Essays on Labor Markets and Globalization

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Dedication

To my parents, Dan Waddle and Barbara Petty, who made this possible.

Abstract

My dissertation consists of three chapters. The common theme that unifies the chapters is the analysis of how globalization and trade impact labor market outcomes. In the first chapter, I summarize the literature on this theme and analyze the shortcomings that are present in existing works. In the early 1990s, a large body of work was developed that showed that many of the predictions of the standard Heckscher-Ohlin theory failed to hold in the data. As a result, many authors disregarded increased trade and globalization as a possible driving force behind the observed changes in labor market outcomes. However, in more recent years, authors have begun modifying new trade theories to begin to explore how trade and globalization might impact wages and unemployment through different channels. In this chapter, I summarize the innovations that have occurred along these lines, as well as the empirical support that exists for the proposed theories.

The second chapter of my dissertation explores the business cycle effects of increased globalization. Over the past 20 years, following recessions, recoveries in labor markets have been slow and weak relative to their post-war average. Over the same period, the United States has become increasingly open to trade and global forces. In this chapter of the thesis, I argue that changes in labor market outcomes can be tied to increased globalization. I build a model in which increased openness to growing economies generates a downward trend in employment which is amplified by recessions, thus generating jobless recoveries. I provide empirical evidence for the relationship between globalization and labor market outcomes and I show that the model is able to qualitatively match not only the targeted changes in labor markets, but also a persistent negative trade balance and increasing income inequality.

In the third chapter of my dissertation, I explore the impact that trade has upon investment in technologies that are skill-augmenting and how this, in turn, impacts the relative return to skilled labor. In the decade following the Mexico-U.S. trade integration, the manufacturing skill premium rose by almost 60 percent in Mexico and by only 12 percent in the U.S. Standard trade theory predicts that when countries with different

levels of skilled labor integrate, the skill premium should fall - not rise - in the skill-scarce country. In the third chapter, I reconcile theory and data by building a model in which intermediate goods are produced using rented technology. After integration, producers in Mexico begin to rent technologies from the United States, which are more advanced and, hence, more skill-intensive. This has two effects: The skill premium in Mexico rises due to adoption of the more advanced technology and the skill premium in the U.S. rises due to increased investment in this technology, which is driven by the increased marginal return on technology arising from to its adoption in Mexico. The mechanism is supported by industry-level evidence: Mexican industries which are integrated into the U.S. supply chain have higher skill premia than their non-integrated counterparts. The calibrated model can account for about two-thirds of the increase in the skill premium in each country.

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Chapter 1

Critical Literature Reveiw

1.1 Introduction

In the last three decades, labor markets have experienced dramatic changes. Wage inequality has increased dramatically in a number of countries and labor market down turns following recessions in the United States have become more prolonged and their recoveries have become less robust. These changes have been accompanied by the decline of labor unions, increased international competition in the form of trade and international financial flows, and changes in technology that potentially favor more skilled workers. As such, much attention has been focused on determining which, if any, of these forces may be responsible for the changes in labor market outcomes that have occurred. In this paper, I will focus on the impact of globalization, though the other explanations have also been explored to a great extent.

Trade, offshoring, declining tariffs, and international capital flows have all experienced a marked increase over the period of interest. Developed and developing countries have become more integrated and their economies have become more interdependent. The fact that increased globalization coincided with the observed changes in labor market outcomes naturally led to the hypothesis that the two were interrelated. Traditional trade theory has strong predictions for what should occur when trade between countries with different factor abundances begin to trade; the Heckscher-Ohlin theory-the Stolper-Samuelson theorem in particular-tells us that trade increases the return to the abundant factor in each of the trade partners. That is, inequality between skilled and unskilled workers should increase in a skill-abundant country and decrease in a skill-scarce one following a trade liberalization between the two. Until the recent past, this was the leading theory used to explore the impact of integration between more and less developed countries. However, a number of predictions of the basic Heckscher-Ohlin theory do not hold in the data. Furthermore, traditional trade theory tends to deal with changes in steady states as a result of long-term changes in trade policy. As such, it has no predictions for how economic variables will respond to business cycles in a world with more free flow of goods and capital between countries.

There is a large literature that documents the failures of the Heckscher-Ohlin theory. Goldberg and Pavcnik (2007) provide a nice summary of the work that has been done to show the failure of the Stolper-Samuelson theory for developing countries. Following trade liberalizations, inequality grew in Argentina, Brazil, Chile, China, Colombia, India, and Mexico. Moreover,Berman, Bound, and Griliches (1994) show that *within* industry demand for skilled workers increased during the 1980s and after, whereas the H-O theory predicts that the shift in demand should occur *across* sectors. Finally, Lawrence and Slaughter (1993) document that the relative price of skill-intensive goods increases following trade liberalizations, while the H-O theory predicts that this price should fall. This evidence led many economist to disregard trade as a candidate explanation for changes in labor demand and rising inequality and, instead, postulate that technological change led to the increase in demand for skilled workers. Recently, however, there has been a resurgence of interest in globalization as a root cause of the observed changes in labor market outcomes. Authors have begun to turn to new trade theories or make modifications to the standard framework, incorporating trade in tasks, heterogeneous firms, innovation and investment, labor market frictions, and consumer-based theories in order to revisit the potential impact of trade on labor markets. This literature has been guided by new empirical evidence which shows that each of these factors may be important in matching the data.

For the purpose of this review, I will use “trade” and “globalization” interchangeably and these terms will encapsulate trade in goods and services, offshoring, and foreign direct investment. I will concentrate on the effects of globalization, though there is a large and growing literature on the impacts of other forces on labor market outcomes.

Although other hypotheses about the root causes of increasing inequality and unemployment exist, I will consider them outside the scope of this work and will, instead, focus only on the models and data that focus on the impacts of trade and globalization. I will predominantly discuss the literature on inequality due to the vast literature dealing with this topic; I will additionally touch on studies that deal with employment and labor force participation effects of globalization, which are not as plentiful.

The rest of this review is organized as follows. Section 2 reviews the theoretical literature on trade and labor market outcomes, emphasizing new developments and modifications to older theory which have been made in order to be more consistent with empirical evidence. Section 3 reviews the empirical support for the proposed theories, as well as the evidence on the implications of these models. Section 4 concludes.

1.2 Theoretical Studies

As inequality began to grow in a number of economies in the 1980s, researchers became increasingly dissatisfied with the inability of standard trade theories to account for new observations from the data regarding labor market impacts of trade liberalizations. In particular, the Heckscher-Ohlin theory was unable to account for growing inequality in both advanced and developing countries following trade liberalizations. Moreover, it had no predictions for how employment and labor force participation would respond to such a liberalization. As such, people began to modify existing theories to make them better able to match observations from the data. In this section, I will review major works in the theoretical literature which modify trade theory to address its inability to match observables from the data.

1.2.1 Comparative Advantage and Trade in Tasks

Traditional trade theory has centered around the idea that trade between countries occurs due to comparative advantage. A strand of literature has built upon this idea, including trade in tasks which is driven by relative abundance of factors of production or comparative advantage. In this section, I will describe four such studies.

The first of these studies is Feenstra and Hanson (1996a), which explores the impact of offshoring upon wages in an advanced country (the United States) and in a developing one (Mexico). They build a simple model of trade in tasks in order to explore how foreign direct investment (FDI), in the form of transfer of physical capital, impacts the relative wages of less skilled workers in the context of a two-country model. A single good is produced competitively by combining a continuum of intermediate goods. The intermediate goods, in turn, are produced by combining both skilled- and unskilled-labor with capital. In the initial two-country equilibrium, the factor endowments are sufficiently different the the factor prices are not equalized across the two countries; specifically, the return to capital in the North is lower than in the South and the ratio of skilled to unskilled wages is also lower in the North. They assume that the flow of capital from the North to the South is exogenously restricted and then they consider the policy experiment where this restriction is lifted. If the intermediate goods, z, are ordered from the least skill-intensive to the most skill-intensive, then there will be a cutoff, z^*, which at which all intermediates that are more skill intensive, $z \in (z^*, 1]$, will be produced in the North and all intermediates that are less skill-intensive, $z \in [0, z^*]$, will be produced in the South. This is because the endowment of skilled workers is such that skilled workers are relatively cheap in the North as compared to the South. So, the production of high-skill intensive intermediates will concentrate in the North and low-skill intensive intermediates will be produced in the South. When the restriction to the flow of capital is reduced, the higher rate of return on this capital in the South causes capital to flow from the North to the South. This, in turn, causes the equilibrium cutoff point to increase to $z^{**} > z^*$. Therefore, the offshore production of intermediates increases the level of skill-intensity of production in both countries, since now the most skill intensive good produced in the South is more skill intensive than in the initial equilibrium and the least skill-intensive good produced in the North is also more-skill intensive than in the previous equilibrium. This causes the demand for skilled workers to increase in both countries, hence driving up the relative wage of skilled workers in both countries. They think of this as endogenous technical change, but in reality, there is no change in the technology used to produce the intermediates in either country. Rather, the flow of capital is what is driving this change. Feenstra and Hanson were among the first to show that trade is not necessarily inconsistent with rising skill premia in both skill-abundant and skill-scarce countries.

The more recent works of Grossman and Rossi-Hansberg (2008), Costinot and Vogel

(2010), and Costinot, Vogel, and Wang (2012) also utilize the idea that trade in tasks or intermediates can yield results that differ from the Stolper-Samuelson predictions, even when trade is driven by comparative advantage. Grossman and Rossi-Hansberg set up a model that is very similar to that of Feenstra and Hanson (1996a) to emphasize that offshoring can result in a Pareto improvement in the North under certain conditions. They focus on the outcomes in the skill-abundant country and are not concerned with outcomes in the low-skill abundant trading partner. In this model, there are two goods, X and Y, each produced by combining a continuum of tasks which are produced by high-skill workers and a continuum of tasks that are produced by low-skill workers. Industry X is relatively skill-intensive, meaning that producing a high-skilled task requires relatively more labor in industry X than it does in industry Y. Firms can undertake tasks either at home or abroad and they have an incentive to offshore tasks to the foreign country because low skill labor is relatively inexpensive in the foreign country due to its relative abundance there. Some tasks may be more difficult to offshore than others, which they model as a function which increases the amount of labor input needed to produce the task. Let a_{Lj}be the amount of domestic labor required to produce a low-skill task (L-task) i for industry j; then $a_{Lj}\beta t_j(i)$ units are required to produce that same task abroad with $\beta t_j(i) \geq 1$ so that the task requires relatively more inputs to produce abroad. They suggest that this distortion could arise from costly monitoring of foreign production. They assume that the function $t_j(i)$ is increasing in i so that more complicated tasks are more difficult to offshore (assuming that the tasks are ranked from least to most complicated). They focus on the offshoring of L-tasks and assume that it is too costly or complicated to offshore all other tasks. If w is the wage of a domestic low-skill worker and $w^*$is the wage of a foreign low-skill worker, there will be a cutoff task I such that

$$w = w^* \beta t_L(I)$$

so that all tasks $i \in [0, I]$ are performed offshore and all tasks $i \in (I, 1]$ are performed at home. Then, for given factor prices, the low-skill labor costs for a domestic producer are reduced by a proportion $\Omega(I)$ due to the ability to offshore all tasks $i \in [0, I]$. Because the firms are competitive, zero profit conditions must hold and so this reduction in costs translates into increased wages for the low-skilled workers. Specifically, the wages increase by a proportion $1/\Omega(I)$. There is no impact upon the wages of the high-skill workers. Hence, they show that a Pareto improvement is possible. The low-skill workers are benefiting because offshoring essentially increases their productivity. The foreign low-skill workers now do the menial tasks that allow the home low-skill workers to concentrate on the more advanced low-skill tasks.

This result is closely related to Feenstra and Hanson (1996a) and, in fact, arises as a special case of their model. The result also may not hold if the home country in question is a large economy and offshoring has terms of trade effects. For showing that the Pareto improvement is possible, they have assumed that both countries are small open economies and so do not have an effect on the relative prices of the two goods (X and Y). However, because offshoring essentially increases the supply of low-skill laborers in the home country, it increases the output of the unskilled-intensive good Y. If this country were sufficiently large to have an impact on the relative price of Y, then an increase in production of the good would push its price down and the conventional Stolper-Samuelson logic would apply. This mitigates some of the wage benefits enjoyed by low-skill workers in the small open economy set up and, in fact, can overturn the result. Moreover, if there were only production of the skill-intensive good at home, increasing the supply of unskilled labor via offshoring would decrease the low skill wage even in the small open economy set up. The result is an interesting one, but arises only under a very special set of assumptions.

Costinot and Vogel (2010) also build a two country model with a continuum of goods, which are each produced using labor but differ in their skill intensities. They are not concerned with the skill premium, but rather, the whole distribution of wages. There is a continuum of skill levels and, hence, a continuum of income levels. Output per worker , A, in a given industry is determined by its skill intensity, σ, and the skill level of the worker, s. So, A is a function, $A(s, \sigma)$, and its increasing in s and satisfies the condition

$$\frac{A(s', \sigma')}{A(s, \sigma')} > \frac{A(s', \sigma)}{A(s, \sigma)}$$

for any s, s', σ, σ' which are such that $s' > s$ and $\sigma' > \sigma$. This last condition just tells us that skill is more valuable in industries that are highly skill intensive. Therefore, higher skill workers will match with more skill intensive industries. They embed this into a world with trade in which the home country is more skill abundant than the Foreign country. Trade will then increase income inequality at home, across the entire income distribution. The most basic model will have strong Stolper-Samuelson effects, with income inequality falling in the foreign country. However, they make a modification to reverse this result. They show that if technology is more productive in the home country and it can be used by offshore foreign workers, then income inequality may rise in the foreign country. They also show that North-North trade can also result in rising income inequality in both countries, a result which was previously not possible in models where comparative advantage was the basis for trade.

In Costinot, Vogel, and Wang (2012), the authors build on Costinot and Vogel (2010) and Costinot, Vogel, and Wang (2011) to explore the impact of interdependent global supply chains on within country income inequality. In their model, there are two countries, each with a continuum of workers that are heterogeneous in their skill level. Production of the single final good is sequential, so in order to produce an intermediate, $\sigma + d\sigma$, an intermediate from the previous stage, σ, is combined with labor. The amount of output depends on the skill level of the worker producing it. This leads to more skilled workers sorting to produce more "advanced" intermediates. They then compare what happens under autarky to outcomes under free trade in order to see how the globalization of the supply chain impacts inequality. They have in mind trade between advanced and developing countries, so there is a difference in the relative supply of skills across the two countries. Comparing the free trade equilibrium to the autarkic one, they show that in the South, free trade results in "stage downgrading" of all Southern workers, meaning that workers in the South match to produce relatively less advanced parts. The converse is true for the North. This results in decreased wage inequality amongst low-skill workers and increased wage inequality amongst high-skill workers in the South. The converse is true in the North. This result is not about inequality across high- and low-skilled laborers, but rather about the distribution of wages. In other words, there is wage compression at the bottom of the wage distribution and wage dispersion at the top of the distribution in the South and, conversely, dispersion at the bottom and compression at the top in the North. This comes about because of the sequential nature of production. The standard Stolper-Samuelson effect is causing the compression at the bottom of the wage distribution in the South. The wage dispersion at the top of the distribution is coming about essentially because of cost savings; increased globalization decreases the relative price of the intermediates used by the high-skill workers to produce the last intermediates in the sequence.

These papers and others like them which concentrate on trade in tasks offer possible mechanisms for rising wage inequality in both advanced and developing countries. However, they are primarily theoretical and are difficult to match up to data. Because of this, it's unclear how well the proposed mechanisms operate in practice.

1.2.2 Modifications to the Eaton-Kortum Model of Trade

The model described in Eaton and Kortum (2002) and Bernard, Eaton, Jensen, and Kortum (2003) has become the basis of a large literature on the impacts of trade. More recently, authors have begun to embed several types of labor into this model in order to explore its implications for inequality. Before I describe those studies, I will first review the basics of Eaton and Kortum (2002) (henceforth EK) and Bernard, Eaton, Jensen, and Kortum (2003) (henceforth, BEJK). There are N countries and a continuum of goods which are produced by firms that are either perfectly competitive (EK) or Bertrand competitors (BEJK). There are Ricardian differences in technological efficiency across producers and countries, with the firm's idiosyncratic productivity being drawn from a Frechet distribution. Labor is the only factor of production. Because of the competitive nature of firms, the lowest cost producer of any given variety will produce that variety; trade costs and the productivity draw of firms jointly determine the lowest cost producer of a given variety. If a domestic firm were to be the lowest cost producer of a good before trade liberalization, there is a chance that it will no longer be after a reduction in trade costs. Therefore, trade liberalizations impact the amount of production that takes place within a given country by affecting which country is home to the lowest cost producer. This induces reallocation of labor across firms in response to a trade liberalization.

These basic versions of the model only has one type of labor and, so, are not suitable for exploring the impact of trade liberalization upon inequality between different types of workers. Burstein and Vogel (2012) modify BEJK to include both high- and low-skilled workers, allowing for the firm's technology draw to be more complementary with high-skilled workers. The model is sufficiently flexible that the extent to which technology is or is not skill-augmenting depends on the value of a particular parameter. This can easily be seen in the following equation, which determined the equilibrium ratio of skilled workers to unskilled workers of a sector j producer in country i with productivity z:

$$\frac{h}{l} = \frac{\alpha_j}{1-\alpha_j}\left(\frac{s_i}{w_i}\right)^{-\rho} z^{\varphi}$$

where $\varphi$is the parameter that governs the extent to which technology is skill-biased. If $\varphi > 0$, then factor reallocation towards higher productivity firms will raise the relative demand for skilled workers and, hence, the skill premium. They dub this the "skill-biased technology mechanism." In the absence of idiosyncratic productivities, z, this equation would be simply

$$\frac{h}{l} = \frac{\alpha_j}{1-\alpha_j}\left(\frac{s_i}{w_i}\right)^{-\rho}$$

which is a more familiar equation that arises out of an extension of the Heckscher-Ohlin model. In this equation, the elasticity of substitution between skilled and unskilled workers, ρ, and sector characteristics, α_j, determine the extent to which wages and relative demand for workers track one another. In this set up, changes in trade costs shift factors of production towards a country's comparative advantage sector and raise the relative return to the factor that is used intensively in that sector. This is called the H-O mechanism by Burstein and Vogel. They embed these two forces into the quantitative framework of BEJK in order to quantify the impact of the reallocation that occurs as part of trade liberalizations upon the skill premium. They find that the skill-biased technology mechanism dominates and the skill premium goes up in all countries due to reallocation of labor toward the more productive, and hence, more skill-intensive firms within an industry and country. The real wage of both types of workers rises, but it rises by more for the skilled workers. They do not find very large increases in the skill premium, but they are among the first authors to show that a model calibrated to match firm-, sector-, and aggregate-level data can generate increasing skill premia in many countries, including the skill-scarce ones.

Kondo (2012) combines the BEJK model with a baseline monopolistic competition model of trade akin to Dixit and Stiglitz (1977) in order to assess the impact of trade upon local labor market outcomes. He specifically wants to see if this type of model can replicate the facts from the data that at the local-metropolitan statistical area or commuting zone-level, import competition is associated with less employment, less labor force participation, reduced job creation, and increased job destruction. The idea behind combining the two types of models is that there may be some goods that are sufficiently differentiated that they will not have close substitutes that will be produced abroad and therefore those buisnesses will not be impacted by trade. However, there are a number of goods which are not very different from something that a foreign producer could make and so are going to be produced by the lowest-cost producer. If localities differ in terms of how many of each type of firm exists within its boarders, this will produce differences in the extent to which different localities are impacted by a trade liberalization. He includes labor market frictions in order to generate unemployment at the local level. He is able to generate varying responses to foreign competition, with employment rates falling dramatically as trade costs increase and falling by much more in localities with a high concentration of BEJK-type firms.

These modifications help to bridge the gap between more modern trade theory and those models that were built to assess the impact of trade on different factors of production. They show that even when comparative advantage is the basis for trade, as in Burstein and Vogel (2012), it is still possible for reallocation to result in increased inequality across workers and decreased employment in areas which compete directly with foreign imports.

1.2.3 Trade and Innovation

Another strand of the literature has focused upon how trade changes investment or innovation decisions. This strand of the literature tends to focus on modeling either technological upgrading in order to gain access to export markets or the import of capital equipment, which is thought to embody technology that is skill-augmenting.

Quality Upgrading

A number of studies focus on quality upgrading, either to produce goods that can be exported or to gain supremacy over competitors. Segerstrom and Dinopoulos (1999) explore the idea that investment in research and development (R&D) can be affected by export opportunities and competition. They build a two country growth model with a continuum of industries. Firms compete for dominance through investment in R&D; they gain dominance by having the most advanced (or productive) technology. The most productive firm captures the entire market for that industry. The dominant firm's price is limited by the marginal cost of the next-best available technology. Each country exports the products for which the industry leader happens to be a domestic firm. Because tariffs cut into the leader's profits, trade liberalization promotes growth by causing the marginal product of innovation to increase, relative to the high tariff regime. If research and development is a skill-intensive activity, then trade liberalization will, in turn, increase the demand for skilled workers. This story is not built upon the more productive technology being more skill-augmenting, so it stands apart from the other studies in the literature. It also would be a set-up in which North-North trade could induce increased inequality, since it is plausible that both countries invest more in innovation activities, driving the demand for skilled labor up in both countries.

The next three papers use a Melitz-type model to explore how heterogeneous firms respond to trade liberalizations. Verhoogen (2008) builds a small open economy Melitz (2003) model in which consumers in different countries differ in terms of their willingness to pay for higher quality goods in order to explore wage inequality in developing countries. There are three key features of his model. First, as in any Melitz model, plants are heterogeneous in productivity and there is a fixed cost to entering the export market, which results in the export market being limited to only the most productive firms. Second, goods are differentiated in terms of quality and he employs a non-homothetic utility function so that consumers with higher incomes have a higher willingness to pay for high quality goods than their low-income counterparts. Therefore, firms in a developing country produce higher quality items for export than for domestic consumption. Lastly, producing higher quality goods requires better technology and more high-quality labor and higher quality workers require higher wages. Therefore, trade liberalization that results in increased incentive to export generates what Verhoogen calls "differential quality upgrading," where the most productive firms (the exporters) increase exports in response to a trade shock. This results in production of more high-quality goods and, hence, increased wages for high-quality workers. Verhoogen focuses on within industry inequality, meaning the variance in wages across firms. It is possible that this same mechanism would produce inequality across workers of skill levels, but this is not the focus of his paper.

Riaño (2009) also builds a Meltiz-style model in which firms can choose to invest in a technology which is skill-augmenting. In his set-up, technology is a random variable, but its realization can be impacted through investment. The firm can choose which “type” of technology to invest in, meaning it can impact the mean realization of the technology, but the actual realization will also be subject to an exogenous shock. He models two different types of technology; the first is a low average productivity technology with low fixed cost of operation and the other has high average productivity but a high fixed cost of operation. As in Melitz, the firms which receive high productivity draws are those that will export and the lowest productivity firms will exit. Therefore, when the country opens to trade, the firms with the highest draws will begin to export and those with the lowest draws will exit. This has two effects; the increased profitability arising from access to exporting also induces the productive firms to invest in the more productive technology. Therefore, these firms become both even more productive and, therefore, more skill intensive. There is also a reallocation of workers from the exiting (less skill-intensive) firms to the larger, more-skill intensive firms. So, the trade liberalization causes an increase in the skill premium via this reallocation and via increased investment in the more productive technology. Riaño calibrates his model to match moments of the data from Mexico and finds that, though this mechanism is present, it can only account for about 12% of the increase in the skill premium in Mexico.

