respect to their previously acquired education. The total population L_1 is composed of N_l individuals that are of *low*-ability and N_h individuals that are of *high* ability. If they are of the *high* type, education causes them a cost of k_h per unit. For the *low* type, the costs are k_l. Clearly, the *high*-ability individuals experience lesser costs for education, therefore $k_h < k_l$. Education is subsidized with s for each consumed unit. These subsidies are financed through a lump sum tax τ, which every individual has to pay in the second period.[3] Stark and Wang (2002) assume an ad-valorem income tax. We depart from this assumption, because a lump sum tax allows us to focus on the implications of migration on education subsidies, without paying increased attention to the implications for the income distribution. This assumption of a lump sum tax to finance education can be equally found in Justman and

[2] Blanchard and Willmann (2013) show how trade liberalization will favor the high-skilled while crowding out the middle-class.

[3] We assume that there is no intertemporal discounting, both for taxes and income.

Thisse (2000), Mechtenberg and Strausz (2008) and Lange (2009).[4]
In addition to their income from work, individuals in the sending country receive remittance payments from emigrated family members, denoted by r.[5]

The expected lifetime income is composed of their earnings in the second period of their lives, and of their investment in education, minus the subsidy, that they make in the first period. The expected lifetime income of an individual of the *low* type, born in the sending country, depending on his education θ is given by

$$I(\theta)_l = \eta \ln(\bar{\theta}_1 + 1) + \alpha \ln(\theta + 1) - \tau_1 + r - (k_l - s_1)\theta \tag{4.1}$$

The lifetime income of the individual depends on her own education θ, but also on the average level of human capital $\bar{\theta}$, which the individual takes as given. Stark and Wang (2002) demonstrate that the fact that individuals neglect the positive externality which their education decision has on the average skill level, leads to an aggregate level of education that is lower than optimal, if there are no subsidies and no emigration possibilities.
The optimal level of education for a *low* type can be calculated to be

$$\theta_l^*(s_1) = \frac{\alpha}{k_l - s_1} - 1 \tag{4.2}$$

$\theta_l^*(s_1)$ has thus the following properties: $\partial\theta_l^*/\partial s_1 > 0$ and $\partial^2\theta_l^*/\partial s_1^2 > 0$.

Individuals of the *high*-ability type are assumed to be able to emigrate to a high wage destination with an exogenous probability p, whereas *low*-ability individuals do not have this opportunity.[6] We now deviate from the initial model by Stark and Wang (2002), by assuming that the income abroad is expected to be $\eta \ln(\bar{\theta}_2 + 1) + (1 - \varphi)\beta \ln(\theta + 1) - \tau_2$, where the subscript 2 denotes variables in the richer host country.
We assume that the social returns to education, η, are of the same size in both

[4]Some of the literature has paid closer attention to the design of the education tax. García-Peñalosa and Wälde (2000) state that a graduate tax can at the same time increase efficiency of the subsidy, by increasing the aggregate education level, and reduce inequality, compared to a traditional tax-financed subsidy. Bucovetsky (2003) argues that a progressive income tax might be an efficient way to redistribute gains from migration between regions without hurting incentives to migrate. Poutvaara (2004) and Poutvaara (2008) show that a graduate tax, as opposed to an income tax, can help to overcome the underprovision of publicly financed education in the presence of mobile skilled labor. Del Rey and Racionero (2010) argue that, if deviating from public education provision, higher education should be financed through an income contingent loan with risk-pooling in order to achieve the optimal level of education.

[5]Justman and Thisse (2000) and Poutvaara (2008) assume that the social planner puts a certain weight on the welfare of expatriated natives. Remittances are one way to explain why national governments would care about the income of expats. If the social planner anticipates that part of the income that the emigrants earn abroad is transfered back, she will implicitly place a weight on the well-being of the emigrants, and act accordingly.

[6]It is a well known finding that skilled individuals are a lot more likely to emigrate than the unskilled. See for example Docquier and Marfouk (2000).

countries, but that the private returns in the high wage destination are significantly higher, $\beta > \alpha$. Since emigrants will have to adapt to the foreign culture and their new environment, part of their productivity is lost. They thus only earn $(1-\varphi)$ of the private returns to their education, where $0 < \varphi < 1$.
Furthermore, we assume that $\bar{\theta}_2 \geq \bar{\theta}$ if there is no migration. This is a reasonable assumption, because the higher return to education in the host country should assure a higher average educational attainment for a similar distribution of abilities. The difference in wages between the two countries has therefore two sources: the direct return to education is higher, which increases the incentives to invest in education. Furthermore, the higher aggregate level of education leads to a higher income for everyone, independent of their own education decision.[7]
When individuals emigrate, their families back home will expect them to send some remittances. We propose that these remittances are proportional to the lifetime income of the emigrant. She will thus send a fraction $\delta < 1$ of her lifetime income. In order to insure that the possibility to emigrate induces individuals to invest more in their education, expected remittance payments and the loss of productivity must be small enough, such that the effective wage difference is still large enough. We therefore assume that $(1-\varphi)(1-\delta)\beta > \alpha$.

The expected lifetime income for *high* ability individuals born in the sending country is then

$$\begin{aligned} I(\theta)_h =& (1-p)\left(\eta \ln(\bar{\theta}_1 + 1) + \alpha \ln(\theta + 1) + r - \tau_1 - (k_h - s_1)\theta\right) \\ &+ p(1-\delta)\left(\eta \ln(\bar{\theta}_2 + 1) + (1-\varphi)\beta \ln(\theta + 1) - \tau_2 - (k_h - s_1)\theta\right) \end{aligned} \tag{4.3}$$

The optimal level of education for a *high* type individual is then calculated as

$$\theta_h^*(s_1) = \frac{\alpha + p(\beta(1-\delta)(1-\varphi) - \alpha)}{(k_h - s_1)(1 - p\delta)} - 1 \tag{4.4}$$

The properties of $\theta_h^*(s_1)$ are
$\partial\theta_h^*/\partial s_1 > 0$, $\partial^2\theta_h^*/\partial s_1^2 > 0$, $\partial\theta_h^*/\partial p > 0$, $\partial^2\theta_h^*/\partial p^2 = 0$, $\partial^2\theta_h^*/\partial s_1 \partial p > 0$ and $\partial\theta_h^*/\partial\delta < 0$.
Obviously, since the educational attainment for *high* and *low* types is determined by the subsidy, also the post-emigration average level of education can be expressed as a function of s.

$$\bar{\theta}_1^*(s_1) = \frac{N_l\theta_l^*(s_1) + (1-p)N_h\theta_h^*(s_1)}{N_l + (1-p)N_h} \tag{4.5}$$

The social planner's aim is to maximize the expected lifetime income per capita of the domestic post-emigration population. Emigration affects this in three ways. First, it raises the educational investment of high skilled individuals, since they expect a higher potential return to education when migration is possible. Second,

[7] We assume that the population of each country is so large, that each individual neglects the effect that her education decision has on the average level of education.

it depletes the stock of high skilled individuals. This affects both the average level of education and the taxable income, since part of the tax base leaves the country. Third, the expected remittances increase when p increases, both because of the sheer mass of emigrants, but also because these emigrants have a higher level of education if they expect that their possibility of emigration is high.
As in Stark and Wang (2002), we assume that the parameters of the model are such that a brain-gain is possible for low-enough emigration rates. This means that the average skill-rate of the source country is increasing in p at low emigration rates. The derivative of the average education level with respect to p is calculated as

$$\frac{\partial \bar{\theta}_1^*}{\partial p} = \frac{N_h}{N_l + (1-p)N_h}\Big((1-p)\big(N_l + (1-p)N_h\big)\frac{\partial \theta_h^*}{\partial p} - N_l(\theta_h^* - \theta_l^*)\Big) \tag{4.6}$$

This becomes negative as p approaches one. For $p = 0$, it is positive if the following condition holds.

$$\frac{N_h + N_l}{N_l}(1-\delta)\frac{(1-\varphi)\beta - \alpha}{\alpha} > 1 - \frac{k_h - s_1}{k_l - s_1} \tag{4.7}$$

This will be fulfilled for a high enough difference between foreign and domestic private returns to education, $(1-\phi)\beta - \alpha$ and for a remittances that are not excessive. For $(1-\varphi)(1-\delta)\beta \geq 2\alpha$ a brain gain exists at $p = 0$ for any values of k_h, k_l and for any values of N_l.[8] For the remainder of the paper, we will assume this effective wage gap is indeed sufficiently large to assure that a brain gain is possible for low emigration rates.

The post-emigration per capita lifetime income of the source country can be calculated as

$$\begin{aligned}
&\bar{W}_1(s_1) = \\
&\frac{1}{N_l + (1-p)N_h} * \\
&[N_l\left(\eta \ln(\bar{\theta}_1^*(s_1) + 1) + \alpha \ln(\theta_l^*(s_1) + 1) + r - \tau_1 - (k_l - s_1)\theta_l^*(s_1)\right) \\
&+ (1-p)N_h\left(\eta \ln(\bar{\theta}_1^*(s_1) + 1) + \alpha \ln(\theta_h^*(s_1) + 1) + r - \tau_1 - (k_h - s_1)\theta_h^*(s_1)\right)]
\end{aligned} \tag{4.8}$$

To insure equilibrium, the social planner has to set the lump sum tax τ_1 such that the inter-temporal budget constraint is fulfilled with equality. Individuals are taxed once they work. High skilled emigrants receive an education subsidy when they are young, but do not pay taxes once they are grown up, because they will earn their

[8] This is analogous to the assumption in Stark and Wang (2002) that $\beta \geq 2\alpha$.

income abroad. This increases the tax burden for all remaining individuals.

$$\begin{aligned}\tau_1(N_l + (1-p)N_h) =& s_1(N_l\theta_l^*(s_1) + N_h\theta_h^*(s_1)) \\ \tau_1 =& s_1\frac{(L_1 - N_h)\theta_l^*(s_1) + N_h\theta_h^*(s_1)}{L_1 - pN_h}\end{aligned} \tag{4.9}$$

In the last line we used $L_1 = N_l + N_h$.

The second constraint is, that the sum of remittances that the inhabitants of the sending country receive have to equal the sum of the share of the lifetime income that the emigrants send back home.

$$\begin{aligned}&(N_l + (1-p)N_h)r = \\ &pN_h\delta\big((\eta\ln(\bar{\theta}_2^*(s_1) + 1) + (1-\varphi)\beta\ln(\theta_h^*(s_1) + 1) - \tau_2 - (k_h - s_1)\theta_h^*(s_1)\big)\end{aligned} \tag{4.10}$$

Setting equations (4.9) and (4.10) into (4.8) and rewriting, we get the following equation for expected per capita lifetime income.

$$\begin{aligned}&\bar{W}_1(s_1) = \\ &\frac{1}{L_1 - pN_h}* \\ &[(L_1 - N_h)\left(\eta\ln(\bar{\theta}_1^*(s_1) + 1) + \alpha\ln(\theta_l^*(s_1) + 1) - k_l\theta_l^*(s_1)\right) \\ &+ (1-p)N_h\left(\eta\ln(\bar{\theta}_1^*(s_1) + 1) + \alpha\ln(\theta_h^*(s_1) + 1) - k_h\theta_h^*(s_1)\right) \\ &- pN_h s_1\theta_h^*(s_1) \\ &+ pN_h\delta\big((\eta\ln(\bar{\theta}_2^*(s_1) + 1) + (1-\varphi)\beta\ln(\theta_h^*(s_1) + 1) - \tau_2 - (k_h - s_1)\theta_h^*(s_1)\big)]\end{aligned} \tag{4.11}$$

We see from this that the remaining members of the source country have to pay for the education subsidies received by the high-skilled emigrants. However, this is partly or entirely offset by the remittances that the emigrants transfer back home. Whether or not the direct effect on the budget is positive or negative depends crucially on the fraction of their income that the emigrants send back. The effect of remittances on the optimal education policy will be discussed in a separate section of this paper.
We now first proceed with the setup for the host country.