Bustos (2011) also embeds a choice of technology within a standard Melitz (2003) model. In her model, firms choose how advanced of a technology to use, as well as making a decision as to whether or not to export. The most productive firms enter the export market because their profits are sufficiently high that they cover the fixed cost of entry. Moreover, these same firms will incur the cost to operate the more advanced technology. This comes about because the benefits of adoption are proportional to revenues, while its cost is fixed. Therefore, the most productive firms (those with the highest revenues) are the most likely to adopt the more advanced technology. Bustos does not focus on the skill premium. Instead, she empirically and theoretically examines the impact of this mechanism upon the skill-intensities of Argentine industries and finds that exporting is associated with higher skill intensities. She also examines how the firm choice of which technology to operate (more or less skill-intensive) is affected by trade liberalization and finds, as does Riaño, that high productivity firms are likely to upgrade to the more skill-intensive technology and low productivity firms are likely to downgrade to the less skill-intensive technology following a trade liberalization.

Trade and Investment in Skill-Augmenting Capital

Another set of papers focuses on the impact of investment in capital equipment on relative wages. This literature draws upon the seminal contribution of Krusell, Ohanian, Rios-Rull, and Violante (2000) (henceforth KORV), which makes the observation that the dramatic decrease in the relative price of capital equipment coincides with the increase in the relative wage of highly educated workers in the United States. KORV then develops a production function in which capital equipment is relatively complementary with skilled labor and substitutes for unskilled labor. Capital structures are complementary with all the other factors of production. In keeping with this idea, Goel (2012) explores the idea that investment in capital equipment is impacted by an industry's use of intermediate imports in the context of a two country trade model. She builds a model in which capital equipment combines with skilled labor in order to make one "skilled good." Unskilled labor can be substituted with intermediate imports from low-wage countries. The composite of these two factors of production, the "unskilled good," then combines with the skilled good in order to make one unit of an intermediate. The intermediates are then aggregated to make a final consumption good. She allows for innovation which results in the production of a new variety. Innovative activities use capital and skilled labor as inputs. The countries differ in their endowments of skilled and unskilled workers: the North is home to both types of workers but the South only has unskilled workers. When the North opens to trade, there are two channels that operate to impact absolute wages and relative wages. First, there is the standard Stolper-Samuelson effect: firms begin to substitute imported intermediates for unskilled labor, which reduces the relative demand for unskilled labor. The novel mechanism is the technology channel; the reduction in the cost of production brought about by the substitution of low-skilled intermediates for low-skilled labor makes additional investment in new varieties possible. She shows that this technology channel dominates the Stolper-Samuelson effect and, in the calibrated version of the model, the wages of both types of workers rise. However, the wage of the skilled worker increases by more than the wage of unskilled worker, so the skill premium rises. Notably, because she does not include a skilled worker in the South, the model cannot address the observation from the data that skill premia rise in both countries.

A number of authors have postulated that perhaps skill-biased technical change is transmitted across boarders via trade in capital equipment. Two such papers are those by Burstein, Cravino, and Vogel (2013) andParro (2013). Burstein, Cravino, and Vogel (2013) embed the production function developed by KORV into an Eaton and Kortum (2002) framework in order to explore the impact of capital-skill complementarity and trade upon the skill-intensity of production and, hence, the skill premium. In an open economy model, the aggregate stock of capital equipment depends on domestic and foreign productivities and labor endowments, as well as all pair-wise tariff rates or trade costs. Changing trade costs only impacts the stock of capital equipment through changes in the share of sectoral absorption that is produced domestically; if the share of a particular sectoral output that is produced domestically falls, the stock of capital equipment dedicated to that sector will also fall. They provide analytical expressions for the relationships between the steady state values of (i) the skill premium, (ii) real wages of skilled workers, and (iii) the real wages of unskilled workers to domestic expenditure shares, productivities, and endowments. Next, they calibrate their model in order to quantify the impact of trade and capital-skill complementarity upon the skill premium in the world economy. They find that moving from autarky to a free trade equilibrium benefits all workers, but skilled workers benefit disproportionately. They quantify these effects for a large number of countries and do sensitivity analysis on key parameters. Parro (2013) builds a very similar model in order to answer similar questions. The two papers differ in two important ways. First, Burstein, Cravino, and Vogel (2013) include the analytical expressions for the impact of trade liberalization on the outcomes of interest. This allows them to make clear the impact of various parameters upon their results, which is useful given that there is not strong agreement amongst economists about the values for a number of key parameters. Second, the counterfactuals that they conduct are different. Instead of studying the extreme cases of autarky to free trade, Parro feeds in the measured changes in trade costs and technologies. This allows him to assess the quantitative impact of these measured changes upon the measured changes in the skill premium, whereas the exercise in Burstein, Cravino, and Vogel

(2013) assesses the total possible impact of the proposed channel. They find that while trade in capital equipment produces some changes in the skill premium, it is unable to match some of the extreme changes in the skill premium that are observed in the data. For example, Parro finds that the reduction in trade costs accounts for about one third of the total change in the skill premium in the median developing country in his sample. Both papers find that a reduction in trade costs is welfare improving, though it disproportionately benefits skilled workers.

1.2.4 Labor Market Frictions and Bargaining

A number of papers have embedded search and matching frictions into trade models in order to assess how labor markets react to free trade. A pioneering work on this front is Davidson, Martin, and Matusz (1999) who embed search frictions and unemployment into a standard trade model. They show that the normal predictions arising from trade models do not extend to an environment with labor market frictions. Notably, the Stolper-Samuelson theorem fails to hold in this environment when it is stated as pertaining to all employed factors in the environment. Instead, it holds when it is a statement about expected lifetime income of searching factors. A detailed reference for the effects of search-frictions on labor market outcomes in models of trade is Davidson and Matusz (2009).

A more recent and highly impactful study which includes these types of frictions is Helpman, Itskhoki, and Redding (2010). They embed search frictions, bargaining between workers and firms, idiosyncratic match quality, and employer testing to identify the most productive workers in to a model with heterogeneous firms. Workers search and find an employer with some probability that depends on the ratio of vacancies to workers that are searching. Workers have an idiosyncratic match quality with any given employer and firms have incentive to only employ the best matches because bad matches can result in a reduction of the firm's output. Therefore, firms test workers to find out the quality of the match and only hire those workers whose match quality is very high; other workers will remain unemployed. The most productive firms have the highest threshold for match quality. Once a firm and worker are matched and the worker is determined to be of sufficiently high quality, the two parties bargain over the wage that the worker will receive. Because the surplus between a highly productive worker and a highly productive firm is high, the wage received by the worker in such a match will receive a higher wage than one in a less productive match. Trade impacts wages and unemployment through a reallocation channel: the most productive firms expand in response to trade liberalization because they now are able to produce for export and the least productive firms exit due to increased pressure from imports (productive foreign firms provide competition). Therefore, the lease productive workers, which are the lowest wage workers, are more likely to be unemployed in the free trade equilibrium than in the autarkic one. Moreover, the wage that lower productivity workers receive is lower since the incentive to screen at the marginal surviving firm is decreased by the decreased volume of sales. This results in inequality increasing between the most productive and least productive employed workers, as well as between the most productive workers and those that are unemployed and receiving zero wages.

Mitra and Ranjan (2007) also include search frictions into a two-sector model of offshoring in which workers are mobile between sectors. Their main focus is the impact of globalization upon employment, both at the sectoral and the economy levels. They find that offshoring can actually reduce unemployment in the domestic economy because offshoring allows for domestic workers to benefit from efficiency gains. The reasoning is similar to that in Grossman and Rossi-Hansberg (2008), but in this case, the efficiency gains that are created induce domestic firms to increase the rate at which they post vacancies. As in any search model, the equilibrium unemployment rate is determined by the ratio of searching unemployed workers to the vacancies, so increasing the rate at which vacancies are posted necessarily decreases the equilibrium unemployment. Moreover, they find that wages for employed workers rise as a result of globalization. If workers are not fully mobile across sectors, these results can be reversed because of general equilibrium effects. In particular, there is a negative price effect in the sector that offshores, which counteracts the incentive for firms to post new vacancies. Because workers are no longer able to move between sectors, this increase in unemployment in the offshoring sector can results in increased unemployment overall.

The predictions that arise from embedding search frictions into models of trade or offshoring are therefore mixed with regards to the impact that these forces have on wages, inequality, and unemployment. Although these models do not deal with the business cycle frequency directly, they are those that most closely study the impact of globalization on employment, which may make them useful for studying how labor markets recover from recessions and how these recoveries have changed over time.

1.2.5 Consumer Effects

The next theoretical contribution that I will discuss departs substantially from the preceding literature in that it focuses on the consumer-side effects of trade on income inequality. Fajgelbaum, Grossman, and Helpman (2011) build a two-country, two-sector model, where one sector is competitive and produces a homogeneous good and the other is monopolistically-competitive which produces goods that are both horizontally differentiated (different types of goods) and vertically differentiated (different qualities of goods). The only factor of production is labor. Workers draw their productivities from an exogenous distribution and have preferences that are non-homothetic. This makes it such that (i) workers will differ in terms of their income and (ii) workers of different incomes will choose bundles of good that are different. Specifically, workers with higher incomes will choose a bundle that is of higher quality than a lower income worker's bundle. When the two countries open to trade, the number of goods available to each consumer changes, as in standard models with monopolistically-competitive firms, and the quality composition of the goods will be affected. The exact effects on quality composition depend heavily on existing income inequality. They study a special case with two almost identical countries, except that one has workers that are more productive on average. In this case, if the cost of transporting high-quality goods falls, this changes welfare in two ways. First, the number of high-quality firms increases in response to a lower marginal cost of production (since transportation costs fell). This, in turn, pulls resources away from the production of low-quality goods, which therefore reduces product diversity for low-income consumers. There is no effect on the income distribution in terms of the numeraire good, but decreased transportation costs can have large effects on the distribution of real incomes. This is novel since in almost all other works, the effects of trade are felt through movements in factor markets and, in this work, the effects are transmitted via the composition of consumption bundles. This is appealing because, observationally, consumers with different incomes do, indeed, consume very different bundles of goods. This line of research is, therefore, potentially quite important to understanding the welfare implications of globalization.

1.2.6 Summary of Theoretical Contributions

When international goods and capital markets began to liberalize, the leading theories for how this would impact labor markets was based on the Stolper-Samuelson theorem. Therefore, it was difficult to rationalize how inequality could rise in most countries and to conceive of how North-North trade to generate any impact on inequality. The theories outlined above give frameworks in which these outcomes are possible and rationalizable. Trade in tasks, investment in capital equipment, and quality upgrading all can contribute to rising skill premia and unemployment of low-skill workers even in skill-scarce countries. Models that incorporate investment in new technologies or innovation provide a framework in which North-North trade may result in rising inequality in both countries. However, special cases of these theories also provide instances in which advanced countries can experience falling inequality as a result of productivity gains resulting from trade or offshoring. Therefore, it still remains for many of these theories to be tested against the data in an attempt to quantify the importance of the proposed mechanisms. Moreover, further exploration of the data may be necessary to look for evidence of the proposed mechanisms.

1.3 Empirical Studies

A number of empirical studies have examined the impact of globalization on labor markets, in terms of both wages and employment. There is a large literature that tests the implications of the Heckscher-Ohlin theory for the impact of inequality on trade. Excellent surveys of this literature can be found in Feenstra and Hanson (2001) and Goldberg and Pavcnik (2007). Much of the early work in this literature was focused on trying to determine whether wage inequality increased due to globalization or skill biased technical change and the findings were mixed. The innovations to theory described in the preceding section were developed, in part, to address the findings of the early literature. Here, I will focus on the papers that test the assumptions and implications of the theories described in Section 2.

1.3.1 Comparative Advantage and Trade in Tasks

Feenstra and Hanson contributed greatly to the empirical literature on the impact of trade in tasks or intermediates on the skill premium. In Feenstra and Hanson (1996b), they argue that the ability to import intermediate inputs affects the relative demand for skilled labor in the United States by allowing U.S. firms to move non-skill-intensive activities overseas. This, in turn, shifts employment towards more skilled workers within a particular industry. They explore this hypothesis using the NBER trade database and the Census of Manufacturers for the years 1972-1990 and find that outsourcing (the use of imported intermediate goods) can account for between 31 and 51 percent of the increase in the relative demand for skills that occurred in the manufacturing sector in the U.S. over the time period of interest. The main innovation of their papers is the recognition that outsourcing may shift resources *within* industries, instead of *across* them. In Feenstra and Hanson (1999), the authors try to disentangle the relative importance of trade versus technology for the increase in the skill premium. They again use imports of intermediate goods as a measure for offshoring and expenditures on high-tech equipment as a measure of technological investment and they find that both variables are important determinants of the change in skill-intensity for different sectors, as well as the change in the ratio of non-production to production wages in manufacturing. They use a two-step procedure to identify the impact of offshoring and high-tech investments on prices and productivity and then to use the induced prices and productivity to calculate changes in both production and non-production wages. In Feenstra and Hanson (1997a), the authors turn their attention to the effects of U.S. offshoring on wages in the Mexican manufacturing sector. They use data on the activities of foreign-owned assembly plants (*maquiladoras*) to measure inflows of FDI or offshoring to Mexico and examine the impact of the increase in this activity upon overall wages in the Mexican manufacturing sector. They find that the increase in outsourcing by foreign multinationals is correlated with a shift in production towards relatively skill-intensive goods, which causes an increase in the relative demand for labor. They use differential changes in FDI across regions to show that in those regions in which FDI was the most concentrated, growth in FDI can account for over 50 percent of the increase in the skilled labor share of total wages that occurred in the late 1980s.

Amiti and Wei (2009) adapt the approach taken by Feenstra and Hanson (1999) so that they can measure the impact of both material and service offshoring on productivity growth in the United States. The employ data from the U.S. Bureau of Labor Statistics for the years 1992-2000 and find that both materials and service offshoring have a statistically significant positive impact on domestic productivity growth; they estimate that materials offshoring has a smaller impact, accounting for about 5 percent of average growth in domestic productivity, and service offshoring has a somewhat larger impact, accounting for about 10 percent of average productivity growth. Moreover, the impact of materials offshoring is not statistically significant under all specifications of their econometric model.

Ebenstein, Harrison, McMillan, and Phillips (2009b) take seriously the idea that different *tasks* are traded and measure a task by an occupation's routineness. They hypothesize, as do Grossman and Rossi-Hansberg (2008), that more routine tasks might be easier to offshore. Moreover, in their econometric specification, they control for the change in computerization rates for different occupations in order to disentagle offshoring from technology substituting for low skilled labor. Autor, Levy, and Murnane (2003) show that occupations that are more routine can be more easily performed by computers and, therefore, workers who perform these jobs are more easily replaced by computers. Therefore, Ebenstein *et al* wish to control for this effect in their empirical exercises. Furthermore, this specification allows them to consider how specific *occupations*, as opposed to *industries*, are impacted by offshoring. This differs from the extant literature in an important way. Various studies have shown that the cross-industry shifts predicted by the Heckscher-Ohlin theory do not seem to hold in the data; this has led researchers to conclude that the shift in relative wages observed in the data could not be attributable to trade. It may be easier for workers to change industries than for them to change occupations. If this is the case, an approach that focuses on changes in industry premia may be missing the main effect of workers changing industries, but maintaining their occupation. They find that, indeed, offshoring has had substantial effects at the occupation-level specifically through displacing workers and inducing them to take jobs in other, lower-paying, industries. They find that occupation-specific changes in offshoring and trade are associated with significant wage effects, especially for workers in routine occupations. They also find that the location of offshoring is important for the sign of the effects: A 1 percent increase in offshore activity in low-income countries is associated with a 0.11 percent decrease in wages, whereas a 1 percent increase in offshore activity in high-income countries is associated with a 0.1 *increase* in domestic wages. Import and export penetration have larger effects but these effects are only statistically significant in some specifications. The authors find that the net impact of offshoring on wages is a function of the extent to which the occupation is routine; they find that the net effect of offshoring on wages is negative for the most routine occupations and positive for the least routine.

1.3.2 Modifications to the Eaton-Kortum Model of Trade

The use of models with a large number of varieties of goods, as in Burstein and Vogel (2012), has implications that are consistent with a number of well-documented outcomes in the data. In particular, these types of models help to replicate the existence of North-North trade, as well as the lack of factor-price equalization and the existence of high variance of goods prices across locations in which they are sold. Embedding two types of labor into this framework allows the authors to match some other key observations in the data that were previously believed to be inconsistent with trade having an impact on inequality. First, as documented in Lawrence and Slaughter (1993), opening to trade is accompanied by a drop in the relative price of skill-intensive sectors. Heckscher-Ohlin would predict that, in order for trade to have a positive impact on the skill premium in a skill-abundant country, the relative price of goods in the skill-intensive sector should fall. Second, most factor reallocation resulting from increased trade happens within, rather than across, sectors, as documented in Berman, Bound, and Griliches (1994). Third, as summarized by Goldberg and Pavcnik (2007), inequality rises following trade liberalization for a number of skill-scarce countries. Therefore, embedding two types of labor, with a productive technology that augments one type of labor more than the other, into an EK model is both supported by the data and helps to resolve some of the puzzles that have been documented.

Autor, Dorn, and Hanson (2013a) document the differential impact of import competition that is captured by Kondo (2012). They combine data on wages, employment, and labor force participation by commuting zones from the Census with data on imports of goods from China from the United Nation's Comtrade database in order to explore the varying impact of imports on different regions within the U.S. They hypothesize that those regions in which the economy is most concentrated in producing goods whose imports have risen most substantially will be those that have the most visible labor effects as a result of increasing trade with China. In order to control for potential endogeneity of Chinese imports in to any given region in the U.S., they instrument for the shock of increasing Chinese imports into the U.S. using Chinese imports into other developed countries. They find that Chinese imports have strong and significant effects on wages, employment, and labor force participation, with the largest effects being on non-participation. In the most conservative case, they find that the measured increase in Chinese imports accounts for one-quarter of the rise in unemployment in the U.S. manufacturing sector from 1990 to 2007. Moreover, they find that the increase in Chinese imports is positively associated with pushing workers towards claiming disability.

1.3.3 Trade and Innovation

Several studies have focused upon the interaction between trade and innovation, as well as the interaction between trade and investment in new technologies or capital. Bloom, Draca, and Reenen (2011) examine the impact of Chinese import competition upon both types of activities using a panel of firms from 12 European Union countries from 1996 to 2007. They specifically examine the impact of import competition upon research and development, patenting activities, investment in information technology (IT), and on firm-level total factor productivity (TFP) over the time period of interest. They propose several different methods to deal with potential endogeneity between technology shocks and increasing imports from China; their preferred method is to use China's entry into the World Trade Organization as an exogenous shock. They find that there are two main effects of increased import competition. First, they find that this increase is associated with increases in all of the examined activities *within* firms. Secondly, there is evidence of reallocation of employment *between* firms from less innovative to more innovative and technologically advanced firms. These two effects are roughly equal in magnitude and together can account for about 15 percent of European technology upgrading over the latter half of the sample (2000-2006). They also find that overall employment, profits, prices, and skill share decrease as import competition from China increases. They compare these results to what happens when import competition from advanced countries increases and find that, in contrast, this type of increase in competition has no effect. This paper provides support both for the idea that innovation is increased (increased investment in research in development and patenting activities) *and* that investment in existing technologies increases (increased investment in information technology).

Quality Upgrading

In addition to making a theoretical contribution, Verhoogen (2008) also provides strong empirical evidence for his proposed mechanism. He uses a panel of Mexican plants, combining data from the Annual Survey of Manufacturers (*Encuesta Industrial Anual*) with data from the National Survey of Employment, Wages, Technology, and Training (*Encuesta Nacional de Empleo, Salarios, Tecnoloía, y Capacitacíon*). The two surveys include information on wages, employment, investment, and a measure of product quality, called the ISO 900 certification. This certification is an international production standard and is viewed by Mexican managers as a signal of a high-quality product. Verhoogen uses it as a indicator variable to identify those plants which are producing a high quality product; changes in ISO 900 certification status indicate changes in the quality of goods produced at a given plant. He uses the peso devaluation that occurred in 1994 as an exogenous source of variation to show that initially more productive plants increase their export share of sales, wages of both white- and blue-collar workers, the relative wages of white-collar workers, and the fraction of goods that are ISO 900 certified by more than initially less productive plants during the peso crisis. Moreover, these variables change by more during the peso crisis than during other periods in the sample. This supports the idea that quality upgrading induced by the exchange rate shock increases within industry inequality. Recall that Verhoogen's interest is across-plant, or within-industry, inequality and not inequality across workers. His empirical work provides support for his hypothesis that variation in plant outcomes is connected to increased access to foreign markets.

Investment in Skill-Augmenting Capital

Caselli (2013) explores the interaction between investment in capital machinery and equipment (M&E) and the skill premium in Mexico in support of the hypothesis that technological change can be *embodied* in capital equipment. He uses the price of M&E as a proxy for skill-biased technical change, as was done in KORV, with the idea that the falling price of M&E is due to technological change. He uses a panel from the Mexican Anual Survey of Manufacturers in order to link changes in the skill premium to changes in M&E, controlling for a number of variables. He shows that increases in foreign direct investment and M&E are both associated with increases in the skill premium at the plant level and that tariffs on M&E are negatively correlated with the skill premium. Moreover, the price of M&E in Mexico is determined predominantly by the price of M&E in the United State and tariffs on the import of M&E. These results indicate that technology may be transferred across borders via trade in machinery and equipment. The estimated magnitudes of the impact of imports of M&E are relatively small, but the results are statistically significant.

1.3.4 Labor Market Frictions and Bargaining

Helpman, Itskhoki, Muendler, and Redding (2012) provide support for the proposed theory in Helpman, Itskhoki, and Redding (2010) using linked employer-employee data from Brazil. They show, first, that much of the measured wage inequality occurs *within* sectors and occupations, as opposed to *across* them. Moreover, a large share of inequality is driven by inequality *between* firms, as opposed to *within* firms. They argue that much of the inequality that they measure is residual inequality; that is, it remains even after controlling for worker characteristics. They find a strong relationship between firm-level inequality and exporter status of the firm; exporters, on average, pay higher wages to all employees than their non-exporting counterparts. Furthermore, exporters on average are much larger than non-exporters in terms of both output and employment. This matches what is documented by Bernard and Jensen (1997) for the United States. The authors then use their data to calibrate a modified version of the model presented in Helpman, Itskhoki, and Redding (2010) and show that the calibrated version of this modified model is consistent with the documented facts from the data. Using the calibrated model, they are able to show that the exporter wage premium depends on both the selection into exporting of the most productive firms that pay higher wages and the increase in firm wages which comes about because of the greater market access of exporters.

Cosar (2013) documents further evidence of labor market frictions and their importance for labor market adjustment to trade liberalization. He shows that labor markets typically exhibit slow reallocation of labor across industries, with large costs for displaced workers and even larger costs of adjustment for the oldest workers. He presents a calibrated overlapping generations model with frictional labor markets and sector-specific human capital. In the context of this model, he is able to show that labor market frictions are not sufficient to explain the sluggishness of adjustment. Instead, sector-specific human capital is necessary to match the documented facts. Together, these two features of the model are able to replicate the patterns observed in the data.

The model presented and estimated in Dix-Carneiro (2013) is similar to that in Cosar (2013). His model features overlapping generations and two sectors, with the accumulation of sector-specific human capital which leads to switches between sectors being costly. In addition to choosing a sector in which to work, workers can choose not to be employed. He also uses the matched employer-employee data from Brazil in order to estimate the model. He estimates that, in this data, workers incur costs equal to 1.4 to 2.7 times individual annual average wages in order to switch sectors. However, these estimates vary dramatically across individuals with different observable characteristics. This leads to large dispersion in inter-sectoral mobility, which implies differing ability to adjust to demand shifts associated with trade liberalizations. This paper is among the first to estimate the actual cost associated with reallocation of labor across sectors or occupations. It provides direct evidence that labor market frictions may play an important role in the response of an economy to a trade liberalization.

1.4 Conclusion

Contrary to findings in the early 1990s, recent modifications to traditional trade theory have shown that globalization may have important impacts on labor market outcomes.

The modifications that have been made to existing theory allow for trade to impact labor markets through a number of new channels, including inducing firms to make additional investments in technologies. This channel seems to be an important one, both for the development of new technologies and for the proliferation of these new technologies across countries. In this sense, it's possible that the two *competing* hypothesis for growing inequality and low-skill unemployment, namely globalization and technological change, could actually be *complementary* hypothesis, mutually reinforcing one another. This line of research deserves more theoretically and empirical attention, as these two trends seem to go hand-in-hand in a number of cases. The literature concerning the changing nature of labor market responses to business cycles has yet to focus much on the role of globalization and trade. Given the growing literature that shows the impact of these forces on longer-run labor market trends, it stands to reason that they could have important implications for cyclical elements of labor markets.

Chapter 2

Globalization and the Changing Shape of Labor Recoveries

2.1 Introduction

In the post-war era, the labor market typically begins to recover one to two quarters after GDP begins to recover. Moreover, once this growth begins, it tends to be strong. However, in the three most recent recessions, labor markets have seen recoveries that have been both slow and weak relative to previous recoveries, earning them the moniker "jobless recoveries." Even when one accounts for the fact that GDP growth has been slower in these recoveries than in earlier ones, the sluggishness of the labor recoveries is remarkable. Much attention has been paid to this change in the business cycle features of labor markets. However, less attention has been paid to the secular changes that have occurred over the same period. In particular, the employment to population ratio has been falling since its 2001 peak and is currently at a level that has not been seen since the early 1980's, having fallen about 6 percentage points, from a peak of about 64% to its current level, 58%. In all previous business cycles, the employment to population recovered to its pre-recession peak. In fact, it has consistently risen since the early 1970's, when women began to join the workforce en mass.

The uncharacteristically high and persistent unemployment rate that has followed the Great Recession has renewed interest in the jobless recovery phenomenon. In particular, many have wondered what has made the recovery following the Great Recession so different from the one in the early 1980's. In this paper, I argue that jobless recoveries are related to trend growth in emerging markets and international opening. I have in mind that these emerging markets offer companies opportunities for expansion but costly reallocation assures that they wait until the potential benefit of reallocation outweighs the costs. Recessions provide such an opportunity since lower productivity in the advanced country makes the cost of reallocating resources relatively lower in a recessionary period. I offer evidence that this reallocation is occurring over the time period in which jobless recoveries have emerged. Moreover, I show that labor market outcomes can be tied to increasing globalization.

In order to explore my hypothesis further, I build a modified growth model. In the model, a multinational cooperation chooses either to produce in an advanced, high productivity country which is not growing or in an emerging, lower productivity country whose productivity is growing. The multinational produces a final consumption good using labor and managerial services [1] which are produced in the advanced economy but can be reallocated and used for production in the emerging economy. There are two forces operating in the model. The first is the relative growth of the emerging country. This leads to the secular shift of managerial services and, thus, production to the emerging market. The second is the mechanism which slows this secular shift and assures that it occurs primarily during recessions: a cost of adjusting the use of managerial services in each country. This is what causes the shift in production to occur primarily during recessions and leads to the emergence of jobless recoveries. Essentially, recessions are "cheap" times to reallocate resources across countries.

I show that falling production of the consumption good in the advanced economy does not coincide with falling GDP. Thus, with no adjustment costs, the model produces increasing GDP and falling labor and labor productivity rises as factors are reallocated. With adjustment costs, recessions are a time when the firm is willing to pay to adjust, shifting resources to the more efficient production location. Therefore, the model produces large and sustained drops in labor in the advanced economy following a recession, while GDP recovers as the emerging market grows. Thus, the model is able to produce a jobless recovery.

[1] Similar to those proposed by Burstein and Monge-Naranjo (2007)

Additionally, the model is consistent with increasing income inequality across individuals in the advanced economy. This is due, in part, to a decrease in labor demand for the low-skilled households in the economy. It is also because labor by the high-skilled households become relatively more valuable as productivity in the emerging market grows.

The results suggest that the mechanism that I propose shows potential to be able to account for both the secular trends and the business cycle anomalies that have arisen in the past 20 to 25 years. In future work, I will calibrate the model in order to assess what share of job losses can be accounted for by the proposed mechanism.

2.1.1 Related Literature

This paper is most closely related to the recent work of Jaimovich and Siu (2012). They hypothesize that jobless recoveries can be tied to the recent reduction in routine jobs in the economy and increased concentration of employment in the tails of the occupational skills distribution. They show that the vast majority of the shift in the occupational distribution occurs around and during the three recessions and recoveries are jobless. Following the literature on job polarization, [2] they attribute the drop in employment in jobs that predominately rely on routine skills to technological change which is skill- or routine-biased. I propose a different mechanism for the shift in the labor composition of employment. As has been recognized in several empirical studies, [3] routine jobs are also those that can be easily offshored. I see my work as complementary to that of Jaimovich and Siu, who recognize that there is a role for offshoring and outsourcing in the job polarization literature, but fail to explore it. Moreover, they fail to provide evidence for the mechanism they do explore. In this paper, I show that increased import competition is associated with decreased job creation, suggesting that international forces should be important in accounting for both trend and cycle declines in employment.

My paper is further related to two strands of literature. The first is a growing literature that explores the jobless recovery phenomenon. Bachmann (2011) offers an increase in labor hoarding as an explanation for jobless recoveries. According to this theory, when firms retain redundant works during downturns, hiring is weak during the

[2] Autor (2010), Autor et al (2006), and Goos et al (2009)

[3] See, for example, Ebenstein et al (2009), Goos et al (2009), and Liu and Trefler (2011)

subsequent recovery. This theory implies, counter factually, that the recent recoveries should be associated with increasingly procyclical labor productivity. Relatedly, Berger (2012) builds a model in which firms use recessions as opportunities to streamline their workforce. He argues that firms are more able to do this in the recent past due to the decline of union power. While Berger is able to generate weak labor recoveries and acyclical labor productivity, his paper suggest, counter factually, that the pattern of joblessness arises from increased job destruction rates. The data show that, while job losses certainly increase around recessions, jobless *recoveries* are related to low job *creation* rates. He relies on firms growing "fat" in good times, or booms, and shedding some of the inefficiencies during recessions. The mechanism that I propose is able to generate acyclical labor productivity and weak job creation after recessions. Pries and Sims (2011) present a theory in which the Great Moderation and jobless recoveries are related. They hypothesize that reallocation shocks are have become relatively more important than aggregate shocks. Therefore, recent recoveries have been marked times of reallocation. They are able to replicate the qualitative changes in business cycles, but they do not offer an explanation as to why reallocation shocks have grown in importance. My work is complementary to theirs in that it offers a more micro-founded explanation of this phenomenon.

The second of strand of literature to which this paper contributes is the theoretical literature on job market impacts of increasing trade and international competition. I draw upon the observations of Autor, Dorn, and Hanson (2011). They show that increased competition from China, in the form of imported goods, can account for a large portion of the decline in U.S. manufacturing employment. Rising import exposure increases unemployment and lowers labor force participation. They concentrate on am empirical exploration of the downward trend from 1990 to 2007, while I offer a reason that this trend exists, as well as tie the trend to jobless recoveries. In a related paper, Kondo (2013) uses an alternate measure of import competition, finding larger impacts on the broader labor market, not just the market for manufacturing employees. He finds that, in addition to reducing unemployment and labor force participation, increased import competition is associated with lower job creation rates and high job destruction rates. To my knowledge, I am the first to consider the business cycle effects of increased globalization on labor markets.

The rest of the paper is organized as follows. Section 2 provides empirical evidence for the existence of jobless recoveries as part of a larger downward trend in employment relative to population. It then provides a link between this observation and increased globalization. Section 3 lays out the model. Section 4 provides a simplification of the model and illustrates the impacts of increased growth in low-income countries on advanced countries. In Section 5, I conduct a quantitative experiment to demonstrate that the model produces jobless recoveries and, in Section 6, I discuss calibration and steps for further research. Section 7 concludes.

2.2 Empirical Evidence

In this section, I first document the existence of jobless recoveries. I also offer some evidence about how overall employment and the employment to population ratio have been impacted by the drastic fall in manufacturing employment. I then turn to evidence of increased productivity in emerging markets and their relative importance in the global economy. Finally, I show some evidence that these two sets of facts are related.

2.2.1 Labor Market Data

In Figure 2.1, I plot total non-farm employees from the Establishment Survey from 1960 to 2012. The figure displays log deviations from a linear trend. Notably, after the two most recent recessions, employment has not recovered to its pre-recession peak. Additionally, in the recovery after the 1991 recession, employment recovered at a much slower rate than is exhibited in the previous recessions.

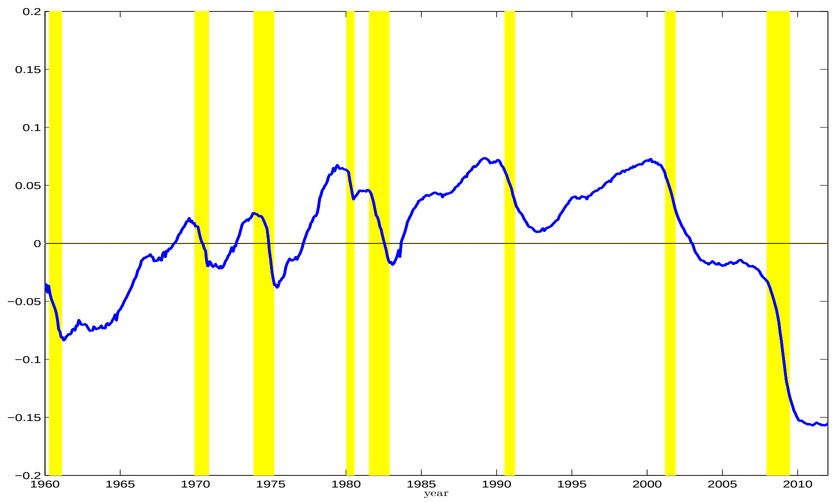


Figure 2.1: Deviations from Linear Trend

This can be seen more clearly in Figure 2.2. Table 1 shows the length (in months) of recovery from three early post-war and the three most recent recessions. It is measured in months from the trough of the business cycle, as dated by the NBER. So, in each of these recoveries, GDP began to recover in zero months. The first row shows a marked increase in the number of months it takes for growth in employment markets to begin. The second row reiterates the point, showing that labor markets take even longer to return to the level that they were at when GDP hit its trough. Note that the second row does not count the number of months it takes for employment to reach its cyclical peak. Rather, it counts the number of months it takes for employment to rebound to a level that it was at when GDP began to exhibit positive growth.

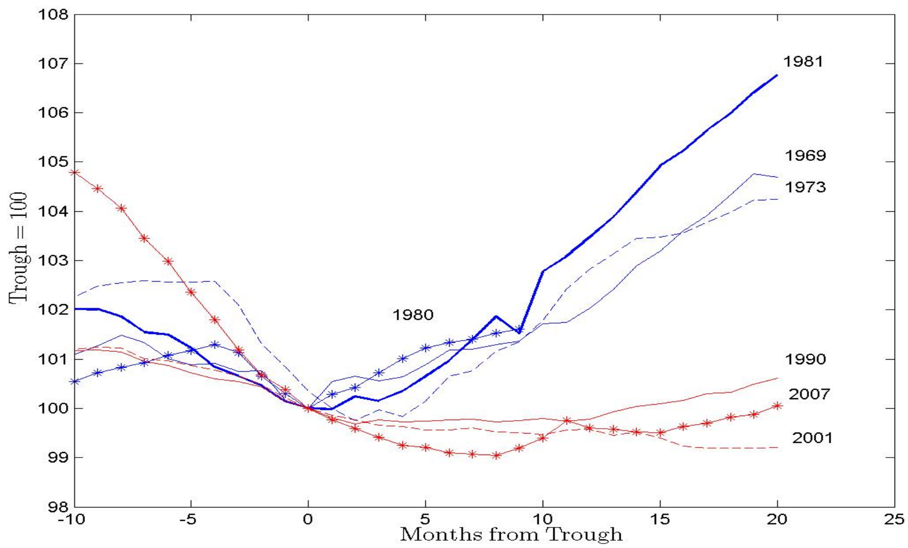


Figure 2.2: Employment relative to Trough

	Early			Recent		
Months to:	1970	1975	1982	1991	2001	2007
Turn-around	1	2	1	18	23	15
Return to Trough	2	2	4	15	55	21

Table 2.1: Measures of Recovery

As Figure 2.3 shows, the employment to population ratio has not recovered from its 2001 pre-recession peak. Much of the fall in employment (and therefore, the employment to population ratio) can be attributed to a substantial drop in manufacturing employment. From 2001 to 2011, manufacturing employment fell from about 17 million employees to just under 12 million. (See Figure 2.4). Figures 2.5 and 2.6 highlight the importance of the decrease in employment in manufacturing. In these counterfactuals, I set manufacturing employment to it's 1991 level (18 million employees) from 1991 to 2012. In each figure, the blue line is the data and the red line is the counter factual experiment. In all three of the most recent recoveries, employment growth would have been much faster had manufacturing employment not dropped so severely. Moreover, the employment to population ratio would have recovered after the 2001 recession and would currently be about four percentage points higher than it is in the data. Obviously, this is not an entirely clean exercise, as some of the workers who lost their manufacturing jobs have found jobs in other sectors of the economy. However, it does serve to illustrate the importance of the decline in manufacturing activity in the U.S.

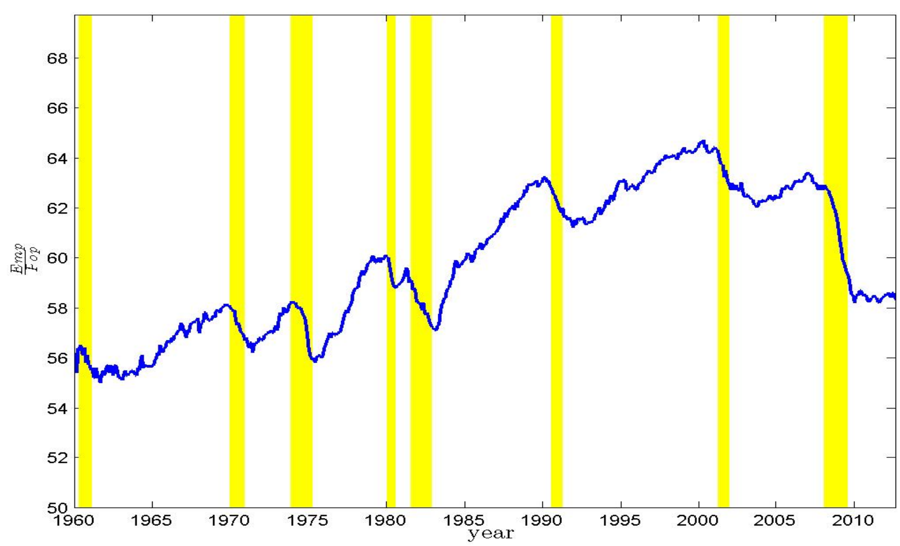


Figure 2.3: Employment to Population Ratio

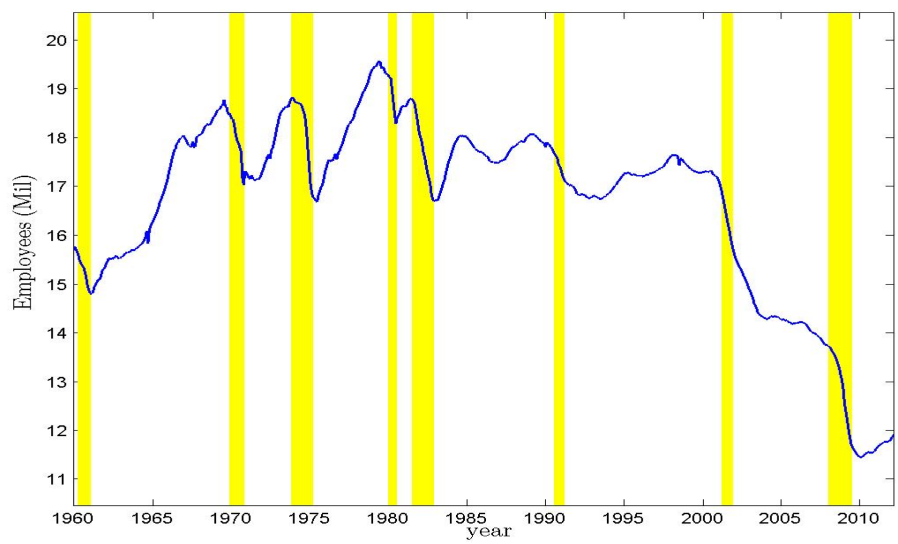


Figure 2.4: Manufacturing Employees

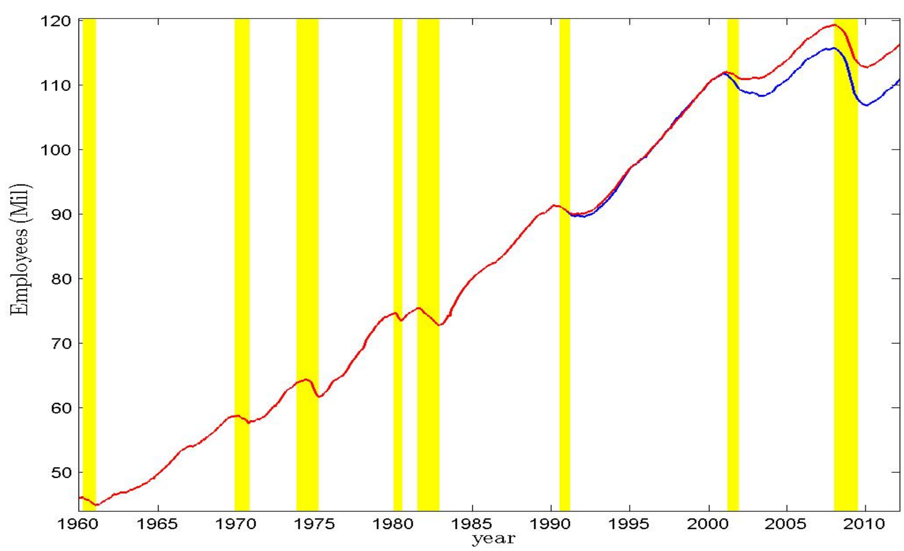


Figure 2.5: Counterfactual: Employees

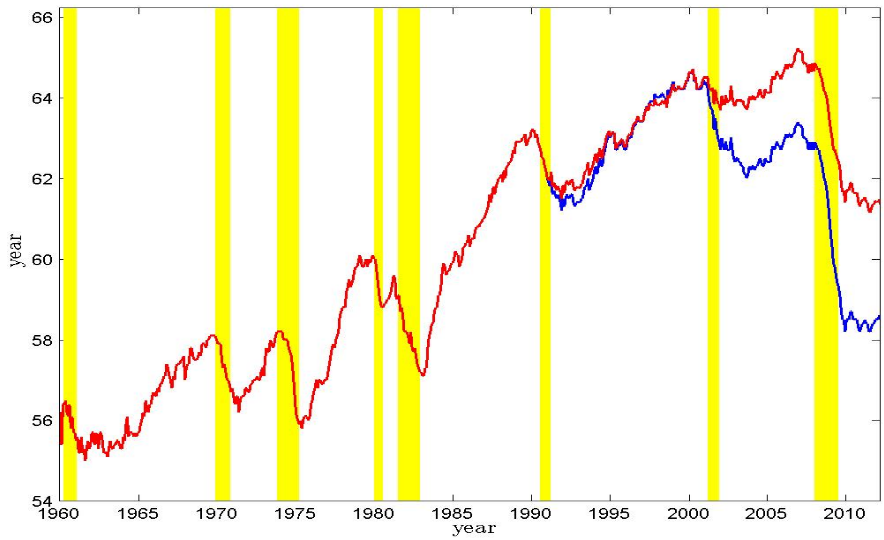


Figure 2.6: Counterfactural: $\frac{Emp}{Pop}$

2.2.2 Emerging Market Data

In this section, I present evidence of the growing importance of emerging markets. First, I show evidence that these countries are "catching up" to their advanced counterparts, in terms of share of world GDP. I then provide evidence that the U.S. economy is more exposed to this competition, both through increased trade and through offshoring opportunities. In particular, U.S. companies (multinationals) have responded by expanding more heavily in developing countries than developed ones.

Figure 2.7 shows the share of GDP accounted for by advanced versus non-advanced countries. The data is from the World Bank's World Development Indicators database. I hold the set of advanced countries fixed over the entire time period. It is notable that in 2000, the share of world GDP accounted for by non-advanced countries began to grow. By 2011, the share of world GDP accounted for by non-advanced countries was almost equal to that of the advanced countries. Most of this shift can be attributed to the emergence of China and its spectacular growth after it joined the World Trade organization in late 2002.

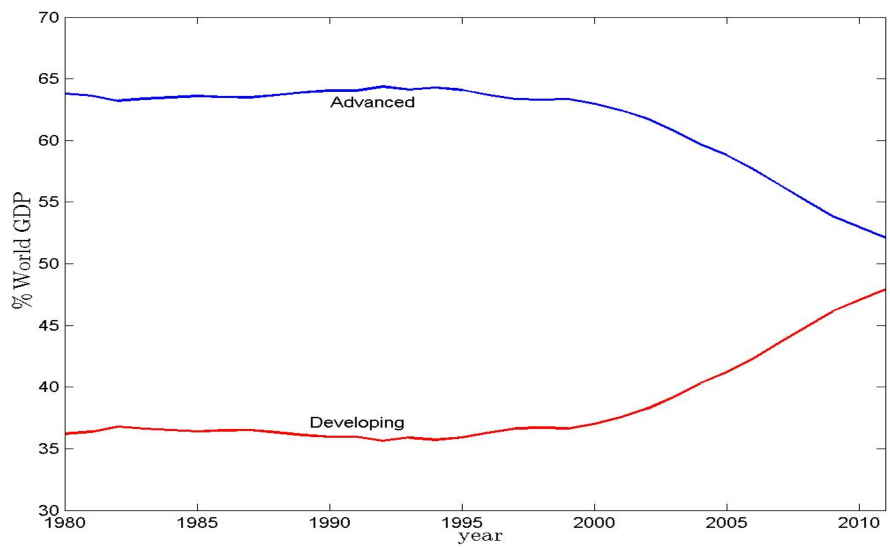


Figure 2.7: Share of per capita World GDP

Figures 2.8 and 2.9 show the trends in multinational employment. In Figure 2.8, I plot the log of the number of employees of U.S.-based multinational companies employed in the U.S., in other advanced countries, and in developing countries.[4] Figure 2.9 normalizes the number of employees in 1990 to 100 in order to show the growth in employment in the three areas. Total employment in multinationals has grown over time, but domestic growth has been almost flat. Similarly, employment in other advanced economies has grown, but only by about 20% over two decades. Employment in emerging markets, on the other hand, has surged, growing by about 280% over the same period. The share of employees in emerging markets began to grow particularly quickly in 2002, as manufacturing employment in the U.S. began to fall off substantially.