4.3.2 Setup Destination Country

We now develop a model that will allow us to analyze the effect of high-skilled immigration on the education policy of a high wage country. Contrary to the sending country, the host country, or destination country as we also call it, will unambiguously benefit from increased openness, as long as the effective productivity of the

high skilled immigrants θ_h^* lies above the average education of the host country under autarky $\bar{\theta}_2^*$. The subscript 2 denotes variables of the host or destination country. The production technology in the high wage country is slightly different from the poorer country, with private returns to education β instead of α. Natives of the host country will not emigrate. Consequently, the inhabitants do not receive any remittance payments. The lifetime income for a native of the destination country can thus be calculated as

$$I_2(\theta) = \eta(\bar{\theta}_2 + 1) + \beta \ln(\theta + 1) - \tau_2 - (k_2 - s_2)\theta \tag{4.12}$$

We implicitly make the assumption, that the spillover effect η of education on the technology of the host country is the same as for the sending country. The private return to education on the other hand is considerably larger than in the sending country, $\beta > \alpha$. As in the sending country, education is partly subsidized with s_2. The subsidy is financed through a lump sum tax τ_2 that individuals have to pay in the second period. To simplify our analysis, we assume that all individuals that are born in the destination country are of the same ability, and their perceived costs of education are k_2 per unit.[9] Any individual born in the host country will choose education in order to maximize her lifetime income.
We then find that the optimal level of education for an individual that is born in the host country is

$$\theta_2^*(s_2) = \frac{\beta}{k_2 - s_2} - 1 \tag{4.13}$$

We impose that β and k_2 are such that $\theta_h^* > \theta_2^* > \theta_l^* \quad p \in (0, 1)$.

As stated in the previous section, immigrants have to be skilled in order to be admitted. However, there is some productivity loss as a result of adapting to a new environment. In addition to the private loss of productivity φ that we already discussed, the education of foreign workers will also contribute less to the positive spillovers than native workers. The spillover effect of foreign worker's education on total productivity is reduced by γ. The effective average level of education in the destination country can then be calculated as

$$\bar{\theta}_2^*(s_2, s_1) = \frac{L_2\theta_2^*(s_2) + pN_h(1 - \gamma)\theta_h^*(s_1)}{L_2 + pN_h} \tag{4.14}$$

[9] This simplification allows us to concentrate on the implications of immigration on education policy, without having to discuss the distributional consequences. However, as shown by Benhabib (1996), the impact of immigration on the income of natives differs considerably when natives have heterogeneous levels of skill (or capital-labor ratios), and the equilibrium immigration policy will then be determined by the skill-level of the median voter, compared to the skill-level of the immigrants. If the skill of the immigrants is complementary to that of natives, they will benefit from immigration. The resulting immigration policy of a country is such that it benefits the median voter. We would expect that allowing for two skill types in the host country would then imply that low-skilled natives benefit from skilled immigration, while high-skilled natives will not. However, since this is not the question of our paper, we choose to abstract from these distributional concerns.

This is increasing in p as long as $(1-\gamma)\theta_h^* > \theta_2^*$. The education level of high skilled immigrants does not depend on the host country's education policy, because they acquire their skills in the sending country, and receive the sending country's subsidy.[10] As stated in the section above, we assume that $\bar{\theta}_2^* \geq \bar{\theta}_1^*$ for all $p \in (0,1)$.

The social planner of the host country anticipates that immigrants will send a fraction δ of their income as remittances to their families abroad, and thus spend less in the host country. As a consequence, she chooses the education subsidy that maximizes the per capita post-immigration, post-remittance lifetime income of the country's population.

$$\bar{W}_2(s_2) =$$
$$\frac{1}{L_2 + pN_h} * [L_2 \left(\eta(\bar{\theta}_2^*(s_2)+1) + \beta \ln(\theta_2^*(s_2)+1) - \tau_2 - (k_2 - s_2)\theta_2^*(s_2)\right)$$
$$+pN_h(1-\delta)\big(\eta(\bar{\theta}_2^*(s_2)+1) + (1-\varphi)\beta \ln(\theta_h^*(s_1)+1) - \tau_2 - (k_h - s_1)\theta_h^*(s_1)\big)] \tag{4.15}$$

The fact that the social planner takes the remittances of the immigrants into account has the effect of putting a lower weight on their lifetime income than on that of the native population.
The social planner of the host country cannot influence the education decision of the high skilled immigrants, because to him, s_1 is an exogenous variable. We will therefore change the notation of immigrant education level from the host county' s point of view to $\theta_h^*(s_1) = \theta_h^*(\bar{s_1}) = \theta_h^*$.
The lump sum tax is set in order to fulfill the intertemporal budget constraint.

$$\tau_2(L_2 + pN_h) = s_2 L_2 \theta_2^*(s_2) \tag{4.16}$$

This simplifies the per capita lifetime income to

$$\begin{aligned}\bar{W}_2(s_2) =& \frac{1}{L_2 + pN_h}[L_2\big(\eta \ln(\bar{\theta}_2^*(s_2)+1) + \beta \ln(\theta_2^*(s_2)+1) - k_2\theta_2^*(s_2)\big) \\ &+ pN_h(1-\delta)\big(\eta \ln(\bar{\theta}_2^*(s_2)+1) + (1-\varphi)\beta \ln(\theta_h^*+1) - (k_h - s_1)\theta_h^*\big) \\ &+ pN_h\delta s_2 \theta_2^*(s_2)\frac{L_2}{L_2 + pN_h}]\end{aligned} \tag{4.17}$$

Since only part of the income of the immigrants remains in the economy of the destination country, the social planner cares less about the loss that the tax im-

[10] It could be argued that the education policy of the host country has an indirect effect on the education in the sending country, because it improves technology in the destination country and thereby the expected return to migration. However, we chose to model the spillover such that it creates a non-skill dependent income effect, and will therefore not influence the education decision of potential immigrants.

poses on the immigrants' lifetime income. The subsidy creates a redistribution of income form the immigrants to the natives: Only the natives receive the subsidy, but it is financed through a tax on both groups. Since the social planners cares implicitly more about the income of the natives under the presence of remittances, this explains the positive last term in equation (4.17).

4.3.3 Education Policy of the Source Country Without Remittances

In order to be able to clearly distinguish the different channels through which emigration influences the education policy in the sending country, we will now first look at a scenario, where the expected remittances are zero. Since there is no formal commitment by the emigrants to send money back home, this might be a realistic starting point for our analysis. Throughout this section we thus set

$$r = \delta = 0 \tag{4.18}$$

We now analyze how a government that wants to maximize the lifetime income of its post-emigration domestic population will adapt its education policy to an increase in the skilled emigration rate. We take the derivative of equation (4.11) with respect to s_1 and set it equal to zero to receive the social planner's first order condition.

$$\begin{aligned}
\frac{d\bar{W}_1(s_1^*)}{ds_1}|_{\delta=0} =& (L_1 - N_h)\Big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_l^*(s_1^*)+1} - k_l\big)\frac{\partial\theta_l^*}{\partial s_1}\Big) \\
&+(1-p)N_h\Big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial\theta_h^*}{\partial s_1}\Big) \\
&-pN_h\left(s_1^*\frac{\partial\theta_h^*}{\partial s_1} + \theta_h^*(s_1^*)\right) \stackrel{!}{=} 0 \\
&\equiv g_1(s_1^*, p)|_{\delta=0}
\end{aligned} \tag{4.19}$$

Proposition 12. *When the social planner of the source country sets the education policy in order to maximize expected lifetime income of the local post-emigration population and if there are no remittances, the optimal education subsidy, s_1^*, is strictly decreasing in the skilled emigration rate p, for p small enough in order to insure $\frac{\partial\bar{\theta}_1^*}{\partial p} > 0$.*

Proof. We refrain from solving explicitly for s_1^* as a function of p, but will instead use the implicit function theorem to obtain an expression for $\frac{ds_1^*}{dp}$. Since

$$\frac{\partial s_1^*}{\partial p}(p) = -\frac{\frac{\partial g_1}{\partial p}(p, s_1^*(p))}{\frac{\partial g_1}{\partial s_1}(p, s_1^*(p))} \tag{4.20}$$

we need to determine the partial derivatives of g_1 with respect to p and s_1.

$\partial g_1/\partial s_1 < 0$ is a necessary condition for s_1^* to be a local maximum.[11]

$$\frac{\partial g_1(s_1^*)}{\partial s_1}|_{\delta=0} < 0 \tag{4.21}$$

It is thus sufficient to show that $\partial g_1/\partial p < 0$.
In order to get to know the effect of migration on the optimal subsidy, we now take the derivative with respect to p.

$$\begin{aligned}
&\frac{\partial g_1}{\partial p}(s_1^*(p),p)|_{\delta=0} = \\
&(L_1 - pN_h)\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial^2\bar{\theta}_1^*}{\partial s_1 \partial p} - \frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\frac{\partial\bar{\theta}_1^*}{\partial p}\right) \\
&-N_h\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial\theta_h^*}{\partial s_1} + s_1^*\frac{\partial\theta_h^*}{\partial s_1} + \theta_h^*(s_1^*)\right) \\
&+(1-p)N_h\left(\frac{\partial^2\theta_h^*}{\partial s_1\partial p}\big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big) - \frac{\alpha}{(\theta_h^*(s_1^*))^2}\frac{\partial\theta_h^*}{\partial s_1}\frac{\partial\theta_h^*}{\partial p}\right) \\
&-pN_h\left(s_1^*\frac{\partial^2\theta_h^*}{\partial s_1\partial p} + \frac{\partial\theta_h^*}{\partial p}\right)
\end{aligned} \tag{4.22}$$

where we used the fact that $\frac{\partial\theta_l^*}{\partial p} = 0$ to simplify. Rewriting the above expression, using the FOC and some other operations[12], we get that

$$\begin{aligned}
&\frac{\partial g_1}{\partial p}(s_1^*(p),p)|_{\delta=0} = \\
&-(L_1 - pN_h)\left(\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\frac{\partial\bar{\theta}_1^*}{\partial p}\right) \\
&-N_h\Big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\big(\frac{\partial\theta_h^*}{\partial s_1} - (1-p)\frac{\partial^2\theta_h^*}{\partial s_1\partial p}\big) + \theta_h^*(s_1^*)\Big) \\
&-(1-p)N_h\Big((s_1^* + \frac{(k_h - s_1^*)p(\beta-\alpha)}{\alpha + p(\beta-\alpha)})\frac{\partial^2\theta_h^*}{\partial s_1\partial p} + \frac{\alpha}{(\theta_h^*(s_1^*))^2}\frac{\partial\theta_h^*}{\partial s_1^*}\frac{\partial\theta_h^*}{\partial p}\Big) \\
&-pN_h s_1^*\frac{\partial^2\theta_h^*}{\partial s_1\partial p}
\end{aligned} \tag{4.23}$$

For p such that $\partial\bar{\theta}_1^*/\partial p > 0$ we can then state that[13]

$$\frac{\partial g_1(s_1^*)}{\partial p}|_{\delta=0} < 0 \tag{4.24}$$

[11] This will be the case if the social planner's objective function is concave in the education subsidy. We verify this in the Appendix.
[12] See Appendix
[13] See Appendix for proof

Together with equation (4.21) this implies that

$$\frac{\partial s_1^*}{\partial p}|_{\delta=0} < 0 \tag{4.25}$$

□

The higher the emigration rate of skilled workers, the lower the optimal education subsidy. This is intuitive. If all educated individuals remained in their birthplace, the increase in the aggregate education induced by the subsidy would be captured entirely by the country. With emigration however, there are five channels that lower the benefits of the subsidy.