[4]Data from the BEA's Direct Investment and Multinational Companies (MNCs) database

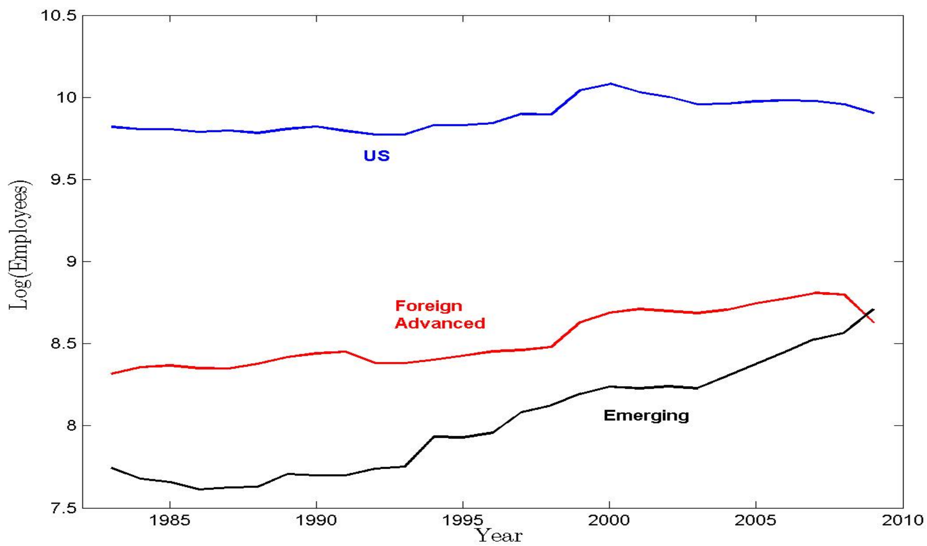


Figure 2.8: Log Employees

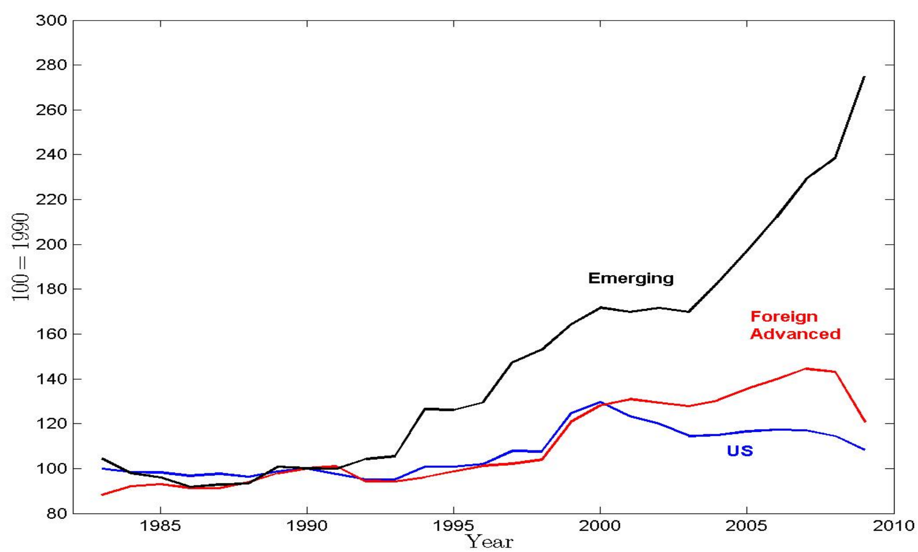


Figure 2.9: Log Employees relative to 1990

I turn now to imports from developing countries. It has been documented elsewhere[5] that in 1991 the low-income country share of U.S. manufacturing imports only accounted for 2.9% of U.S. manufacturing imports. In 2007, they accounted for 11.7%. Imports from China account for over 90% of the total growth in low-income country imports. Moreover, total U.S. spending on Chinese goods grew by almost 700% over the same period.

Figure 2.10 shows the U.S. trade balance. Clearly, during the period in which we observe a secular drop in manufacturing employment is a period of increased trade and competition. Figure 2.11 reiterates that much of this growth in trade can be accounted for by growth in trade with low-income countries.

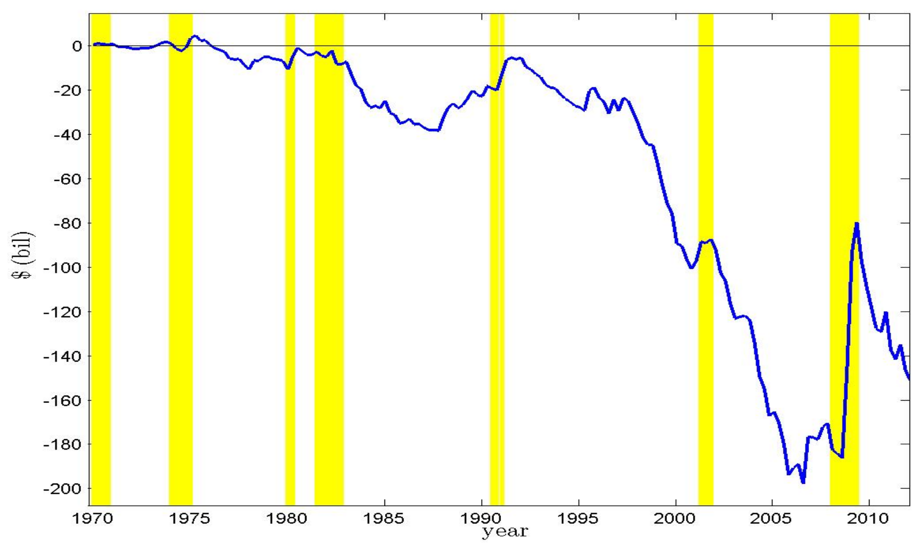


Figure 2.10: U.S. Trade Balance

[5]See, for example, Autor, Dorn, and Hanson (2011)

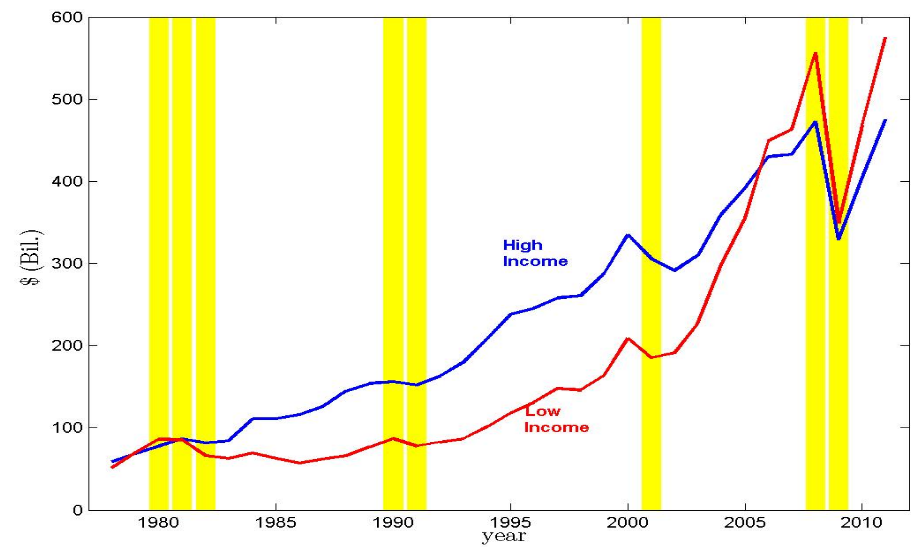


Figure 2.11: U.S. Imports of Intermediate Goods

2.2.3 Increased Globalization and Labor Market Outcomes

Here, I offer evidence that the trend and cyclical changes in labor market outcomes are related to increased globalization and competition from low-income countries. Autor, Dorn, and Hanson (2011) find that about one quarter of the secular drop in manufacturing employment can be accounted for by increased import competition. In a complementary paper, Kondo (2013) extends their work using a different measure of import competition. Furthermore, he considers additional labor market variables, including job creation and destruction. In what follows, I replicate the results in Kondo (2013).

As a measure of import competition, I workers who have been certified to receive Federal TAA (Trade Adjustment Assistance) benefits, as a fraction of working age population. There is substantial variety in this measure across state and years which can be exploited to identify differences in employment rates and job creation and destruction rates. I calculate employment status and weeks unemployed from the Current

Population Survey. Job destruction and creation rates are constructed using the Business Dynamics Statistics database and the definitions of Davis, Haltiwanger, and Schuh (1998). Table 2 reports the results of the following regression:

$$\text{dependent variable}_t^i = \alpha + \beta \text{ x import competition}_t^i + \gamma \text{ x controls}_t^i + \text{error}_t^i$$

These regressions show that increased import competition is associated with lower rates of employment and labor force participation, high job destruction, and lower job creation. Higher destruction rates and lower creation rates clearly lead to a secular decrease in employment. Moreover, the results show that increased import competition results in longer unemployment spells. Therefore, we can say that these results support that hypothesis.

Dependent Variable	Import Competition	R^2	N
Not Employed	3.35*	0.86	1350
	(0.78)		
Not in Labor Force	2.19*	0.86	1350
	(0.86)		
Weeks Unemployed	.51*	0.54	1350
	(0.15)		
Job Destruction Rate	1.82*	0.80	1350
	(0.72)		
Job Creation Rate	-1.276*	0.77	1350
	(0.63)		

Table 2.2: Labor Market Outcomes and Import Competition

There is clearly an endogeneity issue in the regressions above since the measure of import competition being used is essentially a measure of unemployment insurance. Therefore, in future work, I will exploit the method of Autor, Dorn, and Hanson (2011) to instrument for import competition. Additionally, more work needs to be done to relate import competition to business cycle frequency indicators. In particular, I am exploring how months to recovery vary across states, recessions, and industries with increased import competition.

2.3 Model

In this section, I develop a modified growth model in which growth in an emerging country can lead to jobless recoveries in the advanced country. I first describe the problem solved by the firm (the multinational) and then the problem solved by the two types of households.

2.3.1 The Environment

Time is discrete and infinite. There are two countries: Advanced (A) and Emerging (E). In Country A, there are two types of households, whereas in Country E, there is only one type of household. Each household consumes a single consumption good and saves with a one-period bond. Households of type "M" operate a linear backyard technology in order to produce managerial services, which they then rent to the firm. These services can be used in either country but are produced only in Country A. Type-L households live in both countries and rent labor services to the firm's production facility in the country where they reside. The proportion of type-M to type-L households in Country A is fixed at $\frac{\alpha}{1-\alpha}$. The single consumption good is produced by a multinational firm, which is headquartered in Country A. This firm can choose production locations. It will rent labor from the household that is located in the country of production. The two countries differ in their productivities. Country A is more productive than Country E at $t = 0$ but has zero growth, whereas Country E's productivity grows deterministically over time.

2.3.2 The Multinational

The multinational operating in Country i produces output (y_t^i) at time t using labor (l_t^i) and managerial "know-how" or services (m_t^i)

$$y_t^i = z_t^i (m_t^i)^\theta (l_t^i)^\nu$$

where

$$\theta + \nu \leq 1$$

Managerial services are rented from M-type households in Country A and may be reallocated by the multinational across countries. Denote by m_t^i the amount of managerial services that are used in country i and by m_t the total amount of managerial services hired by the firm, which will be the sum of m_t^A and m_t^E. Notice that managerial services are mobile across borders, but labor is not. The term z_t^i is country-specific productivity. The multinational will face productivity processes whose growth vary across countries. In particular,

$$\begin{aligned} z_0^A &> z_0^E \\ z_t^A &= z_0^A, \quad \forall t \\ z_t^E &= \rho^t z_0^E + (1-\rho^t) z_0^A \end{aligned}$$

The multinational pays a local wage to laborers ($w_{L,t}^i$). The rent paid to managerial services will be the same, no matter where the managerial services are used since they are all produced in Country A. The multinational pays a fixed cost of adjusting the level of managerial services in each country.

The multinational firm takes prices as given and maximizes the present value of dividends:

$$\max_{m_t, m_t^A, m_t^E, l_t^A, l_t^E} \sum_t p_t D_t$$

subject to

$$\begin{aligned} D_t &= d_t^A + d_t^E \\ d_t^i &= y_t^i - w_{L,t}^i l_t^i - w_{M,t} m_t - \varphi \mathbb{1}_{m_t^i \neq m_{t-1}^i} \\ y_t^i &= z_t^i (m_t^i)^\theta (l_t^i)^\nu \end{aligned}$$

2.3.3 Households

There are two types of households in the advanced economy: L-type households and M-type households. L-type households make up a fraction $1-\alpha$ of the total economy, where M-type households make up a fraction α. The emerging economy has only L-type households.

In each period, t, the L-type household in country i receives labor income, $w_{L,t}^i n_{L,t}^i$, earnings on his asset position, $(1+r_{b,t})b^i_{L,t}$, and some fraction ϕ^i_L of the total dividends of the firm (D_t). He chooses consumption, $c^i_{L,t}$, labor supply, $n^i_{L,t}$, and asset position, $b^i_{L,t+1}$. The maximization problem for the household is thus

$$\max_{c^i_{L,t},n^i_{L,t},b^i_{L,t+1}} \sum_t \beta^t u\left(c^i_{L,t} - v(n^i_{L,t})\right)$$

subject to

$$p_t(c^i_{L,t} + b^i_{L,t+1}) = p_t\left(w^i_{L,t}n^i_{L,t} + (1+r_{b,t})b^i_{L,t} + \phi^i_L D_t\right)$$

The household take all prices ($p_t, w^i_{L,t}$,$r_{b,t}$) as given.

The M-type household has access to a backyard linear technology which he operates in order to produce an intermediate good, "managerial services", m_t, which it sells to the firm at price $w_{M,t}$. Its income is thus composed of rental income, $w_{m,t}m_t$, earnings of the asset position, $(1+r_{b,t})b_{M,t}$, and a fraction ϕ_M of the firm's dividend payments. It chooses consumption, $c_{M,t}$, labor supply, $n_{M,t}$, and asset position, $b_{M,t+1}$. The maximization problem for the household is thus

$$\max_{c_{M,t},n_{M,t},m_t,b_{M,t+1}} \sum_t \beta^t u\left(c_{M,t} - v(n_{M,t})\right)$$

subject to

$$\begin{aligned} p_t(c_{M,t} + b_{M,t+1}) &= p_t\left(w_{M,t}n_{M,t} + (1+r_{b,t})b_{M,t} + \phi_M D_t\right) \\ m_t &= n_{M,t} \end{aligned}$$

The household takes all prices ($p_t, w_{M,t}$,$r_{b,t}$) as given.

2.3.4 Competitive Equilibrium

A competitive equilibrium in this economy is prices $\{p_t, r_{b,t}, w^i_{L,t}, w_{M,t}\}$ and a set of quantities $\{d^i_t, y^i_t, m_t, m^i_t, n^i_{L,t}, c^i_{L,t}, c_{M,t}, b^i_{L,t}, b_{M,t}\}_{i\in\{A,E\}}$ that are consistent with

1. the firm's maximization problem,
2. the household maximization problems,

3. managerial services market clearing,

$$m_t = m_t^A + m_t^E$$

4. labor market clearing in each country i ,

$$l_t^i = n_{L,t}^i$$

5. bond market clearing,

$$\sum_{i \in \{A,E\}} b_{L,t}^i + b_{M,t} = 0$$

6. the aggregate resource constraint

$$\sum_i c_{L,t}^i + c_{M,t} = \sum_i y_t^i$$

2.4 Effects of Increasing Productivity in Country E: Secular Decrease in Labor

In this section, I explore the qualitative effects of an increase in the productivity of the emerging market, relative to that of the advanced economy. I want to show that, under certain conditions, growth in Country E causes labor in Country A to fall, while GDP in that country rises.

2.4.1 Simplified Model: Abstracting from Adjustment Costs

For the moment, let us abstract from adjustment costs in order to explore the impact of growth in the developing country in a clear way. In this case, the firm is solving

$$\max_{m_t, m_t^A, m_t^E, l_t^A, l_t^E} \sum_t p_t D_t$$

subject to

$$\begin{aligned} D_t &= d_t^A + d_t^E \\ d_t^i &= y_t^i - w_{L,t}^i l_t^i - w_{M,t} m_t \\ y_t^i &= z_t^i (m_t^i)^\theta (l_t^i)^\nu \end{aligned}$$

Let's further assume that the household has preferences that are linear in consumption and take the form

$$u(c - v(n)) = c - \frac{n^{1+\gamma}}{1+\gamma}$$

Assuming that $p_0 = 1$, the household's problem yields first order equations

$$w^i_{L,t} = (n^i_{L,t})^\gamma$$
$$w_{M,t} = (n_{M,t})^\gamma$$
$$(1 + r_{b,t}) = \frac{1}{\beta}$$
$$p_t = \beta^t$$

Assume that $\theta = 1 - \nu$. Then, the firm's problem yields first order conditions:

$$\begin{aligned} w^A_{L,t} &= \nu z^A_t \left(\frac{m^A_t}{n^A_t}\right)^{1-\nu} \\ w^E_{L,t} &= \nu z^E_t \left(\frac{m^E_t}{n^E_t}\right)^{1-\nu} \\ w_{M,t} &= (1-\nu) z^E_t (m^E_t)^{-\nu} (n^E_t)^\nu \\ (1-\nu) z^E_t (m^E_t)^{-\nu} (n^E_t)^\nu &= (1-\nu) z^A_t (m^A_t)^{-\nu} (n^A_t)^\nu \end{aligned}$$

Substituting the equilibrium condition

$$m^E_t = m_t - m^A_t$$

into the firm's first order conditions and the household conditions yields two equations and two unknowns which chacterize the equilibrium:

$$\begin{aligned} m^A_t &= \left(\frac{z^A_t}{z^E_t}\right)^{\frac{\gamma+1}{\gamma\nu}} \left(m_t - m^A_t\right) \\ m_t &= \left[(1-\nu)\nu^{\frac{\nu}{\gamma-\nu+1}} (z^A_t)^{\frac{\gamma+1}{\gamma-\nu+1}}\right]^{\frac{1}{\gamma}} \left(m^A_t\right)^{\frac{-\nu}{\gamma-\nu+1}} \end{aligned}$$

I can then solve for m_t and m^A_t in terms of fundamentals. First, denote

$$\tilde{z} = \left(\frac{z^A_t}{z^E_t}\right)^{\frac{\gamma+1}{\gamma\nu}}$$

Then,

$$
\begin{aligned}
m_t^A &= \left(\frac{\tilde{z}}{1+\tilde{z}}\right)^{\frac{\gamma-\nu+1}{\gamma+1}} \left((1-\nu)^{\gamma-\nu+1}\,\nu^{\nu}\right)^{\frac{1}{\gamma(\gamma+1)}} (z_t^A)^{\frac{1}{\gamma}} \\
m_t &= \left(\frac{\tilde{z}}{1+\tilde{z}}\right)^{\frac{\nu}{\gamma+1}} \left((1-\nu)^{\gamma-\nu+1}\,\nu^{\nu}\right)^{\frac{1}{\gamma(\gamma+1)}} (z_t^A)^{\frac{1}{\gamma}}
\end{aligned}
$$

I would like to see whether there exists a set of parameters under which growth in the developing country causes GDP in the advanced country to rise, while labor in that country falls. Note that gross domestic product (GDP_t^A) and aggregate labor (L_t^A) can be written:

$$
\begin{aligned}
GDP_t^A &= \alpha w_{M,t} m_t + (1-\alpha) w_{L,t}^A n_{L,t}^A \\
L_t^A &= \alpha n_{M,t} + (1-\alpha) n_{L,t}^A
\end{aligned}
$$

Since $w_{M,t} = n_{M,t}^{\gamma}$ and $w_{L,t}^A = (n_{L,t}^A)^{\gamma}$, GDP can be re-written:

$$
GDP_t^A = \alpha m_t^{\gamma+1} + (1-\alpha)(n_{L,t}^A)^{\gamma+1}
$$

I must, therefore, express n_t^A as a function of fundamentals.

$$
n_t^A = \left(\frac{\tilde{z}}{1+\tilde{z}}\right)^{\frac{1-\nu}{\gamma+1}} \left((1-\nu)^{1-\nu}\,\nu^{\frac{(1-\nu)\nu+\gamma(1+\gamma)}{\gamma-\nu+1}}\right)^{\frac{1}{\gamma(\gamma+1)}} (z_t^A)^{\frac{1}{\gamma}}
$$

Plugging in for m_t, m_t^A, and n_t^A, I can express GDP_t^A and L_t^A in terms of fundamentals.

$$
\begin{aligned}
GDP_t^A &= (z_t^A)^{\frac{1}{\gamma}} \frac{\tilde{z}}{1+\tilde{z}}^{\frac{-\nu+\gamma\nu}{\theta}} \left((1-\alpha)(1-\nu)^{\frac{1-\nu}{\gamma}}\,\nu^{\frac{\nu-\nu^2+\gamma^2+\gamma}{(\gamma+\gamma^2)\theta}} \frac{\tilde{z}}{1+\tilde{z}}^{\frac{(\gamma+1)}{\theta}} + \alpha(1-\nu)^{\frac{\theta}{\gamma}}\,\nu^{\frac{\nu}{\gamma}}\right) \\
L_t^A &= (z_t^A)^{\frac{\gamma+1}{\gamma}} \frac{\tilde{z}}{1+\tilde{z}}^{\frac{-\nu}{\theta}} \left((1-\alpha)(1-\nu)^{\frac{1-\nu}{\gamma(\gamma+1)}}\,\nu \frac{\tilde{z}}{1+\tilde{z}}^{\frac{1}{\theta}} + \alpha(1-\nu)^{\frac{\theta}{\gamma(\gamma+1)}}\,\nu^{\frac{\nu}{\gamma(\gamma+1)}}\right)
\end{aligned}
$$

where

$$
\theta = \gamma - \nu + 1
$$

I want to examine what happens when z^E grows but z^A does not. In order to do this, I take derivatives of GDP^A and L^A with respect to z^E. In this environment, I get GDP^A rising while labor, L^A, is falling if the following two inequalities are satisfied.

$$\alpha(1-\nu)\nu^{\frac{\nu}{\gamma}} \quad > \quad \frac{(1-\alpha)(1+\gamma)}{\theta}\nu^{\frac{\nu(1-\nu)+\gamma(\gamma+1)}{\gamma\theta}}\left(1+\left(\frac{z^A}{z^E}\right)^{\frac{\gamma+1}{\gamma\nu}}\right)^{-\frac{\gamma+1}{\theta}}$$

$$\alpha(1-\nu)^{\frac{1}{\gamma+1}}\nu^{\frac{\nu}{\gamma(\gamma+1)}} \quad > \quad \frac{1-\alpha}{\theta}\nu^{\frac{\nu(1-\nu)+\gamma(\gamma+1)}{\gamma(\gamma+1)\theta}}\left(1+\left(\frac{z^A}{z^E}\right)^{\frac{\gamma+1}{\gamma\nu}}\right)^{\frac{-1}{\theta}}$$

Here, I'm assuming that $\nu \in [0,1]$ and that $\gamma > 0$. These assumptions are innocuous given the interpretation of these parameters. The parameter ν maps to labor's share in the economy and γ is the disutility of labor.

2.4.2 Quantitative Exercise

I now turn to a quantitative exercise in which the above conditions are satisfied and show that, in the absence of adjustment costs, the model generates a trend decrease in labor, while GDP continues to grow. Table2.3 reports the parameter values that were used in the quantitative exercise.

Parameter	Value	Governs
ρ	0.95	Growth in Country E
β	0.96	Household Discouting
γ	2	Disutility of labor
θ	0.7	Service share
ν	0.3	Labor Share
α	0.5	Share of Managerial Households
φ	0	Fixed Cost of Adjustment

Table 2.3: Parameter Values

Figures 2.12,2.13, and 2.14 show the model predictions in a frictionless economy for the above parameterization. Notice, in Figure 2.12, that GDP in the advanced economy grows, even as total labor in that economy falls. Managerial services become more valuable as more and more labor is used worldwide. In the background, productivity in the emerging country is rising, increasing demand for both m_t^E and n_t^E. Since all managerial services are produced in the advanced country, GDP rises as a result for increasing world demand for managerial services. Figure 2.13 shows the change in equilibrium outcomes. Notice that m_t is rising as n_t^A is falling. Generating falling labor is essentially a horse race between these two forces. Mechanically, it must be the case that labor productivity is rising in this economy, since GDP is rising as labor is falling. Figure 2.14 shows that this is, indeed, the case.

Figure 2.15 shows the trade balance generated by the model, as a percentage of model GDP in country A. As in the data, the trade balance is falling as the emerging country grows. This observation can later be used in order to guide a more serious calibration.

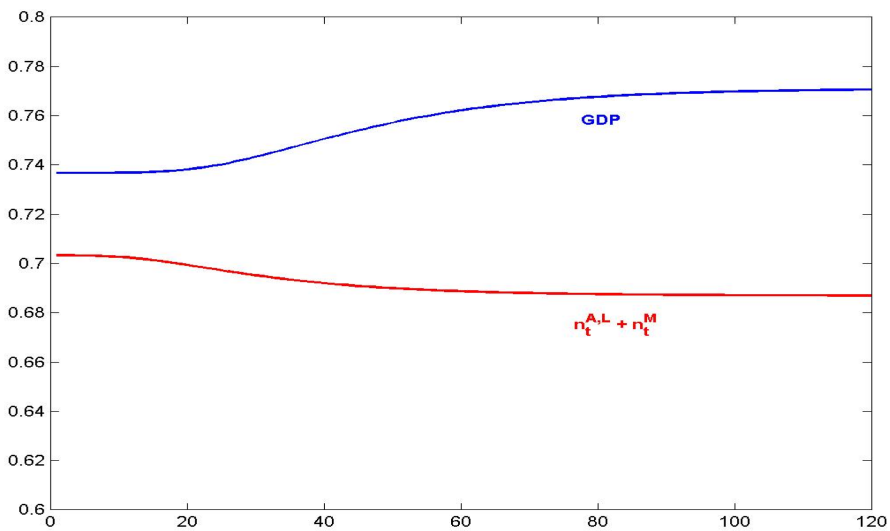


Figure 2.12: GDP and Labor

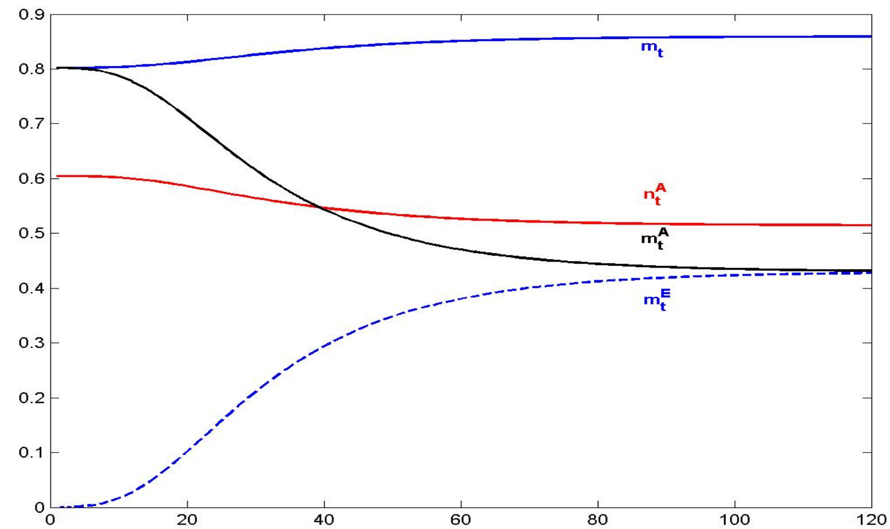


Figure 2.13: Change in Inputs

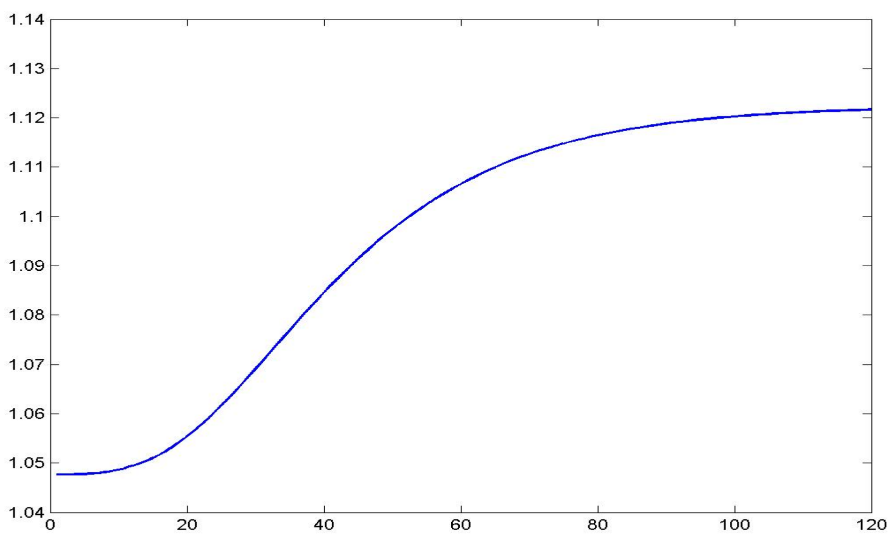


Figure 2.14: Labor Productivity

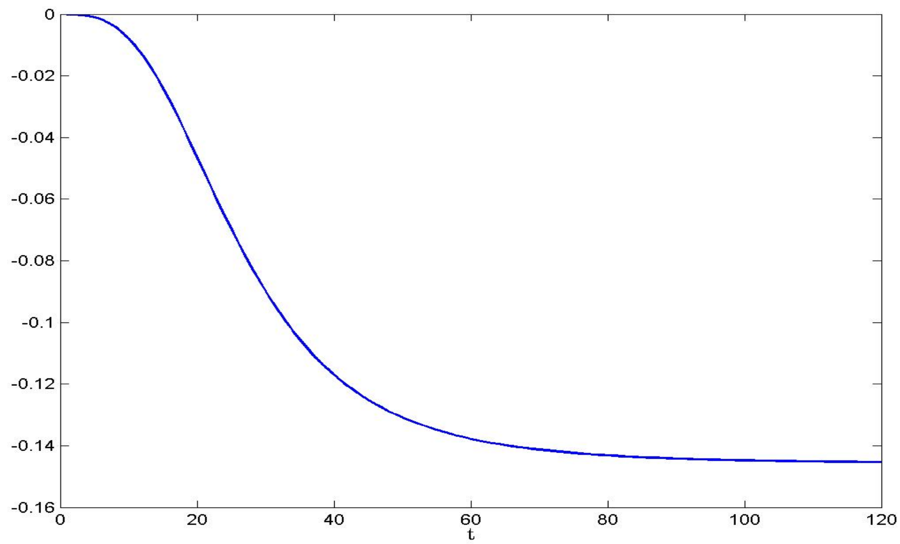


Figure 2.15: Trade Balance as Percent of GDP

In order for GDP to rise, it must be the case that total income in the economy is rising. It must be that wages for the L-type household in the advanced economy are falling since wages simply equal $(n_t^A)^\gamma$ in equilibrium and that is falling. Therefore, the income of the low-skilled household is falling in the model. Then, income for the high-skilled household must be rising in order to generate overall growth in income in the economy. So, income dispersion increases as the emerging country grows and the world demands more labor inputs from the high-skill household and fewer labor inputs from the low-skilled household in the advanced country. Therefore, as an added feature, the model generates rising income inequality.

2.5 Adding Adjustment Costs: Generating Jobless Recoveries

In this section, I allow for adjustment costs and explore whether the model can generate jobless recoveries, or sustained losses in employment accompanied by growth in GDP, via a negative productivity shock to z^A. I return to the model developed in Section 3, which features an adjustment cost that the firm must pay any time it changes m_t^A or m_t^E . Therefore, even though Country E may be growing in the beginning, the firm may not want to pay the adjustment cost until z^E grows sufficiently or z^A falls sufficiently. It is well known that non-convex adjustment costs generate this zone of inactivity.

Parameter	Value	Governs
ρ	0.95	Growth in Country E
β	0.96	Household Discouting
γ	2	Disutility of labor
θ	0.5	Service share
ν	0.3	Labor Share
α	0.5	Share of Managerial Households
φ	0.05	Fixed Cost of Adjustment

Table 2.4: Parameter Values

I parameterize the model such that in a frictionless world, it would always be optimal to shift resources from Country A to Country E. I then set adjustment costs such that when productivity is sufficiently low in Country E, the firm will choose to maintain resources in Country A rather than pay the cost of adjustment. Table2.4 shows the parameterization used in the simulations. I then conduct a simulation to see whether or not the model can generate jobless recoveries. The experiment is to allow growth in country E, as governed by the growth parameter ρ. Then, shock Country A with a one period negative productivity shock, equal to one percent productivity, and allow it to decay over ten periods.

Figures 2.16 through 2.18 show the results of this experiment. As expected, before the negative productivity shock in Country A, which occurs at period 0, the firm chooses not to reallocate workers. Once the negative shock occurs, the firm chooses to reduce the proportion of managers used in Country A, m_t^A. This can best be seen in Figure 2.17. Here we can also see that the reduction in labor is still a horse race between increasing overall demand for managerial services (and thus $n_{M,t}$ since they are created using a linear technology) and falling demand for labor in Country A. During the recovery, we see stagnant labor markets, even as GDP is increasing. In this sense, the model is able to qualitatively match the features of a jobless recovery. Moreover, as Figure 2.18 shows, labor productivity falls initially, but recovers very quickly. In fact, labor productivity is growing even as labor inputs are stagnant or even falling. This is a feature of recent recessions which is puzzling in the context of a standard RBC model. However, in the context of a simple growth model with asymmetric growth, I am able to generate this feature.

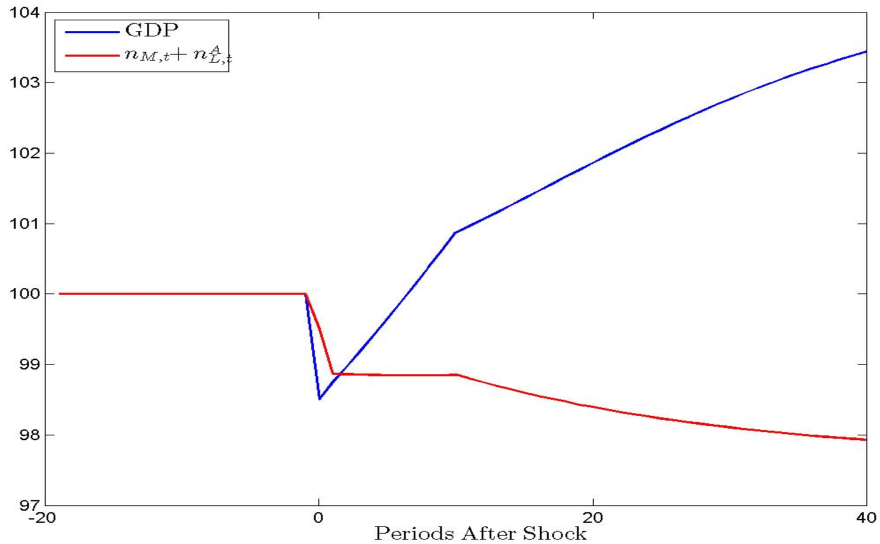


Figure 2.16: GDP and Labor

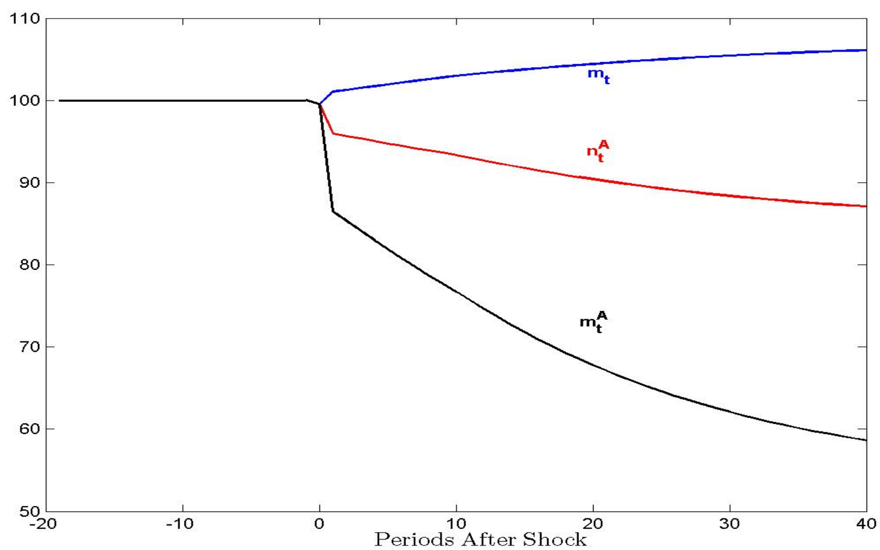


Figure 2.17: Labor Inputs

Figure 2.19 shows the predictions of the model for trade. The model (counterfactually) predicts that imports should increase, causing the trade balance to fall, over the course of the recession. In fact, it predicts a large drop in the trade balance just as the negative productivity shock hits Country A. This is because reallocation occurs during this period, causing more consumption goods to be produced in Country E. Perfect risk-sharing implies that households in Country A simply borrow in order to continue to consume these goods when their income falls during the recession.

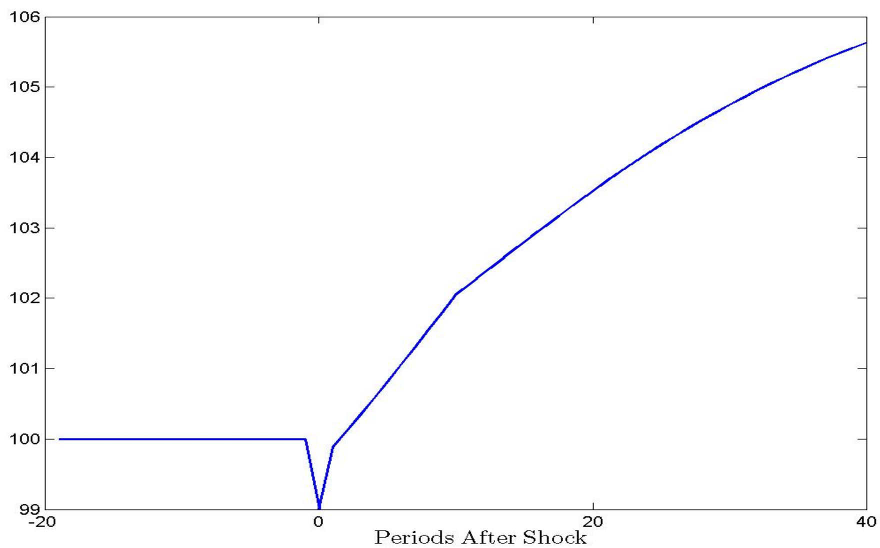


Figure 2.18: Labor Productivity

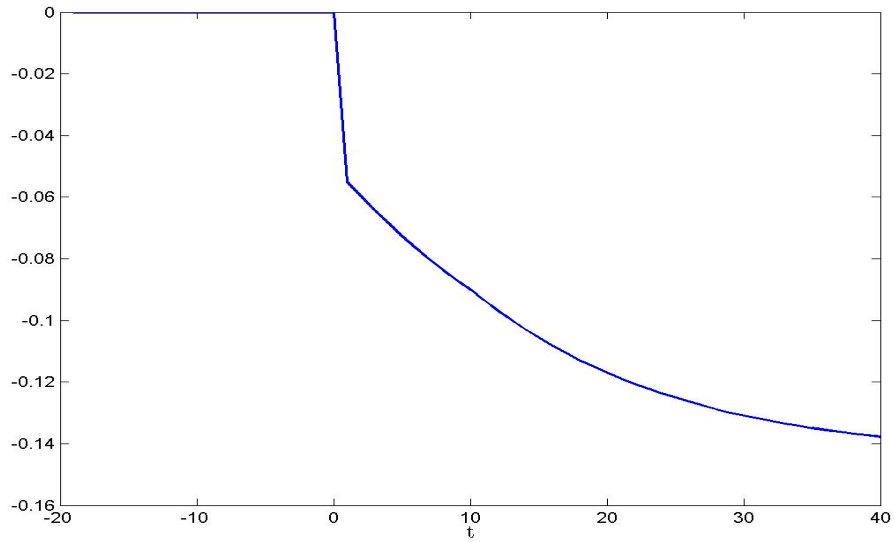


Figure 2.19: Labor Productivity

Overall, the model is able to produce the desired features. It certainly has some limitations, but this section shows that the proposed mechanism is a promising one in being able to account for jobless recoveries. In the next section, I discuss what additional steps need to be taken in order to quantify the impact of the mechanism.

2.6 Calibration and Future Work

Sections 4 and 5 illustrate that globalization shows promise in terms of helping to account for the recent observed changes in labor market outcomes. In order to more fully assess the model's ability to account for jobless recoveries, it will be necessary to use a more seriously calibrated model.

As explored in Section 4, the parameters that are important for the results are the labor and managerial shares (ν and θ), the disutility of labor (γ), and the share of each type of household (α). In the current version of the paper, I use a standard value for measured labor share, ν, and have set managerial share, θ, guided by financial and operating data of multinationals from the BEA. MNCs also provide data that divides employees into job functions and provides data on their compensation. Using this, I can back out the managerial and labor shares for the types of companies I have in mind. In order to match the disutility of labor, γ, I will match the average hours worked by households, calculated using the Current Population Survey (CPS). I will need to assume a number of discretionary hours available to a household and then I will match the fraction of that time spent working. The share of each type of household in the economy, α, can also be inputed from the CPS. I can define M-type households as those that have a certain level of education. Then, I can calculate α directly from the CPS.

The other parameter that will be very important is that that governs adjustment costs, ϕ. In my numerical example above, results are somewhat sensitive to this parameter. It is not possible to measure adjustment costs in the data, since many of the things we think of as causing adjustment to be costly are intangible. For example, the time cost to hiring a manager is an adjustment cost and this is difficult to measure. Moreover, it is difficult to make the case that the cost of hiring a manager to work in the U.S. is the same as the cost of training that manager to go work in China. In order to calibrate this parameter, I plan to close the economy and try to match business adjustments in the pre-1990 period. This will give me a lower bound on what adjustment costs should be since the cost of shifting managerial services to another country should be higher than the cost of hiring an extra manager to work in the U.S. Therefore, a calibration of this sort will give me a lower bound on the share of jobless recoveries that can be accounted for by the mechanism.

I will also need to choose a growth path for z^E. I will use the trend growth in MNC employment in low-income countries in order to discipline this. This will allow me to match hiring trends by construction. Taking those as given, I will be able to then see if these trends can account for jobless recoveries.

In terms of my empirical work, I have applied to use firm-level data from the BEA in order to see whether multinational firms choose to expand more into countries with high growth rates. This could help to support the main idea behind the model. I also am working on the aforementioned extension of Autor, Dorn, and Hanson (2011). Although this is not directly related to the model that I have written down, it will help guide an extension that I have mind.

In future work, I would like to incorporate another type of firm into the economy in order to consider the trade channel as well. I also think it would be interesting to explore the idea that firms may be shifting resources to the emerging country in order to serve the local market in these countries. In this set up, companies again would wait until reallocation is cheap in order to shift resources. I think with this added idea, I might be able to capture the drop in trade flows that occurs around recessions while still capturing a drop in employment.

2.7 Conclusion

In this paper, I construct a model with decreasing cross-country productivity differences in order to explore whether international reallocation contributes to slower labor recoveries in advanced economies. I find that a simple growth model with multinational corporations, asymmetric growth, and adjustment costs is able to generate both a secular decline in the employment to population ratio and a concentration in that decline around recessions, leading to jobless recoveries. Additionally, I show some empirical evidence that the elements that I include in the model are supported by the data.

From a policy perspective, it is important to understand the contributing sources of jobless recoveries. The policy implications might be very different if jobless recoveries arise due to skill-biased technical change than if the root cause of jobless recoveries is increased globalization and competition from emerging markets. The model I have build is a promising step towards quantifying the impact that globalization has had upon the changing business cycle properties of labor markets. This, in turn, can guide policy discussions about the role of globalizaiton in supporting economic growth and its distributional consequences. The model predicts that with GDP growth comes growing inequality. From a welfare perspective, it's not clear what the policy implication of this finding might be. Therefore, a more realistic calibration is an important next step to conducting policy analysis.

Chapter 3

Trade, Technology, and the Skill Premium: The Case Of Mexico

3.1 Introduction

Standard trade theory has stark predictions for how factor prices should respond to trade integration between a skill-scarce and a skill-abundant country. In particular, models that are based on the Heckscher-Ohlin (henceforth H-O) theory predict that the ratio of wages paid to skilled versus unskilled workers (the skill premium) should rise in the skill-abundant country and fall in the skill-scarce country when the two countries open to trade with one another. A puzzle that has arisen in the context of this prediction is that when integrating with the world economy, many skill-scarce countries instead experience *rising* skill premia. Mexico is the canonical example of a country whose skill premium not only rose, but rose by much more than that of its more-developed counterpart, the United States, during the period in which Mexico opened its borders to trade with the United States. These observations have led many researchers to conclude that skill-biased technological change (SBTC), not increased openness to trade, has driven changes in developing economies' skill premia.

In this paper, I argue that trade liberalization, by stimulating investment in SBTC and facilitating cross-border technology adoption, plays an important role in explaining these facts. I modify a standard trade model to include trade in technology, which occurs through the integration of supply chains across borders. I use the case of the Mexican trade liberalization and integration into the supply chain of American companies to explore the impact that technological transfer, which takes place as a part of this integration, has upon the wages of workers in Mexico and the United States. I calibrate the model using surveys of the Mexican and the U.S.

manufacturing sectors and I find that a reduction in barriers to trade in goods and technology can account for about two-thirds of the observed increase in the skill premium in both Mexico and the United States.