First, the effect that the subsidy has on the average skill level is directly influenced by skilled emigration. We call this the *appropriation* effect. The subsidy increases the optimal private level of human capital, both for skilled and unskilled individuals, and through this, the average skill level. However, part of this effect is lost due to migration, because a fraction of the skilled will leave the country, taking with them their human capital. This effect is partly offset, because with a higher migration probability, the incentive effect of the subsidy is magnified for the *high* ability individuals, $\partial^2\theta_h^*/\partial s_1 \partial p > 0$. Overall however, migration makes it more difficult to *appropriate* the positive effects of a subsidy.

Second, as also shown by Docquier et al. (2008), the incentive effect that the possibility of emigration to a high-wage country induces, serves as a substitute for subsidies. The higher the migration rate, the higher the level of education of the *high*-ability individuals. A brain-gain thus brings the economy closer to its optimal average level of education, and a subsidy becomes less necessary. This effect, interacted with the higher tax burden for the remaining population has an additional negative effect on the optimal subsidy. With a higher migration rate, the *high*-ability individuals will invest more in education, thus receiving a higher subsidy. When some of those emigrate, the tax burden for the remaining population becomes even higher.

Third, part of the most skilled individuals will leave the country before they start their productive activities. The welfare effect that the subsidy has on these high-skilled emigrants is not accounted for, if the social planner cares only about the welfare of the post-emigration population. The emigrants will not experience the positive influence that the subsidy has on the source country's productivity, because they choose to work abroad.

Fourth, the high skilled emigrants do not pay taxes once they emigrated. The remaining population has thus to pay for the education subsidy that the emigrants received prior to their emigration. The higher the emigration rate, the higher the per capita tax rate will be, in order to finance the education subsidies. This will lead to a lower optimal education subsidy, in order to lower the taxes for the remaining population.

Fifth and last, the *high*-ability workers will invest more in education if they can

emigrate at a certain probability. Those *high*-ability workers that stay behind, will have over-invested in education, because their actual private return to education α is lower than the expected private return $\alpha + p(\beta - \alpha)$. It is thus, *ex-post*, counter-productive to further increase their investment by subsidizing their education.[14]
Some of the channels are related, but not identical to the ones already identified in the literature. The high tax burden on the remaining population for example has been identified by Wildasin (2000) as one reason for why labor mobility will lower public education expenditure. In Wildasin (2000) however, the reason for the high tax burden is that national governments will lower taxes in order to attract high-skilled immigrants. This motive is absent in our analysis. In our model, the taxes for the *low* ability workers rise, because the tax-base shrinks due to emigration, not because of fiscal competition.

Proposition 13. *With p such that $\partial\bar{\theta}_1^*/\partial p < 0$, it may or may not be that the optimal education subsidy is decreasing in p.*

When we have a situation where the skilled emigration rate p is so high, that the source country experiences a net brain-drain, it depends on the parameters of the model, whether or not a further increase in the emigration rate will lower the optimal education subsidy. If the population of *low* ability workers N_l is large compared to the *high* ability group, it can be that the brain-drain effect on the education subsidy dominates the other effects. An additional condition for this to occur, is that η, the social return to education, must be relatively high compared to α and β, the domestic and foreign private return to education.

The intuition behind this is the following. If η is relatively high, compared to the private return to education, the difference between the optimal private amount of education and the social optimum will be very high. In such a scenario, the need for an education subsidy is especially important. With an important brain drain, a big fraction of the *high* ability workers will leave the country and not contribute to the average skill level of the source country. The social planner may then choose to increase the skill-level of the *low*-ability workers in order to boost the average skill level. Since we only allow for one subsidy, aimed both at *low* and *high* ability workers, it may then be, for large N_l, that the motive to fight off the brain drain by investing more in education, will dominate the other motives.[15]
For moderate values of η, the brain drain motive should typically not dominate the other motives.

4.3.4 Education Policy of the Host Country without Remittances

For the host country as well, we will start to analyze the case without remittances, i.e. $\delta = r = 0$. Taking the partial derivative of equation (4.17) with respect to s_2,

[14] See Appendix for an identification of the five distinct effects in equation (4.22).

[15] This finding is related to Poutvaara (2008), who finds that a government will invest more in non-transferable skills. We find that, if the population of *low* ability workers, who by assumption cannot emigrate, is large, the provision of the subsidy will respond positively to emigration.

the first order condition of the social planner can be calculated as

$$\begin{aligned}\frac{\partial \bar{W}_2}{\partial s_2}(s_2^*)|_{\delta=0} =& (L_2 + pN_h)\left(\frac{\eta}{\bar{\theta}_2^*(s_2^*)+1}\frac{\partial \bar{\theta}_2^*}{\partial s_2}\right) + L_2\left(\frac{\beta}{\theta_2^*(s_2^*)+1} - k_2\right)\frac{\partial \theta_2^*}{\partial s_2} \\ &\stackrel{!}{=} 0 \\ &\equiv g_2(s_2^*(p), p)|_{\delta=0}\end{aligned} \tag{4.26}$$

Proposition 14. *When the social planner of the destination country chooses its education policy in order to maximize the expected lifetime income of the post-immigration population in the host country, the optimal education subsidy s_2^* will be strictly decreasing in the skilled migration rate p, as long as $(1+\gamma)\theta_h^* > \theta_2^*$.*

Proof. Using equation (4.14) and noting that $\partial\theta_h^*/\partial s_2 = 0$, $\partial\theta_2^*/\partial s_2 > 0$ and that $\beta/(\theta_2^*+1) - k_2 = -s^*$, we can further simplify $g_2(s_2^*, p)$.

$$g_2(s_2^*(p), p)|_{\delta=0} = \frac{\eta}{\bar{\theta}_2^*(s_2^*)+1} - s_2^* \stackrel{!}{=} 0 \tag{4.27}$$

As in the previous section, we are now using the implicit function theorem on $g_2(s_2^*(p), p)$ in order to find $\frac{\partial s_2^*}{\partial p}$.
We first calculate $\frac{\partial g_2}{\partial s_2}$.

$$\frac{\partial g_2}{\partial s_2}(s_2^*(p), p)|_{\delta=0} = -\left(\frac{\eta}{(\bar{\theta}_2^*(s_2^*)+1)^2}\frac{L_2}{L_2 + pN_h}\right)\frac{\partial \theta_2^*}{\partial s_2} - 1 < 0 \tag{4.28}$$

As before, average utility is a concave and increasing function of the subsidy, and there therefore exists a maximum. Taking the derivative of g_2 with respect to p, we obtain

$$\frac{\partial g_2}{\partial p}|_{\delta=0} = -\frac{\eta}{(\bar{\theta}_2^*(s_2^*)+1)^2}\frac{\partial \bar{\theta}_2^*}{\partial p} < 0 \tag{4.29}$$

Taken together with equation (4.28) and the implicit function theorem, this implies, that

$$\frac{\partial s_2^*}{\partial p}|_{\delta=0} < 0 \tag{4.30}$$

□

As for the source country, the education optimal education subsidy is thus found to be decreasing in the skilled migration rate p. For the host country, the reasoning behind this is different than for the sending country. Immigration increases the average level of education for the destination country unambiguously, as long as the loss in productivity that relocation induces does not set off the education advantage of the foreigners, i.e. as long as $(1-\gamma)\theta_h^* > \theta_2^*$. Therefore, high skilled immigration can be seen as a subsidy for education subsidies, that does not impose any costs on the host country. The country has to invest less in order to attain the educational

level it is aiming for, if immigration is possible and can free-ride on the education policy of the source country.

4.3.5 The Policy-Effect of Remittances

In the two previous sections, we have shown that in the absence of remittances, migration will unambiguously lower public education provision, both in the sending and in the host country. The problem becomes more complex, if we start to account for remittances.
We will first investigate the effect on the optimal policy of the sending country.

Remittance Effect Sending Country

The social planner's first order condition (4.19) changes to

$$\begin{aligned}\frac{d\bar{W}_1(s_1^*)}{ds_1} =&(L_1 - N_h)\Big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_l^*(s_1^*)+1} - k_l\big)\frac{\partial\theta_l^*}{\partial s_1}\Big)\\ &+(1-p)N_h\Big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial\theta_h^*}{\partial s_1}\Big)\\ &+pN_h\delta\Big(\frac{\eta}{\bar{\theta}_2^*(s_1^*)+1}\frac{\partial\bar{\theta}_2^*}{\partial s_1} + \big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial\theta_h^*}{\partial s_1}\Big)\\ &-pN_h(1-\delta)\left(s_1^*\frac{\partial\theta_h^*}{\partial s_1} + \theta_h^*(s_1^*)\right) \stackrel{!}{=} 0\\ \equiv& g_1(s_1^*, p, \delta)\end{aligned} \tag{4.31}$$

A rational social planner of the source country will take the influence of its education policy on the average foreign human capital level $\bar{\theta_2}$ into account. Increasing the education subsidy in the source country leads to a higher level of education among the emigrants, which will in turn have a positive impact on the average skill level in the destination country. Consequently, this will then also result in higher remittances.
The total influence of remittances on the optimal education policy is described by the following proposition.

Proposition 15. *If emigrants remit a fraction δ of their lifetime income to their country of origin, the optimal education subsidy of the sending country s_1^* will be unambiguously increasing in this fraction, if $\delta \leq 1/2$.*[16]

$$\frac{\partial s_1^*}{\partial \delta} > 0 \tag{4.32}$$

[16]Note that $\delta \leq 1/2$ is merely a sufficient, but by no means a necessary condition for $\frac{\partial s_1^*}{\partial \delta} > 0$. There are many parameter constellations for which $\frac{\partial s_1^*}{\partial \delta} > 0$ is indeed positive for $\delta \in (0, 1)$.

Proof. We make again use of the implicit function theorem and take the derivative of g_1 with respect to δ. As we have shown before, s_1^* describes a local welfare maximum, and it must again be that $\partial g_1(s_1^*)/\partial s_1 < 0$. The sign of $\partial g_1(s_1^*)/\partial \delta$ will thus be the same as for $\partial s_1^*/\partial \delta$. After some operations[17] we get the result that

$$\frac{\partial g_1(s_1^*)}{\partial \delta} =$$

$$\underbrace{-(L_1 - pN_h)\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial \bar{\theta}_1^*}{\partial s_1}\frac{\partial \bar{\theta}_1^*}{\partial \delta}}_{>0} \quad \underbrace{-pN_h(1-\delta)(s_1^*\frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta} + \frac{\partial \theta_h^*}{\partial \delta})}_{>0}$$

$$\underbrace{+(1-p)N_h\Big((\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1} + \frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h)\frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta} - \frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial \theta_h^*}{\partial s_1}\frac{\partial \theta_h^*}{\partial \delta}\Big)}_{>0}$$

$$+ pN_h *$$

$$\Big[\underbrace{\delta\Big(-\frac{\eta}{(\bar{\theta}_2^*(s_1^*)+1)^2}\frac{\partial \bar{\theta}_2^*}{\partial s_1}\frac{\partial \bar{\theta}_2^*}{\partial \delta} - \frac{(1-\varphi)\beta}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial \theta_h^*}{\partial s_1}\frac{\partial \theta_h^*}{\partial \delta} - s_1^*\frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta}\Big)}_{>0}$$

$$\underbrace{+\Big(\frac{\eta}{\bar{\theta}_2^*(s_1^*)+1}(\frac{\partial \bar{\theta}_2^*}{\partial s_1} + \delta\frac{\partial^2 \bar{\theta}_2^*}{\partial s_1 \partial \delta}) + \big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1} - (k_h - s_1^*)\big)(\frac{\partial \theta_h^*}{\partial s_1} + \delta\frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta}) + \theta_h^*(s_1^*)\Big)}_{\lesseqgtr 0}\Big] \tag{4.33}$$

We can show that the last line is unambiguously positive for $\delta \leq 1/2$.[18]
Thus, we find that

$$\frac{\partial g_1(s_1^*)}{\partial \delta}|_{\delta \leq \frac{1}{2}} > 0 \tag{4.34}$$

□

Proposition 15 tells us, that the negative effect that skilled emigration has on education subsidies in the country of origin is countered by a positive remittance effect. Higher expected remittances imply, that the social planner of the sending country will put a greater weight on the influence that its education policy has on the lifetime earnings of emigrants. Indeed, for very large income differences between host and sending countries and at very high remittance rates, it is possible that the total effect of emigration on education subsidies is reversed by the remittance effect. In such a scenario, the tax burden and the appropriation effect are dominated by the increase in net remittances, that an increase in the education subsidies would imply.

Proposition 16. *For large enough differences in the effective private returns to education between sending and host countries,* $(1-\varphi)\beta >> \alpha$*, and for large enough*

[17] See Appendix
[18] See Appendix

remittance shares δ, it is possible that the optimal education policy of the sending country is increasing in p.[19]

The intuition behind proposition 16 is, that at high remittance rates and high differences between foreign and domestic private returns to education, it is worthwhile to increase education subsidies, because the expected increase in remittances this causes will be larger than the net tax loss. While one might suspect that very high private education returns in the destination country would be sufficient to increase private investment in education to the desired point, this is not necessarily the case if the remittance rate is very high. Therefore, the social planner will want to subsidize education in order to give sufficient incentives for potential emigrants to invest in their education, thereby increasing the expected future remittances.

Remittance Effect Host Country

In the destination country as well, remittances will influence the optimal education policy. To get the destination country's FOC with remittances, we take the derivative of equation (4.17) with respect to s_2.

$$\begin{aligned}\frac{\partial \bar{W}_2}{\partial s_2}(s_2^*) =& (L_2 + (1-\delta)pN_h)\left(\frac{\eta}{\bar{\theta}_2^*(s_2^*)+1}\frac{\partial \bar{\theta}_2^*}{\partial s_2}\right) + L_2\left(\frac{\beta}{\theta_2^*(s_2^*)+1} - k_2\right)\frac{\partial \theta_2^*}{\partial s_2} \\ &+ \delta\frac{pN_hL_2}{L_2+pN_h}(s_2^*\frac{\partial \theta_2^*}{\partial s_2} + \theta_2^*) \\ &\stackrel{!}{=} 0 \\ &\equiv g_2(s_2^*(p), p, \delta)\end{aligned} \tag{4.35}$$

It can be immediately seen from the last term, that at higher remittances, the net effect of subsidies on the tax burden is increasing. Since immigrants only spend part of their lifetime income in the destination country, the social planner will be willing to tax them more, in order to be able to afford more public education for the natives. At the same time, the social planner also cares less about the impact of the education induced productivity spillover of subsidies on the immigrants.
We can still formulate a clear proposition with respect to the effect of remittances on the destination country' s policy.

Proposition 17. *If immigrants remit a fraction δ of their lifetime income to their country of origin, the optimal education subsidy in the destination country will be increasing in this remittance rate.*

$$\frac{\partial s_2^*}{\partial \delta} > 0 \tag{4.36}$$

[19] See Appendix for an illustration of this proposition

Proof. We can rewrite equation (4.35), making use of the fact that $\frac{\beta}{\theta_2^*(s_2^*)+1} - k_2 = -s_2^*$ and that $\partial\bar{\theta}_2^*/\partial s_2 = L_2/(L_2+pN_h)(\partial\theta_2^*/\partial s_2)$.

$$g_2(s_2^*,p,\delta) = \frac{L_2}{L_2+pN_h}\Big((L_2+(1-\delta)pN_h)\underbrace{(\frac{\eta}{\bar{\theta}_2^*(s_2^*)+1} - s_2^*)}_{<0}\frac{\partial\theta_2^*}{\partial s_2} + \delta pN_h\theta_2^*(s_2^*)\Big) \stackrel{!}{=} 0 \tag{4.37}$$

The term we have pointed out has to be strictly negative for equation (4.37) to hold.
We now take the derivative with respect to δ, noting that $\frac{\partial\theta_2^*}{\partial\delta} = 0$ and $\frac{\partial\bar{\theta}_2^*}{\partial\delta} < 0$.

$$\begin{aligned}\frac{\partial g_2(s_2^*,p,\delta)}{\partial\delta} =& pN_h\Big(-(\frac{\eta}{\bar{\theta}_2^*(s_2^*)+1} - s_2^*)\frac{\partial\theta_2^*}{\partial s_2} + \theta_2^*(s_2^*)\Big) \\ &-(L_2+(1-\delta)pN_h)\frac{\eta}{(\bar{\theta}_2^*+1)^2}\frac{\partial\theta_2^*}{\partial s_2}\frac{\partial\bar{\theta}_2^*}{\partial\delta} > 0\end{aligned} \tag{4.38}$$

Together with the condition that $\partial g_2/\partial s_2 < 0$, the implicit function theorem then tells us that

$$\frac{\partial s_2^*}{\partial\delta} > 0 \tag{4.39}$$

□

There are thus indeed two effects of remittances on the optimal subsidy in the destination country. First, there is the direct effect, that with higher remittances, less of the lifetime income of the immigrants stays in the host economy. The social planner thus cares less about the lifetime income of immigrants. He will then raise higher taxes in order to subsidize the education of natives. Second, sine remittances decrease the incentives for immigrants to invest in education, the average level of education of immigrants will be lower if their families expect remittance payments. To counter this effect, the social planner of the host country will then increase education subsidies, in order to increase the education of the natives.
As for the sending country, it is possible that this remittance effect leads to an overall positive influence of immigration on education subsidies.

Proposition 18. *For large remittance rates δ and $\partial\bar{\theta}_2^*/\partial p$ small enough, it is possible that $\partial s_2^*/\partial p > 0$.*

We illustrate this in the appendix. This reversal can only occur, if the effective skill difference between sending and host country $(1-\gamma)\theta_h^* - \theta_2^*$ is very small, such that the free-ride motive of the host-country's education policy gets dominated by the remittance-driven tax motive.

4.3.6 A Global View on Education Subsidies

We have shown above that national educational policies depend on the degree of openness of the economies. If migration between the two economies is possible,

both have an incentive to lower or increase their educational subsidies, depending on the level of remittances.

We now want to ask the question of whether this national behavior is optimal from an aggregate view. As has been shown by Justman and Thisse (2000), Poutvaara (2008), Egger et al. (2012), and Demange et al. (2014), if countries are symmetric and national governments take the education spending of the other country as given, than the equilibrium education expenditure in each country will be lower than the globally optimal expenditure. With symmetric countries, this is driven by two main channels. First, each country is concerned about losing its investment, if skilled workers are mobile. Second, with symmetry between countries, the migration decision is typically endogenous. The national governments will then engage in a fiscal race to the bottom and lower expenditures and taxes in order to become attractive for potential immigrants.

We now want to show that the finding, that in a mobile world national public education provision will be lower than globally optimal, also holds for highly asymmetric countries, where the migration is an exogenous variable. As we have shown, in the absence of remittances migration decreases the incentive of each region to invest in education. We will now compare the national education policies, with the one chosen by a social planner, who aims at maximizing the global lifetime income per capita.

We look at a scenario, in which the social planner can set an optimal subsidy in each country and finance it by raising taxes in both countries. The social planner will then set an education policy in order to maximize global per capita lifetime income $\bar{W}_G$

$$\begin{aligned}\bar{W}_G =& \frac{1}{L_1+L_2}[L_2\left(\eta\ln(\bar{\theta}_2^*(s_1,s_2)+1)+\beta\ln(\theta_2^*(s_2)+1)-\tau_2-(k_2-s_2)\theta_2^*(s_2)\right)\\ &+pN_h(1-\delta)*\\ &\Big(\eta\ln(\bar{\theta}_2^*(s_1,s_2)+1)+(1-\varphi)\beta\ln(\theta_h^*(s_1)+1)-\tau_2-(k_h-s_1)\theta_h^*(s_1)\Big)\\ &+(1-p)N_h\left(\eta\ln(\bar{\theta}_1^*(s_1)+1)+\alpha\ln(\theta_h^*(s_1)+1)+r-\tau_1-(k_h-s_1)\theta_h^*(s_1)\right)\\ &+N_l\left(\eta\ln(\bar{\theta}_1^*(s_1)+1)+\alpha\ln(\theta_l^*(s_1)+1)+r-\tau_1-(k_l-s_1)\theta_l^*(s_1)\right)]\end{aligned} \tag{4.40}$$

The global inter-temporal budget constraint [20] is then the following:

$$L_2s_2\theta_2^*+N_hs_1\theta_h^*+N_ls_1\theta_l^*\leq(L_2+pN_h)\tau_2+(L_1-pN_h)\tau_1 \tag{4.41}$$

[20] Note that, if we chose the somewhat stronger budget constraint, that every region has to have a balanced budget, this would not change the result, because both budget constraints cancel out. See Appendix for proof.

The remittance constraint as described by equation (4.10) remains unchanged. Setting the two constraints into the objective function, equation (4.40) simplifies to

$$\begin{aligned}\bar{W}_G =& \frac{1}{L_1+L_2}[L_2\left(\eta\ln(\bar{\theta}_2^*(s_1,s_2)+1)+\beta\ln(\theta_2^*(s_2)+1)-k_2\theta_2^*(s_2)\right)\\ &+pN_h\left(\eta\ln(\bar{\theta}_2^*(s_1,s_2)+1)+(1-\varphi)\beta\ln(\theta_h^*(s_1)+1)-k_h\theta_h^*(s_1)\right)\\ &+(1-p)N_h\left(\eta\ln(\bar{\theta}_1^*(s_1)+1)+\alpha\ln(\theta_h^*(s_1)+1)-k_h\theta_h^*(s_1)\right)\\ &+N_l\left(\eta\ln(\bar{\theta}_1^*(s_1)+1)+\alpha\ln(\theta_l^*(s_1)+1)-k_l\theta_l^*(s_1)\right)]\end{aligned} \tag{4.42}$$

From this we see that the average welfare is only indirectly affected by the policy, through the education choice of the individuals.
We will now compare the globally optimal policies for each country with those chosen by the national governments. First we take the derivative of the global objective function with respect to the subsidy imposed on the sending country.

$$\begin{aligned}\frac{d\bar{W}_G}{ds_1} =& (L_2+pN_h)\frac{\eta}{\bar{\theta}_2^*(s_{G,1}^*)+1}\frac{\partial\bar{\theta}_2^*}{\partial s_1}+(N_l+(1-p)N_h)\frac{\eta}{\bar{\theta}_1^*(s_{G,1}^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\\ &+N_l\left(\frac{\alpha}{\theta_l^*(s_{G,1}^*)+1}-k_l\right)\frac{\partial\theta_l^*}{\partial s_1}+(1-p)N_h\left(\frac{\alpha}{\theta_h^*(s_{G,1}^*)+1}-k_h\right)\frac{\partial\theta_h^*}{\partial s_1}\\ &+pN_h\left(\frac{(1-\varphi)\beta}{\theta_h^*(s_{G,1}^*)+1}-k_h\right)\frac{\partial\theta_h^*}{\partial s_1}\stackrel{!}{=}0\\ &\equiv g_{G,1}(s_{G,1}^*,p)\end{aligned} \tag{4.43}$$

Proposition 19. *The globally optimal education subsidy for the source country $s_{G,1}^*$ will be strictly higher than the optimal national policy s_1^* if the skilled migration rate is strictly positive, $p>0$, for all $\delta\in(0,1)$.*