To support my quantitative analysis, I provide empirical evidence both at the plant- and the industry-level that indicates that Mexican entities which trade more with the United States have higher skill premia on average and have greater increases in their skill premia in the late-1980s than their non-trading counterparts. This analysis suggests that trade connections are an important determinant of skill premia and that supply chains could be channels through which technology is transferred. While I do not have direct information about connections between the Mexican plants and the firms that they are supplying in the United States[1], I show that trade between the two countries rose dramatically over the course of the late-1980s and early 1990s. Moreover, intra-industry trade began to dominate Mexican-U.S. trade during the mid-1980s and has continued to do so ever since. I also show that at the industry-level, the use of intermediate imports is an important predictor of the skill premium, indicating that supply chain relationships play an important role in determining the skill premium in a given industry.

In order to assess the quantitative importance of supply chains on the skill premium, I adapt a standard trade model to allow for trade liberalization to increase both trade in goods and trade in ideas. I model "ideas" as technology capital, similar to the model in McGrattan and Prescott (2009), but I allow for technology capital to be rented from final goods producers, who own and invest in the stock of technology capital, to intermediate goods producers, who use it. I model trade liberalization as a reduction both in tariffs on goods and in taxes on flows of royalties. I discipline my exercise using manufacturing data from Mexico, as well as data on the flow of royalty payments and trade between Mexico and the United States.

My model differs from those in the existing literature by incorporating two key ingredients. First, I allow for skill-biased technology to be endogenously accumulated by permitting firms to invest in a stock of technology that is assumed to be skill-augmenting. I consider a final goods producers who own and invest in technology capital. Intermediate suppliers rent this technology capital in order to produce an intermediate product that will be a component of the final good. Consider for the moment a two country world in which both countries are in autarky. Now, when a country opens to trade, a final goods producer does not need to open a plant in the foreign country in order to use his technology capital there. Instead, he can rent his technology to an intermediate goods producer that is already operating in the foreign country. Opening

[1]The plant-level data provides information on total imports and exports, as well as information on the percent of imports (exports) that come from (go to) the United States. However, I do not have information on the specific trade relationships between the Mexican plants and U.S. producers. This information was not gathered as part of the annual survey and, presumably, is not included in the balance sheets of unaffiliated trade partners.

to trade, therefore, increases the return to technology capital, as in McGrattan and Prescott (2009). Firms respond to these increased returns to their technology capital by investing more. I refer to this as the "investment channel," and it is the main channel that drives the increase in the skill premium seen in the United States. This is consistent with recent empirical work in Goel (2012) which provides evidence that firms in the United States respond to increased trade opportunities by increasing spending on innovation. Moreover, it is consistent with extant literature which has found that the rise in the skill premium in the United States is driven primarily by technological change. Note that this does not mean that opening to trade plays *no* role in increasing the skill premium, but rather, that its role manifests as an increase in technology, driven by increased returns on investment in technology.

Second, I allow technology capital to be rented across borders. I provide plant-level evidence that royalties paid by importers/exporters as a percentage of inputs in Mexico are higher than those of their non-trading counterparts, indicating that these plants pay a greater percentage of their costs for rental of technology than their non-trading counterparts; I take this as evidence of transfer of technology across countries. Allowing for technology to be transferred through rental is the key to having the skill premium rise in both countries because it causes the skill premium to rise in the United States via the investment channel, as discussed above, and it causes the skill premium to rise in Mexico by what I will call the "adoption channel." In the model, intermediate goods producers in Mexico choose to adopt U.S. technology and supply U.S. final goods producers much more than vice versa. This is because, in the initial steady state, U.S. technology is much more productive than Mexican technology.

In my calibrated model, I find that moving from an autarkic steady state to a free trade steady state induces a skill premium increase of 39 percent in Mexico and 8 percent in the United States. This accounts for about two-thirds of the observed rise in the Mexican skill premium, and about three-quarters of the increase observed in the United States.

The adoption channel is key to obtaining these results. If I shut down firms' ability to trade technology, under certain parametrization, results show the standard Stolper-Samuelson effect, with Mexico's skill premium declining and that of the United States increasing. The Stolper-Samuelson effect is offset, however, by the investment channel. I include two sectors in the model-one that is skilled-labor intensive and one that is unskilled-labor intensive-in order to allow for this type of effect, but both sectors use skill-augmenting technology capital. Opening to trade allows countries to specialize in the sector in which they have a comparative advantage, which in turn increases the return to the factors of production, thus inducing firms to invest more in the skill-augmenting technology in that sector. This raises the return to skilled workers for all countries, reducing the decline in the skill premium in Mexico. The big gain in the Mexican skill premium comes, however, through the rental of advanced technology from the United States. In the model, there is an initial jump in the skill premium in Mexico as U.S. technology becomes available to Mexican firms. This results from the sudden inflow of this technology into Mexico, which occurs when the tax on royalties is reduced and the price of renting the U.S. technology falls as a consequence.

My quantitative results are disciplined by manufacturing data for the United States and Mexico. Because my interest lies primarily in how the skill premium *changed* in the two countries, I target the *level* of the skill premium in the initial period. I use aggregated industry data from Mexico on royalty payments to pin down the parameter that governs the importance of technology capital in production. In particular, I match royalty payments as a percentage of payroll payments in the period before trade liberalization. I use 1985 as the "pre-reform" period; as I will document below, the majority of Mexican trade reforms began in 1986. I also match the relative productivity of the manufacturing sectors in the two countries and the relative supply of skilled workers in each country in 1985. I match these moments in a pre-reform steady state.

In order to see how trade reform impacts the skill premium, I then conduct an experiment where I lower tariffs on goods and taxes on royalties. While I am able to directly observe the reduction in tariffs that occurred in the data, I am not able to observe directly a measure of the taxes on royalties. This is because things such as the protection of intellectual property would have a strong impact on firms' willingness to rent proprietary information to other firms and these protections changed substantially over the period of interest. Therefore, I use flows data in order to give an idea of the magnitude of the change on this implicit tax. Using this backed out tax, I calculate a new steady state, holding everything other than the tax rates fixed. I find that opening to trade in both technology and goods increases the skill premium in both countries. I am able to decompose this change in the skill premium and attribute most of the rise in the skill premium in Mexico to the adoption channel and all of the rise in the United States to the investment channel.

Contribution to Related Literature

There is a large body of literature dealing with the rise of the skill premium in the United States, and a somewhat smaller literature on the rise of the skill premium in Mexico. Studies such as Feenstra and Hanson (1996b), Feenstra and Hanson (1997b), and Grossman and Rossi-Hansberg (2008) have shown that increasing imports of intermediate goods from less-developed countries can increase skill premia in advanced economies. For a useful summary of articles that have explored the behavior of the skill premium of developing countries as they open to trade, see Goldberg and Pavcnik (2007).

The paper that is most closely related to my own is Feenstra and Hanson's 1996 empirical and theoretical work on the importance of foreign direct investment (FDI) in Mexico. Empirically, the authors show that regions with a higher proportion of inward FDI from the United States have greater increases in the relative demand for skilled labor. Furthermore, they build a theoretical model which rationalizes this prediction; capital is complementary with skilled labor, and as capital flows from the United States to Mexico via foreign direct investment, demand for skilled labor rises in Mexico. The Mexican subsidiary of the multinational in Mexico produces a less-skilled intermediate which is then substituted for less-skilled workers in the United States. Thus, the relative demand for unskilled workers falls in the United States as well. I see my paper as a complement to their work. At the aggregate level, flows of foreign direct investment between Mexico and the United States did not rise substantially until the mid-1990s. Moreover, the majority of growth in both maquiladora[2] establishments and employment came after the North American Free Trade Agreement (NAFTA) (GAO, 2005), and as such post-dates the observed growth in the skill premium in Mexico. I focus on the transfer of technology through non-ownership channels precisely because trade increases substantially before NAFTA but direct investment does not. I provide evidence that supply chains are an important channel through which technology is transferred. The mechanism proposed in their paper is also similar to what I propose. However, in their setup, the investment channel that I describe is not present. This is because the type of capital they consider is physical capital, which can be only used in one location at a time. I, instead, consider technology capital which can be used in multiple locations at once. Therefore, once a firm has more than one location in which to use its technology, it has an increased incentive to invest in it. This is the primary driver of the increase of the skill premium in the United States in my model, whereas in the Feenstra and Hanson model, the increase in the skill premium in the United States is primarily driven by Stolper-Samuelson effects.

I also contribute to the emerging literature on the interaction between trade, technology, and inequality. Works such as Acemoglu (2009), Acemoglu et al. (2012), Burstein and Vogel (2012), and Goel (2012) all address the idea that trade and technological innovation are linked. All but Burstein and Vogel concentrate primarily on the rise of the skill premium in advanced countries. The papers by Acemoglu and coauthors mention that their mechanism can generate increasing skill premia in developing countries if technology is transmitted, though there is no evident way for the increase in the skill premium in the developing country to be greater than the increase in the skill premium in the developed country. My paper complements their work by providing a plausible mechanism by which this technological transmission occurs as well as provides a framework in which it is possible to get larger increases in the skill premium in the less-developed country. Goel provides evidence for increased investment in innovation resulting from increased imports of intermediate goods from less-developed countries and develops a

[2]manufacturing plants in the free trade zone

model which generates the increasing investment in innovation that she documents. However, her model does not include skilled workers in the developing country. If it did, the skill premium would counter-factually fall in the developing country. Burstein and Vogel build a quantitative trade model a la Bernard et al. (2003) with exogenous productivity which is skill-augmenting. Technology within a country is endogenous in that there is firm entry and exit in response to international competition. The most productive firms, which are consequently the most skill-intensive firms, are those that become exporters. The least productive firms exit in response to head-to-head foreign competition. While the model proposed by Burstein and Vogel allows for a quantitative exploration of trade linkages, it abstracts from the type of trade in ideas that I propose here. Additionally, they are able to account for only a small portion of the observed increase in the skill premium in Mexico and the United States, even when considering the case of complete autarky versus free trade.

This paper is also related to the literature that has explored the impact of globalization on Mexican labor markets. A number of studies (for example, see Esquivel and Rodriguez-Lopez, 2003; Harrison and Hanson, 1999; and Robertson, 2004) explore this question using the Stolper-Samuelson theorem as their basis, and find the correlation between changes in output prices and wages at the industry level to be very low. The conclusion from this strand of literature was that skill-biased technological change, and not trade, was responsible for the observed increase in the skill premium. Verhoogen (2008) explores both overall increase in inequality and the between-plant inequality in Mexico and hypothesizes that exporting opportunities increase wage dispersion across plants due to quality upgrading. Riaño (2009) builds a model in which SBTC is embodied in capital equipment and measures the effect of increasing imports of capital equipment upon the skill premium in Mexico. The idea in his paper is similar to what I model here, but importantly, the capital that is traded in my model is technology capital or "ideas." The non-rivalrous nature of technology capital creates an environment such that even as the capital begins to be used in Mexico, firms in the United States have an incentive to invest more in it. In fact, it is *because* the ideas are being used in an additional location that their marginal product increases.

Also related to this paper is the literature on the skill premia in developing countries. Ripoll (2005) builds a model in which the skill premium in the developing country responds non-monotonically to trade liberalization and depends heavily on the initial conditions in the economy. Trefler and Zhu (2005) show that those countries with the largest increase in skill premia following a trade liberalization are those which export relatively more skill-intensive goods, and they build a model akin to Feenstra and Hanson (1996b), but allowing the "South" to catch up to the technology of the "North" instead of receiving FDI flows. They do not propose a mechanism for how this catch-up occurs. Burstein, Cravino, and Vogel (2013) and

Parro (2013) each propose capital-embodied technology as an avenue by which skill-biased technological change crosses borders. I contribute to this literature by proposing an alternative way that this technology is accumulated and then transmitted from one country to the next, and I provide evidence of my hypothesis.

The paper is organized as follows: In Section 3.2 I provide brief background information on the trade liberalization experience in Mexico in the late 1980s; in Section 3.3 I provide evidence for the importance of trade linkages for the skill premium: Section 3.4 contains my model and its theoretical analysis; Section 3.5 contains my calibration and results; and Section 3.6 concludes.

3.2 Background: Trade Reform in Mexico

This section briefly describes the liberalization policies that were implemented in Mexico in the mid-1980s.

Mexico's Trade Liberalization

During the 1950s, Mexico began to pursue a set of policies based on the theory of import substitution. As such, during this time, Mexico became one of the most closed economies in the world, with more than 90 percent of its domestic production subject to import licenses by 1985. Import licenses are commonly viewed as the main source of restricted trade flows (Kehoe, 1995, TenKate 1992), though, in practice, Mexico utilized three instruments to restrict these flows: (i) ad-velorum tariffs, (ii) official minimum prices for custom valuation, and (iii) quantitative restrictions such as quotas and the aforementioned import licenses. As a result of the balance of payments crisis in 1982, the Mexican government decided to pursue a large-scale liberalization of the Mexican economy, including a massive trade liberalization (*apertura*), in order to restart economic growth.

In 1985, the Mexican government undertook a number of structural reforms, including reducing the import license coverage from 92 percent to 47 percent between June and December of that year. Many of these reforms were requirements of the debt restructuring agreement that Mexico entered with its international creditors in the wake of the debt crisis in the early 1980s. The government continued to phase out import licenses over the course of the decade, with the coverage falling to 23 percent in 1988 and 19 percent in 1989. Most of the remaining import licenses covered agricultural and petroleum refining products. Over the same period, ad-velorum tariffs fell as well. In 1985, the maximum tariff was 100 percent; only a year later, in 1986, it was reduced to 50 percent. By 1987, the maximum tariff was 20 percent and the production-weighted average tariff was 11 percent (Esquivel and Tornell, 1995).

Mexico also entered into trade negotiations with the United States in 1987, which culminated in a four-part understanding known as the "Framework of Principles and Procedures for Consultation Regarding Trade and Investment Relations" or the "Bilateral Accord." This Accord was the first-ever formal bilateral agreement governing commercial relations between the two countries, and it included a statement of principles, a mechanism for consultations, an agreement on data exchange, and an Immediate Action Agenda. The Immediate Action Agenda was the start of negotiations on a number of matters, including technology transfer. In particular, Mexico was interested in obtaining help from developed nations to develop its intellectual property rights protection laws so that technological transfer from companies in the United States would be more forthcoming. Mexico argued that access to new technologies was of utmost importance and was a necessary component to any improved trade arrangement between the two countries (DuMars, 1991). The recognition of intellectual property rights was an important step to allowing for transfer of technology between the two countries.

During this period, the government also began to loosen its restrictions on foreign ownership; however, the process was slower to change than other policies, and significant restrictions remained in place for the next decade. In particular, foreign companies were not allowed to acquire existing Mexican firms without submitting to a lengthy approval process. Establishing a new foreign-owned business was somewhat easier, but only if the business fit certain criteria, which included a requirement that the business have at least a non-negative net export balance over the first three years of its existence. Maquiladora firms were exceptions to these rules, but the process for obtaining a license establishing a firm as a maquiladora was viewed as relatively cumbersome until the process was reformed in December of 1989.

In 1992, the Mexican government signed an agreement to enter into the North American Free Trade Agreement (NAFTA) with the United States and Canada on January 1, 1994. As part of NAFTA, all remaining tariffs on goods traded between the two countries would be phased out over the next decade. Moreover, the three countries agreed to abide by the intellectual property rights laws of the United States.

3.3 Evidence on Skill Premia and Trade

In this section, I present evidence on the rise of skill premia in Mexico and the United States. I also show that trade, both in goods and in ideas (technology), may be an important factor in determining plant-level skill premia. I first describe the data. Second, I establish that over the period from 1985 to 1996, the aggregate skill premium in manufacturing rose by about three times as much in Mexico as it did in the United States. I then show that this coincides with a large rise in trade between the two countries. Next, I turn to plant- and industry-level data in order to show that plants who were integrated into the supply chain of the United States (meaning those who both import from and export to the United States) tend to have higher overall skill premia than their counterparts who do not engage in both of these activities. Moreover, I provide industry-level evidence imports of intermediate goods are an important predictor of the rise in skill premia from 1984 to 1994.

3.3.1 Data Description

Data for Mexico's manufacturing sector comes from INEGI (*Instituto Nacional de Estadística y Geografía*), Mexico's national statistics bureau. I gather aggregate skill premium data from the EIA (*Encuesta Industrial Anual*), which is an annual survey of manufacturers. Aggregate data from 1980 through 2004 is publicly available on INEGI's website. I gather data on production and non-production employees and payments to these two groups and construct the skill premium as the ratio of non-production wages to production wages, as is standard in the literature. Industry-level data is available by request for years 1984 through 1994, and plant-level data is available from 1984 through 1990. The plant-level data includes information on imports and exports by plant for the years 1986 to 1990. This information was gathered in a special survey conducted by the World Bank. I clean the plant-level data to eliminate any unusual observations, which may indicate coding error. The exact procedure used is detailed in the data appendix. For a more detailed description of the plant-level data, see Tybout and Westbrook (1995).

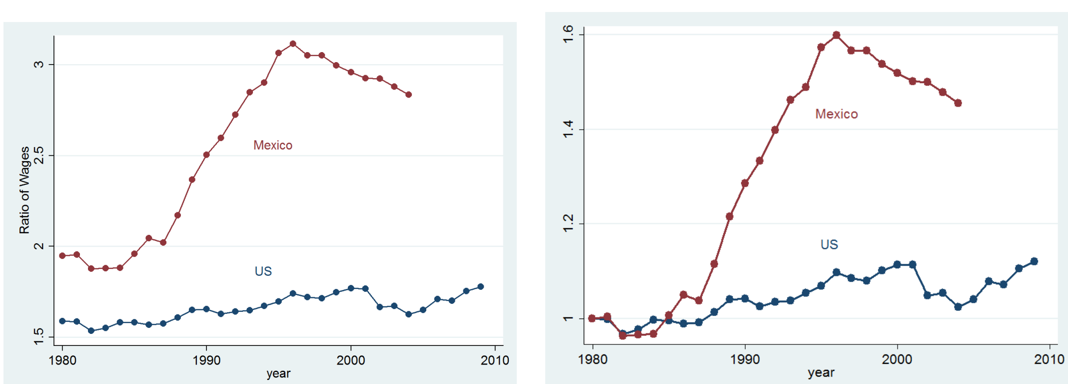
Data for the U.S. manufacturing sector is obtained from the NBER-CES Manufacturing Productivity Database (Bartelsman and Gray, 1996). This data is available from 1959 through 2010. Again, the database provides information on production and non-production employees, as well as payments to each group. I then construct the skill premium as the ratio of non-production wages to production wages. I compare the manufacturing skill premium to the ratio of college to non-college wages, which I compute using the Current Population Survey (CPS). I obtain the March CPS from Integrated Public Use Microdata Series, Current Population Survey (IPUMS CPS) at the Minnesota Population Center. I then compute the ratio of wages for working age people with some college and above to those with no college, and call this the "college premium."

Aggregate trade data for Mexico is obtained from the World Bank World Development Indicators Database (WDI). I gather information on imports, exports, and gross domestic product, as well as subsets of the trade data. In particular, I examine merchandise trade, merchandise trade with advanced economies, and trade in manufactures. Each variable gathered is expressed in millions of U.S. dollars. I then express each trade variable as a percentage of gross domestic product. I cross reference these trade data with data from the NBER's U.S. imports and exports database, 1972-1994, (Feenstra 1996, 1997) to verify that the majority of the increase in Mexico's trade was with the United States.

Information on intermediate imports is gathered from the Organization for Economic Cooperation and Development's (OECD) Structural Analysis (STAN) Database. This database provides total bilateral imports and exports, as well as intermediate bilateral imports and exports, between the U.S. and Mexico for years 1990 through 2010 for broad industries. I match this data (1990-1994) with the industry-level data for Mexican manufacturing for the same broad sectors.

3.3.2 Skill Premia in Mexico and the United States

In Mexico, the skill premium (measured as the ratio of non-production to production wages) was stable at 2 during the late 1970s and early 1980s, but began to rise around 1986. It grew for the next decade and peaked at about 3.1 in 1996. This can be seen in Figure 3.1(a). The U.S. experienced similar timing in the rise of the same variable. Note that the college premium, measured as the ratio of college to non-college wages began to rise earlier in the 1980s. The college premium is the measure which is frequently the concentration of papers dealing only with the United States, but I will concentrate on comparable measures in this paper. As can be seen in Figure 3.1, the manufacturing skill premium in the United States also began to rise in the mid-1980s.



(a) Levels **(b)** Relative to 1980

Figure 3.1: Skill Premia in U.S. and Mexico

Figure 3.1 also shows that the skill premium in Mexico was substantially higher than that in the United States and rose by much more over the period of interest. Figure 3.1(b) shows that the timing of the increases in the two skill premia largely coincided. It also highlights that the increase in Mexico was substantially greater. In particular, over the course of the decade from 1986 to 1996, the skill premium in Mexico rose by about 60%, while the skill premium in the United States rose by about 10 to 15%.[3]The timing and magnitude of the increase in the college premium is similar to that of the manufacturing skill premium, though the manufacturing skill premium does not exhibit the same drop as the college premium in the 1970s.

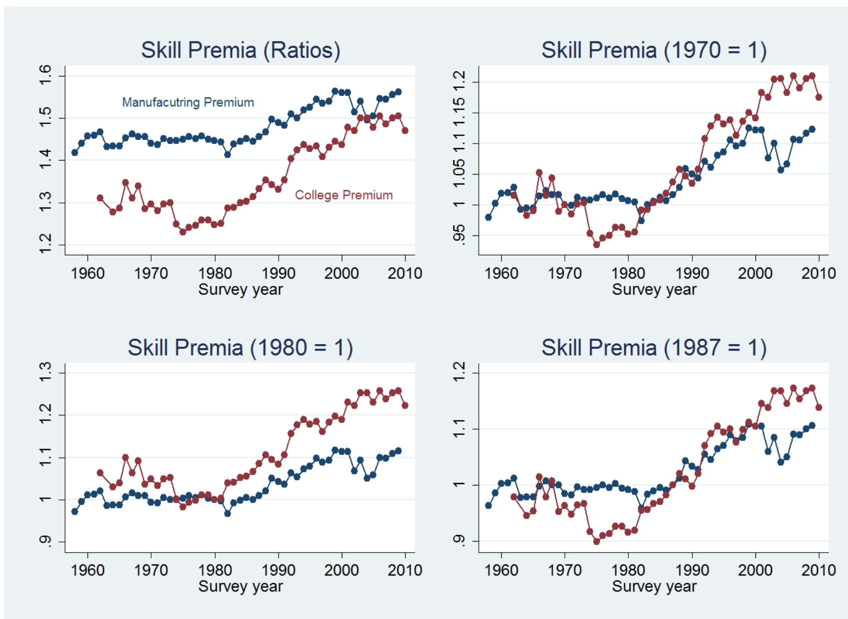


Figure 3.2: Manufacturing Skill Premium and College Premium in U.S.

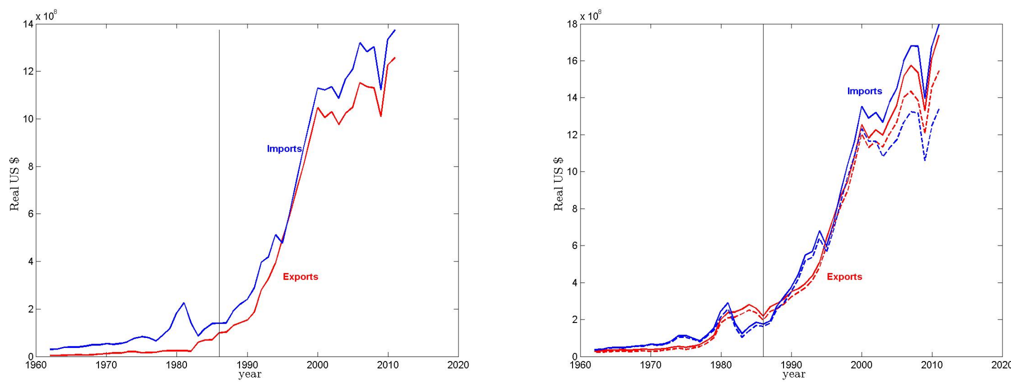
Figure 3.2 shows how the college premium and the manufacturing skill premium move together in the United States. I measure the college premium as the ratio of wages of those with at least one year of college to those with no college education. As is well known, the college premium fell over the course of the 1970s as the supply of college-educated workers grew. During this period, the manufacturing skill premium remained flat. If you disregard the education premium drop that occurred over the 1970s, the panels of Figure 3.2 show that the timing of the rise in the education and manufacturing skill premium largely coincide. In particular, when I normalize the college premium to 1 in 1970 (as in the second panel of the figure), it can be seen that the two series begin to rise above their long-run trend at about the same time, and by 2000 they had risen by roughly the same amount. The rise in the skill and education premia

[3]Again, the measure of the skill premium is different from the one that is often cited in the literature concerning the rise of inequality in the United States.

from 1985 to 2000 is roughly 12 percent. Therefore, the skill premium in Mexico rose by about four times as much from 1986 to 2000.

3.3.3 Increase of Manufacturing Trade

In this section, I show that the increase in the skill premium in Mexico largely coincides with an increase in manufacturing trade. Figure 3.3(a) shows Mexican imports and exports of manufactured goods, measured in real U.S. dollars. This data was gathered from the World Development Indicators database. We can see that trade in manufactured goods began to rise in the mid-1980s and reached its peak in the early 2000s. This timing is consistent with the growth of the skill premium in Mexican manufacturing documented above. Notably, the growth in exports and imports begins well before the implementation of the North American Free Trade Agreement (NAFTA).



(a) Manufacturing Trade

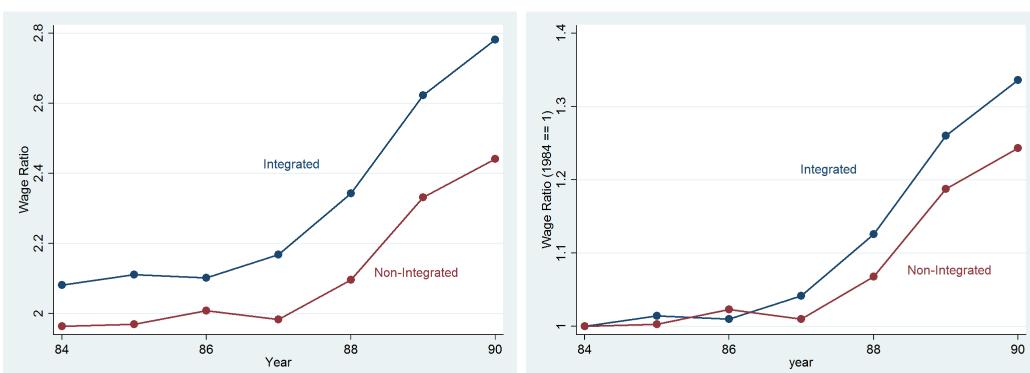
(b) Merchandise Trade

Figure 3.3: Mexican Trade

Figure 3.3(b) documents the percent of merchandise trade that was taking place with high-income countries. The solid lines represent the total amount of merchandise imports (blue) and exports (red) and the dotted lines show the merchandise trade occurring with high-income OECD countries. I use this measure because I do not have an accurate measure of trade in manufactured goods with high-income countries, but I do have a measure of trade in merchandise goods with high-income countries. Merchandise trade consists almost entirely of trade in manufactured products, especially in the later periods. I use aggregated data from the NBERs import and export database to verify that this trade is predominantly with the United States. This figure is meant to illustrate that Mexico's trade liberalization in the 1980s predominantly increased its trade with the United States, a more-developed country. This means that according to a standard H-O model, we should expect to see a falling skill premium in Mexico. If Mexico had opened to more skill-scarce countries during this period, one might anticipate that its skill premium would rise, but since it was increasing trade predominantly with the United States, the opposite should be true.

3.3.4 Evidence that Supply Chains Matter

I now turn to the plant- and industry-level data from INEGI and present evidence that trade linkages may be important for spreading technology and, thus, increasing the skill premium. I first clean the data, as described in the data appendix, to eliminate any odd observations. I then divide the plants into four groups: (1) plants which exported to the U.S. and imported from the U.S. in 1990 (Exporter/Importer); (2) plants which exported to the U.S. but did not import from the U.S. in 1990 (Exporter/Non-importer); (3) plants which did not export to the U.S. but do import from the U.S. (Non-exporter/Importer) in 1990; and (4) plants which did not export to the U.S. and do not import from the U.S. in 1990 (Non-exporter/Non-importer). I have information about both the value of exports (imports) and the percent of exports (imports) that go to (come from) the United States. To be classified as an exporter (importer), the plant must (a) have positive value of exports (imports) and (b) have greater than 0% of its exports (imports) in1990 going to the U.S. I create groups that are fixed with the export status at the end of the sample so that I can see how becoming an exporter/importer impacts skill premia, avoiding any compositional effects. I then create a employment-share weighted skill premium for each category. I follow the same exercise with employee-share-weighted means, and obtain similar results.



(a) Levels　　**(b)** Relative to 1984

Figure 3.4: Skill Premia in Mexican Industries

I will refer to the group of importer/exporters as “integrated plants” and the plants that neither import nor export as "non-integrated plants." Figure 3.4(a) shows how the skill premium for each group changes over time. The integrated plants have, on average, higher skill premia than their non-integrated counterparts. The growth in each type of plant can be seen more clearly in Figure 3.4(b), which shows the skill premium in each group normalized to 1 in 1984. It shows that integrated plants had skill premia that grew by about 10% more than the non-integrated plants. Because I have limited plant-level data, I use the information I have about plants and industries from the plant-level data to inform my industry-level analysis. In particular, I use the plant-level importer/exporter status in order to calculate the concentration of integrated plants in any given industry. In order to do this, I calculate the industry-specific probability that a firm is "integrated" as

$$Pr(integrated) = \frac{N_{importer/exporter,i}}{N_i}$$

for each industry i. I then define an industry as integrated if the fraction of integrated firms in that industry is greater than 40 percent. Examples of integrated industries include manufacture of cars and car parts, glass and glass items, computers and electronics, and household appliances. I then am able to look at how the skill premium evolves in these industries over time using industry-level data from INEGI.

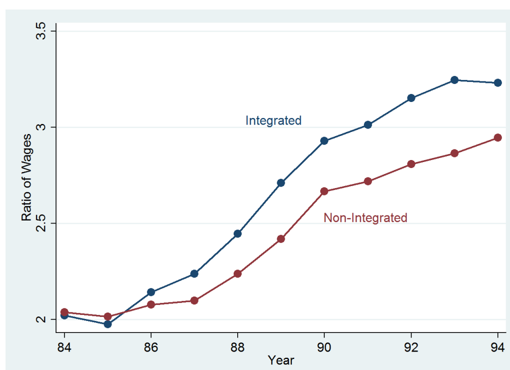


Figure 3.5: Skill Premium by Integrated/Non-Integrated Industry

Figure 3.5 shows the evolution of the skill premium in integrated versus non-integrated industries, with the blue line representing the integrated industries and the red line representing the non-integrated industries. Notice that the skill premia in the two groups is about equal in 1984, with the skill premium in the non-integrated industries being slightly higher. The skill premium rises in both types of industries over the next decade; however, it rises by more in the integrated industries and by 1994, the skill premium is about10 percent higher in the integrated industries.

In order to further explore how trade integration impacts the skill premium, I match the industry-level data on manufacturing wages and employment to trade data from the OECD STAN database. I have information on intermediate imports, intermediate exports, total imports, and total exports for 20 industries from 1990 to 1994. I match this information to the information on the skill premium for the same broad industries. I then examine the relationship between imports of intermediates, exports, royalty payments, and the skill premia by industry. In order to do this, I first estimate the following equation:

$$SP_{i,t} = \beta_0 + \beta_1 \left(\frac{Royalties}{Y}\right)_{i,t} + \beta_2 \left(\frac{Exp}{Y}\right)_{i,t} + \gamma_t + \eta_i + \epsilon_{i,t}$$

Variable	$SP_{i,t}$ (1)	$SP_{i,t}$ (2)
Constant	1.894***	2.749***
	(0.027)	(0.149)
$\frac{Royalties}{Y}_{i,t}$	1.220***	2.230***
	(0.116)	(1.154)
$\frac{Exports}{Y}_{i,t}$	0.308***	0.413***
	(0.095)	(0.243)
Industry Fixed Effects?	No	Yes
Time Fixed Effects?	Yes	Yes
R^2	0.064	0.200

Table 3.1: Regression Results

Table 3.1 reflects that this estimation mimics what other authors have found. In particular, exporting is associated with increasing skill premia when we do not consider other sources of variation. Moreover, royalties are positively correlated with increasing skill premia, indicating that those industries that make large payments for technology rental (as a percentage of output) have, on average, higher skill premia. In order to test whether integration into supply chains is an important factor, I include both imports of intermediates and exports of intermediates and estimate the following equation.

$$SP_{i,t} = \beta_0 + \beta_1 \left(\frac{Royalties}{Y}\right)_{i,t} + \beta_2 \left(\frac{Exp}{Y}\right)_{i,t} + \beta_3 \left(\frac{Imp}{Y}\right)_{i,t} + \gamma_t + \eta_i + \epsilon_{i,t}$$

Variable	$SP_{i,t}$ (1)	$SP_{i,t}$ (2)
Constant	2.783^{***}	2.695^{***}
	(0.030)	(0.151)
$\frac{Royalties}{Y}_{i,t}$	1.451^{***}	2.518^{***}
	(0.118)	(1.157)
$\frac{Exports}{Y}_{i,t}$	-1.251^{***}	-0.305
	(0.378)	(0.369)
$\frac{Imports}{Y}_{i,t}$	2.549^{***}	1.378^{***}
	(0.317)	(0.532)
Industry Fixed Effects?	No	Yes
Time Fixed Effects?	Yes	Yes
R^2	0.075	0.200

Table 3.2: Regression Results

From Table 3.2, we can see that including intermediate imports negates the effects of exporting. In particular, the coefficient on exporting becomes negative, which is in line with the Stolper-Samuelson predictions, whereas the coefficient on intermediate imports is positive, statistically significant, and large. So, exporting is associated with low skill premia and importing is associated with high skill premia. I interpret these results as indicating that supply chains are an important determinant of skill premia. In light of this evidence, I build a model in which importing plays a role in determining the skill premium. I am going to think of this as importing "ideas" or technology. Those plants that export intermediate goods are going to need to use imported ideas in order to produce intermediate goods for the final goods producer in the United States. I will have a single wage in Mexico, so all plants will experience the same increase in the skill premium, but the increase in the skill premium will be driven by the plants who integrate with the supply chain of the United States and share the technology of the U.S. final goods producers. There will also be trade in goods and this will produce the standard

Stolper-Samuelson effect. Therefore, the relative importance of technology in production will determine the size of the increase of the skill premium.

3.4 Model

In this section, I first lay out a modified trade model with two sectors and trade in both goods and in ideas. I then illustrate how the mechanism operates in the context of the one-sector model. Finally, I compare the model to the Heckscher-Ohlin model and discuss how the two differ from one another.

3.4.1 Model of Trade in Goods and Ideas

I describe a two-sector trade model in which allow labor is allowed to move freely across sectors but not across countries. In this environment, I can explore how technology sharing interacts with Stolper-Samuelson effects.

Environment

There are two countries (U and M), each with two perfectly competitive final good producing sectors (sector X and sector Y) which purchase differentiated intermediate goods from monopolistic competitors. Final goods producers invest in a stock of technology capital (Z) which is assumed to be skill augmenting. Households in country k value consumption, inelastically supply skilled labor (H_k) and unskilled labor (L_k), and save using a one period bond (b). Time is infinite and discrete.

Final Goods Producers: Sector X

The final good producers in sector X in country k maximize the discounted stream of dividends. They produce a single final consumption good (X_k), using differentiated intermediates produced in country k ($x_k(i)$), and invest in a skill-augmenting technology capital ($Z_{k,x}$) that they rent to the intermediate goods producers. The numeraire good will be Y and $P_x$is the relative price of good X in terms of good Y.

The problem of the final goods producers in country k is:

$$V(Z_X) = max\left(D_{k,X} + mV(Z_x^{'})\right)$$

s.t.

$$
\begin{aligned}
D_{k,X} &= P_x(\quad X_k - I_{k,x}) + r_{k,x}Z_{k,X} - \int_{N_{k,x}} p_x(i)x_k(i)di \\
I_{k,x} &= \quad B_k(Z^{'}_{k,x} + (1-\delta_y)Z_{k,x}) \\
X_k &= \quad \left[\int_{N_{k,x}} x_k(i)^{\phi}di\right]^{1/\phi}
\end{aligned}
$$

where m is the households' discount rate. Here, dividends are equal to output minus investment plus royalties minus payments for intermediates. I am assuming that the investment technology converts a single unit of good X into $B_k$units of investment goods.

Intermediate Goods Producers: $x_k(i)$

The intermediate goods producer in country k can produce both for the domestic market and for the foreign market. He chooses output $(x(i))$, skilled labor $(h_{k,x}(i))$, unskilled labor $(l_{k,x}(i))$, and amount of technology $(Z_{k,x})$ to maximize profits, taking wages and the rental rate for technology as given. The producer must use the technology of the firm that they are supplying in order to produce the intermediate for that firm. There is a country-specific productivity parameter, A_k.

$$
\max_{x(i),h_{k,x}(i),l_{k,x}(i),Z_x} p_x(i)x(i) - w_k^H h_{k,x}(i) - w_k^L l_{k,x}(i) - r_{k,x}Z_{k,x}
$$

s.t

$$
\begin{aligned}
x_k(i) &= A_k\left[\omega_x\left(Z^{\alpha}_{k,x}h_{k,x}(i)^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_x)l_{k,x}(i)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \\
x(i) &= p_x(i)^{\frac{1}{1-\rho}}X_k
\end{aligned}
$$

Here, I assume that intermediate goods producers of goods $x_k(i)$ only supply the final goods producers in their own country. Therefore, they only have access to the technology of the final goods producers in their own country; in other words, there is trade in technology in sector X. I will assume that sector X is more unskilled labor intensive than sector Y.

Final Goods Producers: Sector Y

The final good producers in sector Y in country k maximize the discounted stream of dividends. They produce a single final consumption good (Y_k), using differentiated intermediates produced in country k $(y_k(i))$, and invest in a skill-augmenting technology capital $(Z_{k,y})$ that they rent to the intermediate goods producers.

The problem of the final goods producers in country k is:

$$V(Z_{k,y}) = max D_{k,y} + mV(Z^{'}_{k,y})$$

s.t.

$$\begin{aligned} D_{k,y} &= Y_k - I_{k,y} + Z_{k,y}\left(r_{k,y} + r_{-k,y}\right) - \int_{N_{k,y}} p_y(i)y_k(i)di - (1+\tau_y)\int_{N_{-k,y}} p_y(i)y_{-k}(i)di \\ I_{k,y} &= B_k\left(Z^{'}_{k,y} + (1-\delta_y)Z_{k,y}\right) \\ Y_k &= \left[\int_{N_{k,y}} y_k(i)^{\rho}di + \int_{N_{-k,y}} y_{-k}(i)^{\rho}di\right]^{1/\rho} \end{aligned}$$

Again, dividends are equal to output minus investment plus royalties received for rental of technology minus the cost of intermediate inputs. In sector Y, the final goods producer rents its technology to and buys intermediates from firms in the foreign country, as well as the home country. In this sense, in sector Y there is "trade in ideas", or technology sharing. Moreover, notice that in sector Y, the final good producer purchases intermediates from both countries, so they integrate over all intermediates in their own country ($N_{k,y}$) and intermediates from the foreign country ($N_{-k,y}$).

Intermediate Goods Producers: y(i)

The intermediate goods producer in country k can produce both for the domestic market and for the foreign market. He chooses output ($y_k(i)$), skilled labor to produce for the domestic market ($h_{k,k,y}(i)$), skilled labor to produce for the foreign market ($h_{k,-k,y}(i)$), unskilled labor to produce for the domestic market ($l_{k,k,y}(i)$), unskilled labor to produce for the foreign market ($l_{k,-k,y}(i)$), and amount of domestic and foreign technology ($Z_{k,y}$,$Z_{-k,y}$) to maximize profits, taking wages and the rental rate for technology as given. Here, the first subscript refers to the country in which the good is produced and the second refers to the country which is being supplied. Again, the producer must use the technology of the firm that they are supplying in order to produce the intermediate for that firm.

These firms solve the following problem:

$$\max_{y_k(i),h_{k,y}(i),l_{k,y}(i),Z_y} p_y(i)(y_k(i)+y_{-k}(i)) - w_k^H(h_{k,y}(i)+h_{-k,y}(i)) \\ - w_k^L(l_{k,y}(i)+l_{-k,y}(i)) - r_{k,y}Z_{k,y} - (1+\tau_z)r_{-k,y}Z_{-k,y}$$

s.t.

$$\begin{aligned} y_k(i) &= A_k\left[\omega_y\left(Z_{k,y}^{\alpha}h_{k,k,y}^{1-\alpha}(i)\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y)\, l_{k,k,y}^{\frac{\sigma-1}{\sigma}}(i)\right]^{\frac{\sigma}{\sigma-1}} \\ y_k(i) &= A_k\left[\omega_y\left(Z_{-k,y}^{\alpha}h_{k,-k,y}^{1-\alpha}(i)\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y)\, l_{k,-k,y}^{\frac{\sigma-1}{\sigma}}(i)\right]^{\frac{\sigma}{\sigma-1}} \\ y_k(i) &= p_y(i)^{\frac{1}{1-\rho}}Y_k \\ y_{-k}(i) &= p_y(i)^{\frac{1}{1-\rho}}Y_{-k} \end{aligned}$$

I assume that if an intermediate goods producer supplies intermediates to the foreign final goods producer, it must pay a tax τ_z on the royalties paid to the final goods producer. I allow for intermediate goods producers to supply both the domestic and the foreign markets and the amount of production they choose to do in each will endogenously adjust to the amount of tax they have to pay on royalties. I will discuss this tax in detail in the next section.

Households

Households in country k choose a consumption bundle $(c_{k,x}, c_{k,y})$ and bonds $(b_k^{'})$ to solve the following problem:

$$\max \sum_{t=0}^{\infty} \beta^t \left(u(c_{k,x}) + u(c_{k,y})\right)$$

s.t.

$$c_{k,x} + c_{k,y} + b_k^{'} = w_k^H H_k + w_k^L L_k + (1+r)b_k$$

In a given country, the households are identical and so in the closed economy, no bonds will be traded. Across countries, the endowment of high- and low-skilled labor varies.

Market Clearing

Market clearing requires that bond, labor, and goods markets clear:

$$
\begin{aligned}
\sum_k b_k &= 0 \\
H_k &= \int_{N_k} \left(h_{k,x}(i) + h_{k,k,y}(i) + h_{k,-k,y}(i)\right) di \\
L_k &= \int_{N_k} \left(l_{k,x}(i) + l_{k,k,y}(i) + l_{k,-k,y}(i)\right) di
\end{aligned}
$$

$$
\begin{aligned}
\sum_{k \in U,M} X_k &= \sum_{k \in U,M} c_{k,x} + B_k \left(Z_{k,x} + (1-\delta) Z_{k,x}\right) \\
\sum_{k \in U,M} Y_k &= \sum_{k \in U,M} c_{k,y} + B_k \left(Z'_{k,y} + (1-\delta) Z_{k,y}\right)
\end{aligned}
$$

Efficiency

It can be shown that the allocations resulting from solving the above problem are efficient. Therefore, I can solve for the allocations by solving for the efficient allocation. Consider first a completely closed economy. The efficient allocation for a given country k solves:

$$
\max \sum_{t=o}^{\infty} \beta^t \left(u(c_{x,t}, c_{y,t})\right)
$$

s.t.

$$
\begin{aligned}
c_{x,t} + B_{k,x}(Z_{x,t+1} + (1-\delta) Z_{y,t}) &= A_k \left[\omega_x \left(Z_{k,x}^{\alpha} {h_{k,x}}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_x) l_k^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \\
c_{y,t} + B_{k,y}(Z_{y,t+1} + (1-\delta) Z_{y,t}) &= A_k \left[\omega_y \left(Z_{k,y}^{\alpha} {h_{k,y}}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y) l_k^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \\
H_k &= h_{k,x} + h_{k,y} \\
L_k &= l_{k,x} + l_{k,y}
\end{aligned}
$$

Consider now the open economy. In this economy, final and intermediate goods are traded and technology is shared in sector Y between the United States (U) and Mexico (M). In sector X, only final goods are traded. The efficient allocation for the open economy solves:

$$
\max \sum_{t=o}^{\infty} \beta^t \left(\lambda u(c_{U,x,t}, c_{U,y,t}) + (1-\lambda) u(c_{M,x,t}, c_{M,y,t})\right)
$$

s.t

$$\begin{aligned}
X_t =& A_U X_{U,t}^{\frac{\sigma}{\sigma-1}} + A_M X_{M,t}^{\frac{\sigma}{\sigma-1}} \\
Y_t =& \left[A_M^\rho Y_{M,M,t}^{\frac{\rho\sigma}{\sigma-1}} + A_U^\rho Y_{U,U,t}^{\frac{\rho\sigma}{\sigma-1}} + \left(\frac{A_M}{1+\tau_z}\right)^\rho Y_{M,U,t}^{\frac{\rho\sigma}{\sigma-1}} \right]^{1/\rho} \\
X_t =& \sum_k \left(c_{k,x,t} + B_{k,x}(Z_{k,x,t+1} + (1-\delta)Z_{k,x,t}\right) \\
Y_t =& \sum_k \left(c_{k,y,t} + B_{k,y}(Z_{k,y,t+1} + (1-\delta)Z_{k,y,t}\right) \\
H_k =& h_{k,x} + h_{k,-k,y} + h_{k,k,y} \\
L_k =& l_{k,x} + l_{k,-k,y} + l_{k,k,y}
\end{aligned}$$

where

$$\begin{aligned}
X_{U,t} =& \quad \omega_x \left(Z_{U,x}^\alpha {h_{U,x}}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_x) l_{U,x}^{\frac{\sigma-1}{\sigma}} \\
X_{M,t} =& \quad \omega_x \left(Z_{M,x}^\alpha h_{M,x}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_x) l_{M,x}^{\frac{\sigma-1}{\sigma}} \\
Y_{M,M,t} =& \quad \omega_y \left(Z_{M,y}^\alpha h_{M,M,y}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y) l_{M,M,y}^{\frac{\sigma-1}{\sigma}} \\
Y_{U,U,t} =& \quad \omega_y \left(Z_{U,y}^\alpha h_{U,y}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y) l_{U,y}^{\frac{\sigma-1}{\sigma}} \\
Y_{M,U,t} =& \quad \omega_y \left(Z_{U,y}^\alpha h_{M,U,y}^{1-\alpha}\right)^{\frac{\sigma-1}{\sigma}} + (1-\omega_y) l_{M,U,y}^{\frac{\sigma-1}{\sigma}}
\end{aligned}$$

Now, when the implicit tax on foreign technology (τ_z) is lowered, more technology ($Z_{U,y}$) is shared between the United States and Mexico. The total amount of technology used by producers of intermediate goods $y_m(i)$ will be an average of the technology capital produced by local producers and that produced by foreign producers. Therefore, if this economy goes from being in autarky (or near autarky) to totally open ($\tau_z = 0$), there will be a substantial jump in the technology capital used in Mexico.