Proof. We simplify equation (4.43), using equation (4.19) and compare it to $g_1(s_{G,1}^*,p)$ as defined in equation (4.31).

$$\begin{aligned}&g_{G,1}(s_{G,1}^*,p)=\\ &g_1(s_{G,1}^*,p)+(L_2+(1-\delta)pN_h)\frac{\eta}{\bar{\theta}_2^*(s_{G,1}^*)+1}\frac{\partial\bar{\theta}_2^*}{\partial s_1}\\ &+(1-\delta)pN_h\Big(\underbrace{\left(\frac{(1-\varphi)\beta}{\theta_h^*(s_{G,1}^*)+1}-(k_h-s_{G,1}^*)\right)}_{>0}\frac{\partial\theta_h^*}{\partial s_1}+\theta_h^*(s_{G,1}^*)\Big)\stackrel{!}{=}0\end{aligned} \tag{4.44}$$

The global FOC is the same as for the sending country if $p=0$, since $\frac{\partial\bar{\theta}_2^*}{\partial s_1}|_{p=0}=0$. Under autarky, the global government and the national government would thus

choose the same education policy.
The second term and third term are strictly positive for $p > 0$ and $\delta < 1$. For the FOC to be fulfilled, it has to be that $s^*_{G,1} > s^*_1$ for $p > 0$, because $\partial g_1/\partial s_1 < 0$. □

From this we can conclude, that the globally optimal education policy that the government of the source country sets, given that $p > 0$, will be strictly lower than the subsidy which maximizes global welfare. This is driven by the fact that the global social planner takes the effect of the subsidy on the lifetime income of the emigrants fully into account, whereas the national social planner cares only about the fraction that is remitted. Furthermore, the global social planner also considers the spillover effect that the subsidy of the sending country has on the average level of education in the host country and thus on the income of the foreign natives. Additionally the tax motive for subsidy reduction does not exist anymore. The national planner does not take into account that emigrants have a direct income effect from the subsidy, which cancels out the higher tax burden on the non-migrants.
This discrepancy between globally and nationally optimal education policy becomes smaller as remittances increase. With a high δ, the social planner of the source country will care more about the effect that its policy has on the lifetime income of the emigrants, because they will send a significant part of this income back home. Also, the tax motive to reduce education subsidies decreases when remittances increase. Note however that even at a remittance rate of 100 percent, the nationally optimal education subsidies will be lower than the global optimum. This is the case, because the national social planner does not take the international spillover effect of its subsidy on the income of the foreign-born citizens of the host country into account.

We now investigate the globally optimal education subsidy for the host country. Taking the derivative of (4.42) with respect to s_2, we get that

$$\begin{aligned}\frac{\partial \bar{W}_{Global}}{\partial s_2} =& (L_2 + pN_h)\left(\frac{\eta}{\bar{\theta}^*_2(s^*_{G,2}) + 1}\frac{\partial \bar{\theta}^*_2}{\partial s_2}\right) + L_2\left(\frac{\beta}{\theta^*_2(s^*_{G,2}) + 1} - k_2\right)\frac{\partial \theta^*_2}{\partial s_2} \\ &\stackrel{!}{=} 0 \\ &\equiv g_{G,2}(s^*_{G,2}, p)\end{aligned} \tag{4.45}$$

where the subscript $G, 2$ identifies this as a function that determines the globally optimal policy for country 2.

Proposition 20. *Without remittances, the globally optimal education subsidy for the host country $s^*_{G,2}$ is identical to the optimal national policy s^*_1.*
With strictly positive remittances and migration rate, $\delta > 0, p > 0$, $s^*_{G,2}$ is strictly smaller than the optimal national policy s^*_1.

Proof. Comparing equation (4.26) with (4.45), we see directly that $g_{G,2}(s_2^*(p), p) = g_2(s_2^*(p), p)$ if $\delta = 0$. This implies that the subsidy that the global social planner will impose on the host economy will be the same as the country would choose itself, if there are no remittances.
With remittances, we have that

$$g_{G,2}(s^*_{G,2}, p) =$$
$$g_2(s^*_{G,2}, p) + \frac{\delta p N_h L_2}{L_2 + pN_h}\Big(\underbrace{(\frac{\eta}{\bar{\theta}_2^*(s^*_{G,2}) + 1} - s^*_{G,2})}_{\leq 0} \frac{\partial \theta_2^*}{\partial s_2} - \theta_2^*(s^*_{G,2})\Big) \stackrel{!}{=} 0 \tag{4.46}$$

For the FOC to be fulfilled, it has to be that $s^*_{G,2} < s_1^*$ for $p > 0, \delta > 0$, because $\partial g_2 / \partial s_2 < 0$. □

Under autarky, we find again that the optimal national education policy for the host country is the same as the optimal global policy. With migration and no remittances, the optimal policies are still the same, since the policy of the host country does not have any spillover effects on the source country, and the social planner weights immigrants' and natives' income in the same way. Once remittances become possible and anticipated, the optimal global education subsidy of the host country will be smaller than the one set by the national social planner. This is the case, because the national social planner will put a lesser weight on the income of immigrants if they remit part of their earnings back home. The social planner thus sets an inefficiently high education subsidy that is cross-financed by higher taxes at the cost of the immigrants. As a result, only the level of education of the natives increases, but both immigrants and natives have to pay more for it.

We can draw another conclusion from this analysis.

Proposition 21. *Under national education regimes and without remittances, the average level of education in each country $\bar{\theta}_j$, $j \in (1, 2)$ is strictly lower than under the globally optimal subsidies, if $p > 0$.*

$$\bar{\theta}_j^*(s_j^*) < \bar{\theta}_j^*(s^*_{G,j}) \quad j \in (1, 2) \tag{4.47}$$

Proof. As we have shown in proposition 19, $s^*_{G,1} > s_1^*$. We then have that

$$\begin{aligned} \bar{\theta}_1^*(s_1^*) &= \frac{N_l \theta_l^*(s_1^*) + (1-p) N_h \theta_h^*(s_1^*)}{N_l + (1-p)N_h} \\ &< \frac{N_l \theta_l^*(s^*_{G,1}) + (1-p) N_h \theta_h^*(s^*_{G,1})}{N_l + (1-p)N_h} = \bar{\theta}_1^*(s^*_{G,1}) \end{aligned} \tag{4.48}$$

because both θ_l^* and θ_h^* are strictly increasing in s_1.

For the host country, we have that

$$\begin{aligned}\bar{\theta}_2^*(s_1^*) &= \frac{L_2\theta_2^*(s_2^*) + (1-\gamma)pN_h\theta_h^*(s_1^*)}{L_2 + pN_h} \\ &< \frac{L_2\theta_2^*(s_{G,2}^*) + (1-\gamma)pN_h\theta_h^*(s_{G,1}^*)}{L_2 + pN_h} = \bar{\theta}_2^*(s_{G,1}^*)\end{aligned} \tag{4.49}$$

which holds because θ_h^* is strictly increasing in s_1 and $\theta_2^*(s_2^*) = \theta_2^*(s_{G,2}^*)$.

□

The intuition behind proposition 21 is clear for the source country. Since it invests less in education than what would be globally optimal, the average education level is lower. For the host country, the intuition is less clear. Even though it spends as much in education as is globally optimal, the average education level is lower than in the globally optimal equilibrium. The reason for this is, that due to the low education subsidies of the source country, the skill-level of the immigrants will be lower than under the global optimum. This then lowers the average education rate of the host country.
Note that the skill-level of the immigrants in the host country is by assumption still higher than the average of the population of the host country. Thus immigration still increases the average skill level in the destination country. It just increases it less than what would be globally optimal.

With remittances, the proposition becomes less clear.

Proposition 22. *Under national education regimes and with remittances, the average level of education in the source country $\bar{\theta}_1$ is strictly lower than under the globally optimal subsidies, if $p > 0$.*

$$\bar{\theta}_1^*(s_{1,\delta}^*) < \bar{\theta}_1^*(s_{G,1,\delta}^*) \tag{4.50}$$

The average level of education in the host country $\bar{\theta}_2$ is higher or lower than under the globally optimal subsidies, if $p > 0$.

$$\bar{\theta}_2^*(s_{1,\delta}^*, s_{2,\delta}^*) \lessgtr \bar{\theta}_2^*(s_{1,\delta}^*, s_{G,2,\delta}^*) \tag{4.51}$$

Proof. For $\bar{\theta}_1^*$ the proof remains the same, since $s_{1,\delta}^* < s_{G,1,\delta}^*$ for $\delta \in (0,1)$. For $\bar{\theta}_2^*(s_{1,\delta}^*, s_{G,2,\delta}^*)$ it depends on whether the effect of the increase in the foreign subsidy offsets the decrease in the national subsidy. □

With remittances, the level of human capital in the sending country under the policy of a national social planner will still be unambiguously lower than what would be globally optimal. The gap is however becoming smaller if remittances are higher.
For the level of education in the host country, it depends on the level of remittances

and on the total number of immigrants. If remittances are not excessively high, we should still see the previous finding, that the average education level in the host country is lower than globally optimal: For non-excessive remittance rates, the effect of the less than globally optimal education subsidy of the sending country will dominate the more than globally optimal spending of the host country .

4.3.7 Extension for $(1-\gamma)\theta_h^* < \theta_2^*$

It might be argued that the adaption cost of immigration is so large that even the high skilled immigrants will effectively be less productive abroad than the average native. In such a scenario, immigration will lower the average skill level in the host country.[21] We have shown in the previous section of this paper that the social planner of the destination country will lower the education subsidy as a result of immigration, if remittances are not too high. This was driven by the assumption that high skilled immigration will increase the average skill-level of the economy and therefore serve as a substitute for subsidies. If however immigration lowers the average skill level, the optimal policy response should change.
In such a case, where $\theta_2^* > (1-\gamma)\theta_h^*$, we can see from equation (4.29), that whether or not the optimal policy response to immigration changes signs depends also on the incentive effect of emigration on the migrant's education decision. We rewrite equation (4.29) to see this.

$$\frac{\partial g_2}{\partial p} = -\frac{\eta}{(\bar{\theta}_2^*(s_2^*)+1)^2}\frac{N_h}{L_2+pN_h}(-\bar{\theta}_2^*(s_2^*)+(1-\gamma)\theta_h^*+(1-\gamma)p\frac{\partial \theta_h^*}{\partial p}) \qquad (4.52)$$

Equation (4.52) implies that even if $(1-\gamma)\theta_h^* < \theta_2^*$, it might be that $\partial\bar{\theta}_2^*/\partial p > 0$, if the difference between $(1-\gamma)\theta_h^*$ and θ_2^* is small and p is large. This is the case, because additional immigrants will have a lower level of education than the native population, but the level of education of the immigrants is increasing in their education prospects.
For $(1-\gamma)\theta_h^* << \theta_2^*$, equation (4.52) becomes positive. This shows that if more immigration leads to a lower aggregate level of education in the host country, the social planner will react by increasing education expenditure. The host country can then no longer boost its productivity by skilled immigration, but instead has to invest more in order to react to the lower average education by making education cheaper for its own native population.

This result does not have any implications for the difference between the globally optimal education policy and the national ones. The host country will adopt the policy that maximizes global welfare, as long as there are no remittances, and spend

[21] As Benhabib (1996) shows, in such a case immigration might still be beneficial for some of the natives, if skill-rates are heterogeneous and skills complementary. Thus, even if immigration decreases the aggregate skill-level, a positive amount of immigration can still be a desirable policy for the host country.

more than globally optimal, if remittances are positive. We can immediately see this from proposition 20.

4.4 Conclusion

This paper has demonstrated, that both source and host countries will lower their optimal education subsidies as a response to high skilled migration, if remittances are not excessively high. In the case of the source country, this behavior implies that not only do they lose part of their *high*-ability workers, but also, the *low*-ability workers that stay behind will have a lower than optimal level of education. With lower education subsidies, the *low*-ability individuals will choose to invest less in education than they would under autarky, because the subsidy is decreasing in the level of skilled migration. For the remaining *high*-ability workers, it might be that the possibility to emigrate will give them a sufficient incentive to invest more in education, despite the low subsidy.

What we find suggests, that migration from third to first world does not only entail a direct brain-drain effect, but also, it will lead to a lower public investment in education in the source country. Even if the incentive effect of migration on the private education decision of the *high*-ability workers outweighs the loss of skilled workers, the additional decrease in public funding makes it highly unlikely that migration will have a beneficial brain-gain effect on the poor source countries. The "brains" will already be "drained" before they are formed, because of the insufficient public incentives to invest in their education. This effect is especially strong when there are two groups of workers, one with the prospect of migration, and one without it. The potential migrants might still attain a high level of education, because the motivation to earn a high salary abroad can set off the lacking public education provision. Those that do not consider emigration an option however, will unambiguously suffer from migration for three reasons. First and foremost, they will attain a lower level of education, because public education provision decreases. Second, they will have to pay higher taxes in order to cover the free education that the high-skilled emigrants have enjoyed. Third, if the decrease in education subsidies and the loss of skilled migrants outweighs the private incentive effect of the non-migrants, their productivity will be lower, because the average education level and thus the level of technology in the economy will be lower.

On the other hand, we have shown that these findings can be mediated, and even potentially reversed, once the policymakers anticipate that migrants will send remittances to their families back home. For the source country, anticipated remittances will imply that the social planner cares about the income of the emigrants, since they will send part of their earnings to the source country. Since these earnings depend on the emigrants education, and thus on the education policy in the source country, the social planner can increase the expected remittance payments

by setting higher education subsidies. For high enough income differences between country of origin and destination, and for high remittance rates, this effect can even dominate the negative direct effect of emigration on education subsidies.
For the host country, remittances imply that less of the income of the immigrants will be spend domestically. The social planner will anticipate this and therefore care less about the impact of taxes on the earnings of the immigrants. He will then set higher taxes, and finance higher education subsidies for the natives, thereby decreasing the remittances to the source country.

This analysis has severe policy implications. If there are very asymmetric migration streams between two countries, driven by high income differences, then the education policy should absolutely be coordinated between the two countries. Poutvaara (2008) has shown for the case of two symmetric countries, with endogenous migration decisions, that graduate taxes might be one way to overcome the dilemma of an underprovision of public funding for education. In our case, this would only resolve one of the five reasons that drive an underinvestment in the source country. However, encouraging migrants to send back remittances will have beneficial effects from a global point of view. Therefore, it would be very helpful to facilitate financial transactions between host countries and countries of origins. Additionally, the host country will have an incentive to contribute to the education expenditures of the source country, because the skill-level of the immigrants it receives will be higher, if they have acquired a better education. One way to encounter this problem, that might be beneficial to all, could be to link development aid to a binding commitment of the developing countries to invest a considerable amount of the aid in education.

If however remittances are not sufficient and it is not possible to find a way to successfully coordinate education policy between sending and host countries, the repercussions are particularly grim for the source countries. As we have argued, human capital formation is key to economic growth and technological innovation. However, if the social returns to human capital formation outweigh the private returns, there will be an underinvestment in education if it is not publicly financed. Decreasing education expenditures as a response to labor mobility will thus lead to an inefficiently low level of human capital in the developing countries, and thereby decrease their chances of ever catching up with the industrial countries. Furthermore, it is the remaining individuals of the poor source economy who finance the education for the emigrants, which essentially benefits the richer country and the emigrants who are better off than the population of the source country. From an egalitarian point of view, this injustice is yet another reason that necessitates the international coordination of public education expenditures.

Appendix

4..1 Showing that $\partial g_1/\partial s_1 < 0$

We take the derivative of $g_1(s_1^*)$ with respect to s_1 in order to make sure that s_1^* is a local maximum.

$$\begin{aligned}\frac{\partial g_1}{\partial s_1} =&(L_1 - pN_h)\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial^2\bar{\theta}_1^*}{\partial s_1^2} - \frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\right)\\ &+(L_1 - N_h)\left(\big(\frac{\alpha}{\theta_l^*(s_1^*)+1} - k_l\big)\frac{\partial^2\theta_l^*}{\partial s_1^2} - \frac{\alpha}{(\theta_l^*(s_1^*)+1)^2}\frac{\partial\theta_l^*}{\partial s_1}\frac{\partial\theta_l^*(s_1^*)}{\partial s_1}\right)\\ &+(1-p)N_h\left(\big(\frac{\alpha}{\theta_l^*(s_1^*)+1} - k_h\big)\frac{\partial^2\theta_h^*}{\partial s_1^2} - \frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial\theta_h^*}{\partial s_1}\frac{\partial\theta_h^*}{\partial s_1}\right)\\ &-pN_h\left(2\frac{\partial\theta_h^*}{\partial s_1} + s_1\frac{\partial^2\theta_h^*}{\partial s_1^2}\right)\end{aligned} \tag{4.53}$$

Noting that

$$\frac{\partial^2\bar{\theta}_1^*}{\partial s_1^2} = \frac{(L_1 - N_h)\frac{\partial^2\theta_l^*}{\partial s_1^2} + (1-p)N_h\frac{\partial^2\theta_h^*}{\partial s_1^2}}{L_1 - pN_h} \tag{4.54}$$

and making use of the fact that $\frac{\alpha}{\theta_l^*(s_1)+1} - k_l = -s_1$ and that $\frac{\alpha}{\theta_h^*(s_1)+1} - k_h = -(s_1 + (k_h - s_1)\frac{p(\beta-\alpha)}{\alpha+p(\beta-\alpha)})$ we can simplify the equation.

$$\begin{aligned}\frac{\partial g_1}{\partial s_1} =&\big(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1} - s_1^*\big)\Big((L_1 - N_h)\frac{\partial^2\theta_l^*}{\partial s_1^2} + (1-p)N_h\frac{\partial^2\theta_h^*}{\partial s_1^2}\Big)\\ &-p(1-p)N_h\frac{\partial^2\theta_h^*}{\partial s_1^2}\frac{(k_h - s_1^*)(\beta-\alpha)}{\alpha+p(\beta-\alpha)} - pN_h\big(2\frac{\partial\theta_h^*}{\partial s_1} + s_1^*\frac{\partial^2\theta_h^*}{\partial s_1^2}\big)\\ &-(L_1 - pN_h)\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}(\frac{\partial\bar{\theta}_1^*}{\partial s_1})^2 - (L_1 - N_h)\frac{\alpha}{(\theta_l^*(s_1^*)+1)^2}(\frac{\partial\theta_l^*}{\partial s_1})^2\\ &-(1-p)N_h\frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}(\frac{\partial\theta_h^*}{\partial s_1})^2\end{aligned} \tag{4.55}$$

Using the convenient transformation of

$$\frac{\partial^2\theta_j^*}{\partial s_1^2} = \frac{2}{k_j - s_1^*}\frac{\partial\theta_j^*}{\partial s_1} \quad j \in (h,l) \tag{4.56}$$

Using equation (4.19) and modifying it slightly, we can then rewrite equation (4.55) as

$$\begin{aligned}\frac{\partial g_1}{\partial s_1} =& \frac{2}{k_h - s_1^*}\big(g_1(s_1^*) - pN_h\big) \\ &-(L_1 - pN_h)\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}(\frac{\partial \bar{\theta}_1^*}{\partial s_1})^2 - (L_1 - N_h)\frac{\alpha}{(\theta_l^*(s_1^*)+1)^2}(\frac{\partial \theta_l^*}{\partial s_1})^2 \\ &-(1-p)N_h\frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}(\frac{\partial \theta_h^*}{\partial s_1})^2 < 0\end{aligned} \tag{4.57}$$

It is immediately clear that this has to be negative since $g_1(s_1^*) = 0$ follows from the first order condition.

4..2 From Equation (4.22) to (4.23)

Using equation (4.5), we can make the following simplification.

$$\frac{\partial^2 \bar{\theta}_1^*}{\partial s_1 \partial p} = \frac{N_h}{L_1 - pN_h}\frac{\partial \bar{\theta}_1^*}{\partial s_1} + \frac{(1-p)N_h\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p} - N_h\frac{\partial \theta_h^*}{\partial s_1}}{L_1 - pN_h} \tag{4.58}$$

As a last step, we then note that

$$-\big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial \theta_h^*}{\partial s_1} = s_1^*\frac{\partial \theta_h^*}{\partial s_1} + p\frac{\partial \theta_h^*}{\partial p} \tag{4.59}$$

Substituting equation (4.58) and (4.59) into equation (4.22), this results into equation (4.23) after reshuffling terms.

4..3 The Five Channels through which Migration Lowers the Optimal Education Subsidy.

We rewrite equation (4.22) in order to identify the different influences of migration on the optimal subsidy.

$$\begin{aligned}\frac{\partial g_1}{\partial p}(s_1^*(p),p) =&(N_l+(1-p)N_h)\Bigg(\underbrace{\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial^2\bar{\theta}_1^*}{\partial s_1\partial p}}_{\textit{1st effect: Appropriation}} - \underbrace{\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial\bar{\theta}_1^*}{\partial s_1}\frac{\partial\bar{\theta}_1^*}{\partial p}}_{\textit{2nd effect: Substitute for subsidies}}\Bigg)\\ &\underbrace{-N_h\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial\bar{\theta}_1^*}{\partial s_1}+\left(\frac{\alpha}{\theta_h^*(s_1^*)+1}-k_h\right)\frac{\partial\theta_h^*}{\partial s_1}\right)}_{\textit{3rd effect: Subsidy's influence on emigrants' welfare}}\\ &\underbrace{\underbrace{-N_h\left(s_1^*\frac{\partial\theta_h^*}{\partial s_1}+\theta_h^*(s_1^*)\right)-\underbrace{pN_h\left(s_1^*\frac{\partial^2\theta_h^*}{\partial s_1\partial p}+\frac{\partial\theta_h^*}{\partial p}\right)}_{\textit{Interaction term: Brain-gain x Tax burden}}}_{\textit{4th effect: Tax burden}}}\\ &\underbrace{-(1-p)N_h\left(\frac{\partial^2\theta_h^*}{\partial s_1\partial p}\left(k_h-\frac{\alpha}{\theta_h^*(s_1^*)+1}\right)+\frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial\theta_h^*}{\partial s_1}\frac{\partial\theta_h^*}{\partial p}\right)}_{\textit{5th effect: Overeducation of high-ability stayers}}\end{aligned} \tag{4.60}$$

For the *appropriation* effect, we have that

$$\frac{\partial^2\bar{\theta}_1^*}{\partial s_1\partial p}=\frac{N_h}{N_l+(1-p)N_h}\Big(\underbrace{-\left(\frac{\partial\theta_h^*}{\partial s_1}-\frac{\partial\bar{\theta}_1^*}{\partial s_1}\right)}_{\textit{Subsidy effect is lost on h-ability}}+\underbrace{(1-p)\frac{\partial^2\theta_h^*}{\partial s_1\partial p}}_{\textit{p magnifies impact of s on h stayers}}\Big) \tag{4.61}$$

For a high brain-gain effect, it can be, that the second part dominates the first. In total, all the five channels together imply that migration has a negative effect on the optimal subsidy.

4..4 Proof for $\frac{\partial g_1}{\partial p} < 0$ when $\frac{\partial \bar{\theta}_1^*}{\partial p} > 0$

Proof. We can write equation (4.23) as

$$\begin{aligned}\frac{\partial g_1}{\partial p} = &-(L_1 - pN_h)\left(\frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial \bar{\theta}_1^*}{\partial s_1}\frac{\partial \bar{\theta}_1^*}{\partial p}\right)\\ &-(1-p)N_h\frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial \theta_h^*}{\partial s_1}\frac{\partial \theta_h^*}{\partial p} - N_h\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial \theta_h^*}{\partial s_1}\\ &-(1-p)N_h\Big(s_1^* + \frac{(k_h - s_1^*)p(\beta-\alpha)}{\alpha + p(\beta-\alpha)}\Big)\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p} - pN_h s_1^*\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p}\\ &+N_h\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}(1-p)\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p} - N_h\theta_h^*(s_1^*)\end{aligned} \tag{4.62}$$

Since the first row of (4.62) is strictly negative, it is sufficient to show that the last two lines are negative for all p. We denote the last two lines as $\Delta(s_1, p)$. Δ can be written as

$$\begin{aligned}\Delta(s_1^*, p) = &\underbrace{N_h(1-p)\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p}}_{Ib}\underbrace{\Big((\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1} - s_1^*) - p\big(\frac{(k_h - s_1^*)(\beta-\alpha)}{\alpha + p(\beta-\alpha)}\big) - \frac{p}{1-p}s_1^*\Big)}_{IIb}\\ &-\underbrace{N_h\theta_h^*(s_1^*)}_{IIIb}\end{aligned} \tag{4.63}$$

We can now compare Δ to the FOC g_1. For this purpose, we rewrite g_1.

$$\begin{aligned}g_1(s_1^*, p) = &\underbrace{N_h\frac{(1-p)}{p}\frac{\partial \theta_h^*}{\partial s_1}}_{I,\quad >0}\underbrace{\Big(\varepsilon(p)\,(\underbrace{\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1} - s_1^*}_{\geq 0}) - p\big(\frac{(k_h - s_1^*)(\beta-\alpha)}{\alpha + p(\beta-\alpha)}\big) - \frac{p}{1-p}s_1^*\Big)}_{II,\quad \geq 0}\\ &-\underbrace{N_h\theta_h^*(s_1^*)}_{III,\quad >0} \stackrel{!}{=} 0\end{aligned} \tag{4.64}$$

where $\varepsilon(p) = \frac{(L_1 - N_h)\frac{\partial \theta_l^*}{\partial s_1} + (1-p)N_h\frac{\partial \theta_h^*}{\partial s_1}}{(1-p)N_h\frac{\partial \theta_h^*}{\partial s_1}} > 1$. We can thus see that $III = IIIb$, $II > IIb$ and $I > Ib$ because $\frac{\partial \theta_h^*}{\partial s_1} \geq p\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p}$. It must thus be that

$$\Delta(s_1^*, p) < 0 \tag{4.65}$$

This concludes the proof. □

4..5 Calculations and Proof for Proposition 15

First note that

$$\begin{aligned}\frac{\partial\theta_h^*}{\partial\delta} &= -\frac{p(1-p)\big((1-\varphi)\beta-\alpha\big)}{(k_h-s_1)(1-\delta p)^2} < 0\\ \frac{\partial^2\theta_h^*}{\partial s_1\partial\delta} &= -\frac{p(1-p)\big((1-\varphi)\beta-\alpha\big)}{\big((k_h-s_1)(1-\delta p)\big)^2} = \frac{1}{k_h-s_1}\frac{\partial\theta_h^*}{\partial\delta} =< 0\end{aligned} \tag{4.66}$$

$\frac{\partial g_1(s_1^*)}{\partial\delta}$ is calculated as

$$\begin{aligned}&\frac{\partial g_1(s_1^*)}{\partial\delta} =\\ &-(L_1-pN_h)\frac{\eta}{(\bar\theta_1^*(s_1^*)+1)^2}\frac{\partial\bar\theta_1^*}{\partial s_1}\frac{\partial\bar\theta_1^*}{\partial\delta}\\ &+(1-p)N_h\Big((\frac{\eta}{\bar\theta_1^*(s_1^*)+1}+\frac{\alpha}{\theta_h^*(s_1^*)+1}-k_h)\frac{\partial^2\theta_h^*}{\partial s_1\partial\delta}-\frac{\alpha}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial\theta_h^*}{\partial s_1}\frac{\partial\theta_h^*}{\partial\delta}\Big)\\ &+pN_h\Big(\frac{\eta}{\bar\theta_2^*(s_1^*)+1}\frac{\partial\bar\theta_2^*}{\partial s_1}+\big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1}-(k_h-s_1^*)\big)\frac{\partial\theta_h^*}{\partial s_1}+\theta_h^*(s_1^*)\Big)\\ &-pN_h(1-\delta)(s_1^*\frac{\partial^2\theta_h^*}{\partial s_1\partial\delta}+\frac{\partial\theta_h^*}{\partial\delta})\\ &+pN_h\delta\Big[\frac{\eta}{\bar\theta_2^*(s_1^*)+1}\frac{\partial^2\bar\theta_2^*}{\partial s_1\partial\delta}-\frac{\eta}{(\bar\theta_2^*(s_1^*)+1)^2}\frac{\partial\bar\theta_2^*}{\partial s_1}\frac{\partial\bar\theta_2^*}{\partial\delta}+\big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1}-k_h\big)\frac{\partial^2\theta_h^*}{\partial s_1\partial\delta}\\ &-\frac{(1-\varphi)\beta}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial\theta_h^*}{\partial s_1}\frac{\partial\theta_h^*}{\partial\delta}\Big]\end{aligned} \tag{4.67}$$

We know from the social planner's first order condition that at $p=0$ we have that $\frac{\eta}{\bar\theta_1^*+1}=k_h-\frac{\alpha}{\theta_h^*+1}$. We know that $\frac{\partial\bar\theta_1^*}{\partial p}<\frac{\partial\theta_h^*}{\partial p}$, and can thus easily show that

$$\frac{d\frac{\eta}{\bar\theta_1^*+1}}{dp}=-\frac{\eta}{(\bar\theta_1^*+1)^2}\frac{\partial\bar\theta_1^*}{\partial p}<\frac{d(k_h-\frac{\alpha}{\theta_h^*+1})}{dp}=\frac{\alpha}{(\theta_h^*+1)^2}\frac{\partial\bar\theta_h^*}{\partial p} \tag{4.68}$$

We can thus state that for $p>0$, $\frac{\eta}{\bar\theta_1^*+1}+\frac{\alpha}{\theta_h^*+1}-k_h<0$. This ensures, that the second term is positive.

In a next step, we add up line three and five, and add and subtract $s_1^*\frac{\partial^2\theta_h^*}{\partial s_1\partial\delta}$. The new line four of equation (4.33) is easily seen to be unambiguously positive. Line five of equation (4.33) can be expressed as

$$pN_h\Big(\frac{\big((1-\gamma)pN_h}{L_2+pN_h}\frac{\eta}{\bar\theta_2^*(s_1^*)+1}+\big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1}-(k_h-s_1^*)\big)\big)(\frac{\partial\theta_h^*}{\partial s_1}+\delta\frac{\partial^2\theta_h^*}{\partial s_1\partial\delta})+\theta_h^*(s_1^*)\Big) \tag{4.69}$$

It can also easily be shown that

$$\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1} - (k_h - s_1^*) = \frac{(k_h - s_1^*)(1-p)\big((1-\varphi)\beta - \alpha\big)}{\alpha + p\big((1-\varphi)(1-\delta)\beta - \alpha\big)} > 0 \tag{4.70}$$

We then have that $\frac{\partial \theta_h^*}{\partial s_1} + \delta \frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta} > 0$ is a suffcient condition for the entire expression to be positive. At $\delta \leq 1/2$ this is fulfilled for all $p \in (0,1)$.

$$\frac{\partial \theta_h^*}{\partial s_1} + \delta \frac{\partial^2 \theta_h^*}{\partial s_1 \partial \delta}|_{\delta \leq \frac{1}{2}} = \frac{(1-p)\alpha + p(1-\varphi)\beta(1-2\delta+p\delta^2)}{\big((k_h - s_1)(1-\delta p)\big)^2} > 0 \tag{4.71}$$

4..6 Illustration of Proposition 16

It is sufficient to show that $\frac{\partial g_1}{\partial p} > 0$ is possible for some values of $(1-\varphi)\beta$ and δ. With remittances equation (4.22) becomes

$$\begin{aligned}
&\frac{\partial g_1}{\partial p}(s_1^*(p), p) = \\
&(L_1 - pN_h)\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial^2 \bar{\theta}_1^*}{\partial s_1 \partial p} - \frac{\eta}{(\bar{\theta}_1^*(s_1^*)+1)^2}\frac{\partial \bar{\theta}_1^*}{\partial s_1}\frac{\partial \bar{\theta}_1^*}{\partial p}\right) \\
&-N_h\left(\frac{\eta}{\bar{\theta}_1^*(s_1^*)+1}\frac{\partial \bar{\theta}_1^*}{\partial s_1} + \big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial \theta_h^*}{\partial s_1} + (1-\delta)\Big(s_1^*\frac{\partial \theta_h^*}{\partial s_1} + \theta_h^*(s_1^*)\Big)\right) \\
&+(1-p)N_h\left(\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p}\big(\frac{\alpha}{\theta_h^*(s_1^*)+1} - k_h\big) - \frac{\alpha}{(\theta_h^*(s_1^*))^2}\frac{\partial \theta_h^*}{\partial s_1}\frac{\partial \theta_h^*}{\partial p}\right) \\
&-(1-\delta)pN_h\left(s_1^*\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p} + \frac{\partial \theta_h^*}{\partial p}\right) \\
&+\delta N_h\Big(\frac{\eta}{\bar{\theta}_2^*(s_1^*)+1}\frac{\partial \bar{\theta}_2^*}{\partial s_1} + \big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial \theta_h^*}{\partial s_1}\Big) \\
&+\delta p N_h\Big(\frac{\eta}{\bar{\theta}_2^*(s_1^*)+1}\frac{\partial^2 \bar{\theta}_2^*}{\partial s_1 \partial p} - \frac{\eta}{(\bar{\theta}_2^*(s_1^*)+1)^2}\frac{\partial \bar{\theta}_2^*}{\partial s_1}\frac{\partial \bar{\theta}_2^*}{\partial p} \\
&\quad + \big(\frac{(1-\varphi)\beta}{\theta_h^*(s_1^*)+1} - k_h\big)\frac{\partial^2 \theta_h^*}{\partial s_1 \partial p} - \frac{(1-\varphi)\beta}{(\theta_h^*(s_1^*)+1)^2}\frac{\partial \theta_h^*}{\partial s_1}\frac{\partial \theta_h^*}{\partial p}\Big)
\end{aligned} \tag{4.72}$$

It is clear that for very large $(1-\varphi)\beta$ and δ, the two last terms of the above expression can dominate the entire equation, and change its sign.

4..7 Illustration of Proposition 18

Equation (4.35) can be written as

$$g_2(s_2^*(p), p, \delta) = \big(\frac{\eta}{\bar{\theta}_2^*(s_2^*)+1} - s_2^*\big)\frac{\partial \theta_2^*}{\partial s_2} + \frac{\delta p N_h}{L_2 + pN_h}\big(s_2^*\frac{\partial \theta_2^*}{\partial s_2} + \theta_2^*\big) \stackrel{!}{=} 0 \tag{4.73}$$

Noting that $\frac{\partial \theta_2^*}{\partial p} = 0$, we can then calculate the derivative with respect to p as

$$\frac{\partial g_2(p,\delta)}{p} = -\frac{\eta}{(\bar{\theta}_2^*(s_2^*)+1)^2}\frac{\partial \bar{\theta}_2^*}{\partial p}\frac{\partial \theta_2^*}{\partial s_2} + \frac{\delta N_h}{(L_2+pN_h)^2}(s_2^*\frac{\partial \theta_2^*}{\partial s_2} + \theta_2^*(s_2^*)) \tag{4.74}$$

It is then clear that, if $\frac{\partial \bar{\theta}_2^*}{\partial p}$ is small, it is possible that $\frac{\partial g_2(p,\delta)}{p} > 0$ for δ sufficiently large.

4..8 Showing that National Budget Constraints lead to the Same Result as a Global Budget Constraint

The budget constraint for the destination country is

$$s_2\theta_2 L_2 \leq \tau_2(L_2 + pN_h) \tag{4.75}$$

At a balanced budget, this implies that it will set the following taxes.

$$\tau_2 = s_2\theta_2\frac{L_2}{L_2+pN_h} \tag{4.76}$$

For the source country, the budget constraint is given by

$$s_1\big(N_h\theta_h + (L_1 - N_h)\theta_l\big) \leq \tau_1\big((1-p)N_h + (L_1 - N_h)\big) \tag{4.77}$$

At a balanced budget, this results in the following tax.

$$\tau_1 = s_1\frac{N_h\theta_h + (L_1-N_h)\theta_l}{(1-p)N_h + (L_1-N_h)} \tag{4.78}$$

Even though this implies that the net income effect of education policy on the remaining population in the source country is negative, i.e. that they pay in total more in taxes than they receive in education subsidies, this negative effect is set off if we take into account the effect on the emigrants, who receive the education subsidy from the source country, but pay their taxes abroad. The net income effect of the subsidy for all four groups is calculated as

$$\begin{aligned}\sum_{i\in(1,2)}(s_i\theta_i - \tau_i) = &\underbrace{L_2(s_2\theta_2 - s_2\theta_2\frac{L_2}{L_2+pN_h})}_{\textit{natives receiving country}} + \underbrace{pN_h(s_1\theta_h - s_2\theta_2\frac{L_2}{L_2+pN_h})}_{\textit{emigrants}} \\ &+ \underbrace{(1-p)N_h(s_1\theta_h - s_1\frac{N_h\theta_h + (L_1-N_h)\theta_l}{(1-p)N_h+(L_1-N_h)})}_{\textit{high abilitiy workers, source country}} \\ &+ \underbrace{(L_1-N_h)(s_1\theta_l - s_1\frac{N_h\theta_h + (L_1-N_h)\theta_l}{(1-p)N_h+(L_1-N_h)})}_{\textit{low abilitiy workers, source country}} = 0\end{aligned} \tag{4.79}$$

Thus, in total, the income effect of education subsidies is zero, if each country balances its budget. Clearly, there are several groups that fare better than others. The natives of the receiving country make a net benefit, whereas the low ability workers of the source country cross-subsidize the high education of the skilled emigrants[22]. Setting equation (4.79) into equation (4.40), we then get

$$\begin{aligned}\bar{W}_G =& \frac{1}{L_1+L_2}[L_2\left(\beta\ln(\theta_2^*+1)+\eta(\bar{\theta}_2^*+1)-k_2\theta_2^*\right)\\ &+pN_h\left(\beta\ln(\theta_h^*+1)+\eta(\bar{\theta}_2^*+1)-k_h\theta_h^*\right)\\ &+(1-p)N_h\left(\eta\ln(\bar{\theta}_1^*+1)+\alpha\ln(\theta_h^*+1)-k_h\theta_h^*\right)\\ &+(L_1-N_h)\left(\eta\ln(\bar{\theta}_1^*+1)+\alpha\ln(\theta_l^*+1)-k_l\theta_l^*\right)]\end{aligned} \tag{4.80}$$

which is the same as equation (4.42). We have thus shown, that a balanced global budget leads to the same result as balanced national budgets.

[22]This result can also be found in Wildasin (2000)

5 Concluding Remarks

The aim of this thesis was to point out cases in which national economic policy either has an incentive to influence the degree of globalization or in which it is influenced by an exogenously given degree of integration.
We started by showing that free trade in goods might not be optimal for a country, if this implies an overspecialization in one sector of production and thus an increased exposure to terms of trade risks. At the same time, we have shown that trade itself can also be a remedy against domestic production risks, if the degree of specialization is not too high and foreign markets are not overly volatile. Economic policy should take the risk structure of domestic and world markets into account, and the optimal degree of openness should be chosen accordingly.
In the second chapter, we demonstrated that a poor source country of skilled migration can benefit from globalization, even if in the short run it will lose some of the stock of its human capital. In the longer run, the probability to emigrate to high-wage countries will increase private incentives to invest in education and change the social and cultural norms of the emigrants, which will lead to an intergenerational increase of educational attainment. The optimal degree of openness of such a country should thus be determined with a view on the long-run, and not only with respect to the short-term losses of skilled workers this entails.
In the third chapter, we have shown that globalization will influence national education policy. Under the presence of education spillovers on productivity, private education provision will not result in a socially optimal aggregate skill level. It is thus necessary to subsidize education. We have demonstrated that the subsidy for both source and destination countries of skilled migrants will be decreasing in the skilled migration rate, but that remittances can help to dampen this effect. Consequently, policies that aim at maximizing national income per capita will result in an aggregate underprovision of education subsidies from a global point of view. We argued that it is thus imperative that national education policies be coordinated on a supranational level, to prevent situations where rich-countries free-ride on the public education expenditures of poor economies and the remaining population of sending countries end up paying for the transfers that benefit the emigrants and the inhabitants of the rich country.

The conclusions of this thesis are not straightforward and must be handled with care, if one wants to apply them to specific examples.
Whether or not a country should decrease its trade barriers in order to improve

the expected welfare of its citizens depends on a variety of factors. It must take into account both its comparative advantage, but also its *volatility advantage* with respect to the uncertainty in the world market.
While we have argued in the second chapter that skilled emigration can benefit the remaining population of the source country, and even more than previous research has suggested, this result was obtained under the assumption that education is an entirely private investment decision, and that education policy does not play any role. As we have seen in the third chapter, once education is in part publicly provided, the picture might change.
While the private incentives to invest in education are unambiguously positively influenced by an increased possibility to emigrate to a high-wage destination, the public incentives to subsidize education will be lower under globalization. We cannot clearly establish which of the two motives is dominant and it will depend on the individual situation. In countries where education is mainly privately provided and where budget constraints do not play an important role, the first channel is likely to be more important, implying that a positive and moderate skilled migration rate will leave the remaining population better off. On the other hand, in a country where budget constraints are binding for a large part of the population, an increase in the private incentives to invest in education will not change much in the actual education rate, since many households will be willing to send their children to school, but cannot afford it. In such a situation, an increase in public education provision will have a more pronounced effect than an increase in private incentives. We can thus suspect that for the poorest countries, the negative impact of migration on education subsidies is likely to dominate the positive incentive and aspirations effect.
However, this suspicion depends crucially on whether or not emigrants remit part of their income back to their families, which in turn will relax binding budget constraints and encourage national policymakers to invest in public education.

To sum up, globalization is likely to have a large influence on the welfare of a country. This work does not have the ambition to deliver a clear-cut generalized answer to whether or not globalization is good or bad, and to how policy should deal with its repercussions. The answer, as so often in economics, is: It depends.

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Department of Economics
Bielefeld University
Universitätsstr. 25
33615 Bielefeld, Germany
+49 (0)157-89486729
toni.glaser@kuleuven.be

Toni Glaser

Education

2010 – 2015 **KU Leuven**, *Center for Economic Studies, Leuven, Belgium*,
Ph.D. Candidate, Economics,
Joint Degree with Bielefeld University, Bielefeld, Germany.
Thesis: "Essays on Globalization and Economic Policy".

2009 – 2010 **KU Leuven**, *Faculty of Economics and Business, Leuven, Belgium*,
Master of Advanced Studies in Economics (*magna cum laude*),
Dissertation: "Aspirations, Segregation and Occupational Choice".

2004 – 2009 **University of Konstanz**, *Department of Economics, Konstanz, Germany*,
M. Sc. in Economics ("Very Good", 1.5),
Dissertation: "Aspirations, Contests and Economic Development".

2006 – 2007 **Université de Nantes**, *Department of Economics, Nantes, France*,
Erasmus Exchange Program.

Working Papers

"Migration Experience, Aspirations and the Brain Drain: Theory and Empirical Evidence",
with Marcus H. Böhme (OECD), Job Market Paper.

"Education Subsidies in a Globalized World: Endogenous Policy as a Source of Brain Drain".

"Choosing between Protectionism and Free Trade in an Uncertain World",
with Peter Debaere (University of Virginia) and Gerald Willmann (Bielefeld University).

Research and Teaching Interests

Primary **International Trade, Migration**.

Secondary **Development Economics, Microeconomics, Political Economy**.

References

Gerald Willmann, *Department of Economics*, Bielefeld University,
gwillmann@wiwi.uni-bielefeld.de.

Johannes Van Biesebroeck, *Department of Economics*, KU Leuven,
jo.vanbiesebroeck@kuleuven.be.

Peter Debaere, *Darden School of Business*, University of Virginia,
DebaereP@darden.virginia.edu.

Hale Utar, *Department of Economics*, Bielefeld University,
hale.utar@uni-bielefeld.de.

Fellowships and Visits

2013 – 2015 **International Research Training Group EBIM**, *BiGSEM, Bielefeld University*, Ph.D.Fellowship, Awarded by the German Research Foundation (DFG).

2014 **Merit-based Reduction of Student Loan Debt**, *German Federal Ministry of Education and Research*.

04/2014 **Tuborg Research Centre for International Economics**, *Aarhus, Denmark*, Research stay.

2010 – 2013 **Center of Excellence**, *KU Leuven*, Ph.D. Fellowship.

08/2012 **Institute for the World Economy (IfW)**, *Kiel, Germany*, Research Stay.

Teaching

2013 – 2014 **Advanced International Trade**, *Graduate*, Bielefeld University, Teaching Assistant for Prof. Gerald Willmann.

2010 – 2012 **Advanced International Trade**, *Graduate*, KU Leuven, Teaching Assistant for Prof. Gerald Willmann.

2011 **General Equilibrium Theory**, *Graduate*, KU Leuven, Teaching Assistant for Prof. Gerald Willmann.

2009 **Statistics I**, *Undergraduate*, Konstanz University, Teaching Assistant for Prof. Ralf Brüggemann.

Employment

08/2008 – 10/2008 **German Federal Ministry for Economic Cooperation and Development (BMZ)**, *Bonn, Germany*, Internship, Department for Sub-Saharan Africa.

Conferences and Seminars

2014 **Macroeconomics Lunch Seminar**, *UCL, Louvain la Neuve, Belgium*.
GEP Postgraduate Conference, *Nottingham, UK*.
Tuborg Research Centre for Globalisation and Firms-Seminar, *Aarhus University, Denmark*.
Lunch-time Seminar in International Economics, *IfW Kiel, Germany*.

2013 **Aarhus Kiel Workshop**, *Kiel, Germany*.
8th EBIM Doctoral Workshop on Economic Theory, *Bielefeld University, Germany*.
ETSG Meeting, *Birmingham, UK*.
Norface Conference: "Migration: Global Development, New Frontiers", *London, UK*.
Göttinger Workshop Internationale Wirtschaftsbeziehungen, *Göttingen, Germany*.

2012 **ETSG Meeting**, *Leuven, Belgium*.
Belgian Trade Day, *Gent, Belgium*.

Languages

English (Full Professional Proficiency), German (Native Proficiency), French(Full Professional Proficiency).

IT Skills

Windows, Linux, LaTeX, Stata, Mathematica, EViews.

Doctoral dissertations from the Faculty of Economics and Business,
see: http://www.kuleuven.be/doctoraatsverdediging/archief.htm