In order to see how this mechanism operates, consider the following simplified problem in which there is only the integrated sector:

$$\max \sum_{t=o}^{\infty} \beta^t \left(\lambda u(c_{U,t}) + (1-\lambda) u(c_{M,t})\right)$$

s.t

$$
\begin{aligned}
Y_t = & \left[A_M^\rho Y_{M,M,t}^{\frac{\rho\sigma}{\sigma-1}} + A_U^\rho Y_{U,U,t}^{\frac{\rho\sigma}{\sigma-1}} + \left(\frac{A_M}{1+\tau_z}\right)^\rho Y_{M,U,t}^{\frac{\rho\sigma}{\sigma-1}} \right]^{1/\rho} \\
Y_t = & \sum_k \left(c_{k,t} + B_k (Z_{k,t+1} + (1-\delta) Z_{k,t}\right) \\
H_k = & h_{k,k} + h_{k,-k} \\
L_k = & l_{k,k} + l_{k,-k}
\end{aligned}
$$

I have written the planner's problem for the open economy; recall that in the closed economy, each country only operates and invests in its own technology (Z_k). In the context of this problem, it is easier to see how reductions in $\tau_Z$will affect both the United States and Mexico. First, consider the effect in Mexico. As τ_Z falls, Mexican firms substitute towards using $Z_y$because it is becoming relatively more productive. Therefore, the overall level of technology used in Mexico increases. Because technology is skill-augmenting, this increases the skill premium. The increasing productivity of Z_U will also affect the incentive to invest in that technology. As τ_Z falls, the productivity of Z_U rises, inducing increased investment in this technology. Therefore, the level of Z_U is higher in the open economy than the closed economy. In this setting, Z_U is decreasing in τ_z.

Skill Premium

The skill premium can be expressed as

$$
\begin{aligned}
SP_k &= \frac{w_k^H}{w_k^L} \\
&= (1-\alpha)\frac{\omega_y}{1-\omega_y}\left(\frac{Z_{k,y}}{H_{k,y}(Z_{k,y})}\right)^{\alpha\frac{\sigma-1}{\sigma}}\left(\frac{H_{k,y}(Z_{k,y})}{L_{k,y}(Z_{k,y})}\right)^{-1/\sigma}
\end{aligned}
$$

In order to contrast this with the standard Heckscher-Ohlin model, let's turn again to the stylized model. First, recall that in the standard H-O model, the skill premium is expressed as

$$
\begin{aligned}
SP_k &= \frac{w_k^H}{w_k^L} \\
&= \frac{\omega_y}{1-\omega_y}\left(\frac{H_{k,y}}{L_{k,y}}\right)^{-1/\sigma}
\end{aligned}
$$

And in the stylized model, we have:

$$SP_k = (1-\alpha)\frac{\omega_y}{1-\omega_y}\left(\frac{Z_k}{H_k}\right)^{\alpha\frac{\sigma-1}{\sigma}}\left(\frac{H_k}{L_k}\right)^{-1/\sigma} \tag{3.1}$$

In the simplified model, there is no shifting of labor from one sector to the next. Therefore, in the H-O analogue with only one sector, opening to trade does not affect the skill premium. Equation 3.1 is reminiscent of the expression for the skill premium that is typically derived in models of skill-biased technical change. From this expression, we can see that in the simple model there are two forces at play. The first ratio, the ratio of technology to skilled workers $\left(\frac{Z_k}{H_k}\right)$, can be interpreted as the demand for skilled workers. The second ratio, the ratio of unskilled to skilled workers $\left(\frac{L_k}{H_k}\right)$, is the relative supply of each kind of worker. In the most basic H-O model, the skill premium is determined solely by the relative supply of skilled to unskilled workers and the skill-intensity of production. In the modified model, however, increasing technology serves to increase the skill-intensity of production and so the demand for skilled workers changes as the level of technology (Z) changes. Therefore, when Mexico begins to adopt the technology of the U.S. final goods producer, the demand for skilled workers will increase and, as a result, so will the skill premium. In the U.S., the increase in the skill premium is driven by the "investment channel." Because investment in Z_U is decreasing in τ_Z, when the level of distortions to the use of U.S. technology fall in Mexico, total investment in technology increases, thus increasing the *level*of technology in the U.S. Therefore, the ratio of technology to high skilled workers in the United States $\left(\frac{Z_U}{H_U}\right)$ must increase. In Mexico, instead, in the basic model, the skill premium increases due to the "adoption channel." The stock of technology in the U.S. is greater than that in Mexico initially because there are more skilled workers in the U.S. than in Mexico. Therefore, in the closed economy, technology is more productive in the U.S. and is accumulated to a greater extent. When Mexican firms switch from less productive technology (Z_M) to more productive technology (Z_U), the relative demand for skilled labor also increases in Mexico. The size of the initial jump in the skill premium in Mexico will be equal to the difference in the initial steady state levels of technology between the two countries. Then, the skill premium in Mexico will continue to grow with the skill premium in the U.S. as Z_U grows to its new steady state level. So, the increase in the skill premium in Mexico is substantially larger than the increase in the skill premium in the U.S.

In the full model, there is also a Stolper-Samuelson effect whereby workers are reallocated towards sectors in which the country has a comparative advantage. However, this effect is offset by the adoption of U.S. technology (Z_U) in Mexico. The extent to which this effect is offset is dependent on the specific parametrization that is used. I will parametrize the model to match some key observations in the "pre-reform" period and will conduct sensitivity analysis to show

how my results would change for different parameter choices. If technology's share of income (α) is low, for instance, the offsetting effects of technology adoption may not be large enough to completely overturn the Stolper-Samuelson result. This is intuitive: If technology is relatively unimportant in production, then having access to new technology will have little impact upon the skill premium.

I now turn to the calibration of the model and the implications of the calibrated model for the skill premium in both countries. Additionally, I discuss sensitivity of the results to the selected parametrization.

3.5 Calibration and Quantitative Results

3.5.1 Calibration

I now calibrate the model to quantify the extent to which it can account for the increase in the skill premia. Table 3.3 details the fixed parameter values chosen, as well as the source for these parameter selections.

Parameter	Value	Source
β	0.96	Annual return on risk-free bonds
ρ, ϕ	0.63	Trade literature
δ_j	0.08	McGrattan & Prescott
A_M	0.25	Relative value-added per worker in 1985
H_U	0.28	CPS - Some College 1985
H_M	0.10	ENOE - Some College 1985
L_U	0.72	Normalize population to 1
L_M	0.92	Normalize population to 1

Table 3.3: Fixed Parameter Values

Some of these parameters deserve discussion. In particular, I calculate the relative total factor productivity (TFP) in Mexico (A_M) to be 0.25. Note that I normalize TFP in the United States to be 1. I then calculate the relative value added per worker in the manufacturing sector in Mexico in 1985. I choose the manufacturing sector instead of the overall economy because my skill premium data pertains to the manufacturing sector only. For the relative supply of high-skilled workers, I use the household surveys that are available for both countries. The data analogue to high-skilled workers are non-production employees. Since these are defined to be managers and technicians, I look at individuals with some college. This includes individuals with technical training. I do not want to rely on the ratio of non-production to production employees in manufacturing because this is an equilibrium outcome which is reflective of the skill intensity of manufacturing. While two countries have similar ratios of non-production to production employees, the ratio of college to non-college individuals differs substantially. I need this difference in order to rationalize the large observed difference in initial skill premia. The rate of time discounting (β) and the substitutibility of intermediate goods (ρ, ϕ) are taken directly from the literature. Although changing these parameters would affect the initial calibration, they do not impact the results in terms of changes in skill premia. Moreover, the initial calibration is not particularly sensitive to these parameter choices. As in McGrattan and Prescott (2009), δ_j is not separately identified from α; the parameters jointly determine the return to technology capital. I am going to hold fixed δ and conduct sensitivity analysis on α but it should be noted that each value of α is dependent upon the associated rate of depreciation, δ.

Parameter	Value	Interpretation
ω_x	0.45	Skilled Labor's Share - Industry X
ω_y	0.58	Skilled Labor's Share - Industry Y
α	0.34	Technology Capital's Share
σ	1.98	Elasticity of Substitution between H & L

Table 3.4: Calibrated Parameters

The most important parameters for the results are technology capital's share of income (α) and the elasticity of substitution between high- and low-skill labor (σ). Also important are the share parameters in the production function (ω_x,ω_y) which determine how skill intensive each sector is. In order to pin these parameters down, I match three moments in the data: (1) the ratio of royalties to payroll in Mexico in 1985; (2) the Mexican skill premium in 1985; and (3) the U.S. skill premium in 1985. I estimate the parameters via the general method of moments (GMM).

Moment	Data	Model
Ratio of Royalties to Payroll - Mexico 1985	0.055	0.065
Skill Premium - Mexico 1985	2.03	2.03
Skill Premium - U.S. 1985	1.42	1.38

Table 3.5: Target Moments

Table 3.4 shows the parameter values resulting from the calibration exercise and Table 3.5 displays the targeted moments in the data and the model's fit with them. I am able to exactly match the level of the skill premium in Mexico in 1985, but the model does not exactly replicate the other two moments. If I were to allow the substitution between skilled and unskilled workers As Table 3.5 shows, the model exactly hits the target moments. The estimated elasticity of substitution between high- and low-skill labor is in keeping with estimates from the literature. I assume that the elasticity of substitution is the same across countries. Likewise, I assume that technology's share of income is the same across countries. I do this for two reasons. The first is that I have data on royalty payments only for Mexican manufacturing. Because royalty payments over payroll is the obvious data analogue to technology's share of income, I want to match this moment precisely in order to discipline α. In the absence of royalty data, I have no way of pinning down this parameter. The second reason is that these two parameters (α, σ) are the parameters to which my model results are most sensitive. I do not want the difference in production functions to be driving the results. I will conduct sensitivity analysis to the choice of these variables but will not allow them to vary across countries.

3.5.2 Results

I now conduct an experiment in which I move the countries from the fully closed economy (autarky) to the one with no barriers to trade or technology flow ($\tau_y, \tau_z = 0$). This is the extreme case and will serve as an illustration for how much of the skill premia increase can be accounted for by the proposed mechanism.

	Closed		Open		%Δ	
	Data	Model	Data	Model	Data	Model
Mexico	2.03	2.03	3.1	2.8	50.4	39.4
U.S.	1.42	1.38	1.6	1.5	11.0	8.0

Table 3.6: Results: Autarky to Free Trade

As Table 3.6 shows, the model is able to capture over three quarters of the rise in the skill premium in Mexico and about two thirds of the rise in the skill premium in the United States. For contrast, in Table 3.7, I report the rise in the skill premium that occurs in the model without technology capital. Notice that I only report the percent change between the closed and open steady states. This is because the initial steady state in the closed economy without technology capital will be different than the targeted values since I am running this particular experiment using the parameter values which I calibrate to the model that includes technology capital. In this case, the Stolper-Samuelson effect is present for Mexico; the skill premium in Mexico in the open economy is 10% lower than it is in autarky. You will notice that, perhaps surprisingly, the increase in the skill premium in the United States is less in the world without technology capital. This is because intermediate inputs are relative complements; in the standard H-O model, there are only two goods, which are substitutes for one another. Therefore, when industries integrate, there is a tenancy for demand for the factors of production in both countries to move in the same direction in the two countries. This implies that the fact that Industry Y integrates is, in part, responsible for the skill premia moving in the same direction. In the absence of technology capital, however, the increased (world) supply of unskilled workers dominates and the skill premium falls. There are parameter values for which the skill premium rises in the United States and falls in Mexico. However, the skill premium in the United States never rises as much as it would in a world in which all goods are gross substitutes.

	%Δ		
	Data	Model	
		With Z	No Z
Mexico	50.4	39.4	-9.78
U.S.	11.0	8.0	1.00

Table 3.7: Results: With and Without Technology Capital

Recall that this experiment is for the extreme case of complete autarky to fully open trade. This may not be a bad exercise to do because in the early 1980s, Mexico was one of the most closed economies in the world and by the late 1990s, it was one of the most open and in many ways was almost completely integrated into the U.S. market. Notably, full adoption of the intellectual property rights laws of the United States was part of the NAFTA agreement, though Mexico began to adopt these laws as early as 1989 (DuMars, 1991). I view this adoption as one of the important reduction in distortions that occurred to allow supply chains to integrate and final goods producers to share technology with their intermediate goods producers.

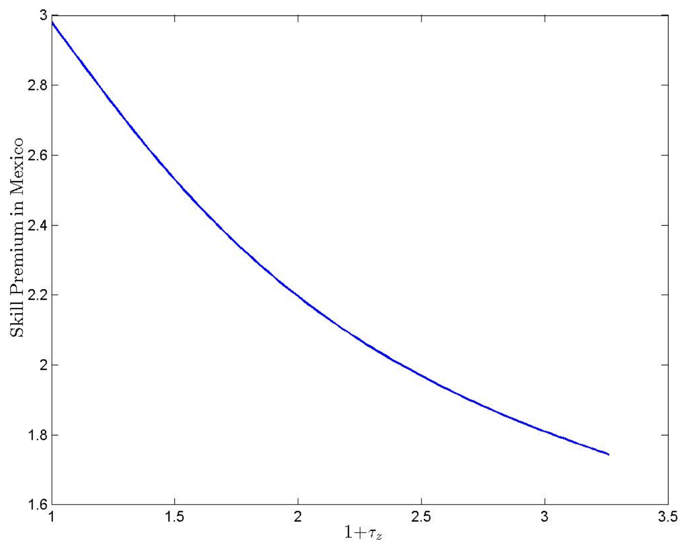
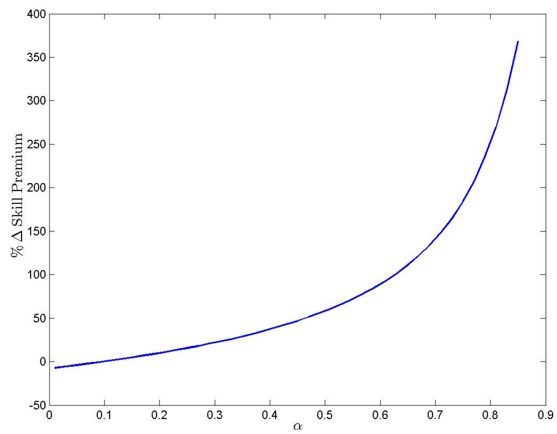


Figure 3.6: Sensitivity to Changes in τ_Z

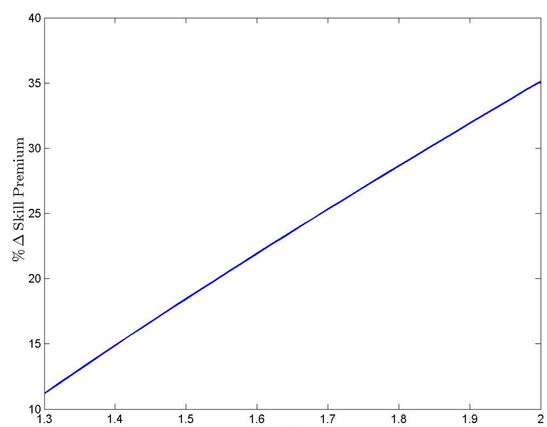
In Figure 3.6, I show the sensitivity of my results to the proposed change in τ_Z. Recall that moving from autarky to free trade is essentially moving from a high level of distortions to no distortions (τ_z high to $\tau_z = 0$). Figure 3.6 shows how my results would change in a less extreme case. Notice that if these distortions are sufficiently high ($\tau_z > 3$) the Mexican intermediate goods producing firms choose to specialize in producing intermediates for Mexican final goods producers using Mexican technology. If the change in this distortion is sufficiently small, there are no changes in the skill premium due to the "investment channel" in the United States. This is because sufficiently small amounts of U.S. technology are adopted so that the return on technology capital does not change. This, in turn, reduces the firms' incentive to increase investment, thus eliminating the investment channel. As discussed above, the skill premium may rise as a result of integration of supply chains, depending on the relative complementarity of intermediate goods.

3.5.3 Sensitivity Analysis

The most important parameter for determining the change in the skill premium is α, as it governs the importance of technology in production and its complementarity with high-skilled labor. Figure 3.7(a) shows how the skill premium changes with α.



(a) Sensitivity to α



(b) Sensitivity to σ

Figure 3.7: Sensitivity of Change in Skill Premium to Technological Parameters

Notice that when α is very close to zero, the Stolper-Samuelson effect dominates and the skill premium in Mexico actually falls as Mexico integrates with the United States. However, as α approaches one, the Stolper-Samuelson effect is no longer important and trade in ideas dominates.

Also important for determining the change in the skill premium is σ, which dictates how substitutable skilled and unskilled labor are. Figure 3.7(b) shows the sensitivity of the change in the skill premium to this variable. Estimates in the data for σ range between 1.4 and about 2, so I show that range of value for σ on the x-axis of Figure 3.7(b). Because A_M is the relative productivity of Mexican manufacturing, which is greater than zero but less than one, I show a range of values between 0 and 1 on the x-axis of Figure 3.8. In figure 3.7(b), we see that if skilled and unskilled labor are more substitutable, the change in the skill premium is greater in the open economy than if the two types of labor are less substitutable. Moreover, in Figure 3.8 if the countries have greater differences in their productivity, trade increases the skill premium in Mexico by much more.

This exercise indicates the implications of the model for the impact of trade in technology between two countries with similar productivities. In particular, if two advanced economies, such as Canada and the United States, were to engage in trade in technology, it would be far less likely that Canada would adopt the technology of the United States to the same extent that Mexico did. The investment channel would still be at work, however, and so there could be a modest rise in the skill level of technology capital in each country, depending on how much of the American technology was used in Canada and vice versa. The increased marginal return to technology capital of the final goods producer in the U.S. depends on the Canadian intermediate's willingness to switch from producing for the domestic final goods producer to producing for the American final goods producer. Because the two countries would have initial stocks of technology capital that would be similar, it is unlikely that the return to investing in the technology would change substantially after liberalization. This is broadly consistent with the data on the Canadian manufacturing skill premium following NAFTA. The skill premium in Canada rose by an amount similar to the increase in the skill premium in the U.S.

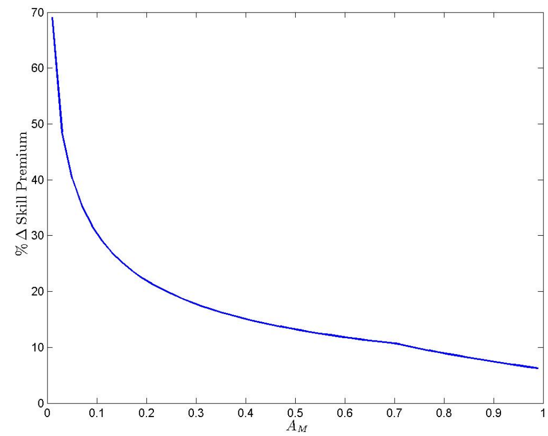


Figure 3.8: Sensitivity of Changes in Skill Premium to A_M

Now I show how the variables interact with one another. In particular, figure 3.9 shows the interaction between α and σ. As both parameters increase, the change in the skill premium in response to a trade liberalization increases. These parameters cannot be estimated individually from the data, but will have to be determined jointly from a calibration procedure.

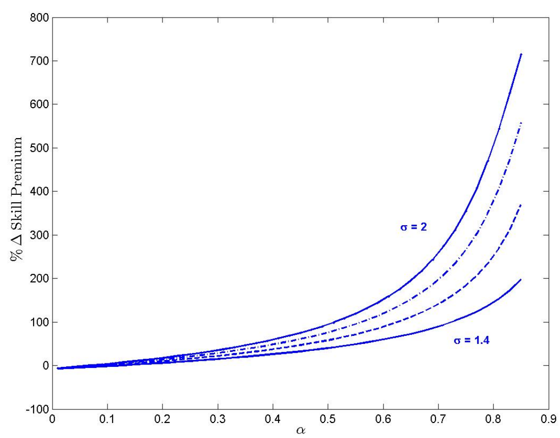


Figure 3.9: Sensitivity of Changes in Skill Premium to α and σ

The sensitivity analysis suggests that even for values of α and σ which are lower than the calibrated values, the model can deliver growth in the skill premium of the sort that we observed over the late 1980s and early 1990s in Mexico. Notice that the sensitivity analysis was all done with respect to changes in the Mexican skill premium. A robust feature of the model is that it delivers a relatively larger increase in the skill premium in Mexico than in the United States, which is a feature that other models of the skill premium lack. The disproportionate rise of the skill premium that occurs in Mexico arises because of the adoption of the technology of the U.S. producers. There is an investment effect on the skill premium in both countries, but the majority of the increase in the skill premium in Mexico will come from the adoption of the American technology.

3.6 Conclusion

In this paper, I have shown that integration of supply chains is an important consideration for the effects of trade liberalization on relative wages. The theoretical model that I use to generate predictions for the changes in the skill premia following a trade liberalization is a standard two-country trade model, modified to include technology capital which can be traded across countries. I conclude that, once we consider the trade in technology that inherently occurs as part of integrated supply chains, the increase in the skill premia in both the United States and Mexico, with a disproportionate increase in the Mexican skill premium, is not a puzzle. The model predicts that, while the skill premium rises in both countries, it rises in Mexico by much more than the skill premium in the United States. I have provided evidence of supply chain linkages, as well as evidence that these linkages are important predictors of technological transfer and increasing skill premia. I have further shown that the patterns observed empirically are quantitatively consistent with those predicted by this theory.

My model embeds the standard Heckscher-Ohlin forces and when I shut down the importance of technology in production, I find the standard prediction of a falling skill premium in the Mexico and a rising skill premium in the United States. Allowing for trade in technology overturns this result because it allows for technology adoption in Mexico to spur increases in investment in that same technology in the United States. A key reason that this was possible in the case of Mexico is Mexico's adherence to U.S. intellectual protection laws, which decreased the distortions to using American technology in Mexico. This has implications for other trade relationships and liberalizations. Perhaps the reason that we do not observe such large increases in the skill premium in other developing countries as they open to trade is that trade in technology is hindered by the lack of intellectual property protection in those countries. I plan to extend the analysis to other countries whose skill premia rose following trade liberalization, such as Chile and Colombia, but by much more modest amounts. As a first pass, it is evident that these countries conduct far less intra-industry trade with the developed world than Mexico does, which indicates that their firms are far less integrated into the supply chains of the United States.

The framework developed here can be extended along a number of dimensions. An interesting avenue for future research would be to model the strategic interaction between the final goods producer and the intermediate goods producer which gives rise to the distortion on the use of technology capital in the foreign country, τ_z. Better understanding of this relationship will provide a framework to explore the disparate responses to trade liberalization across countries. Another possible extension would be to allow for heterogeneity in some exogenous productivity at the firm-level. Burstein and Vogel (2012) show that reallocation across firms can have an impact on inequality at the household-level. Allowing for this feature in my current framework would allow me to use more of the plant-level data to test the accuracy of the model. Moreover, it would allow me to study how technology capital gets allocated across intermediate goods producers in Mexico and, therefore, how this contributes to cross-plant variation in wages and the skill premium. A third extension is to model the costs to the worker of changing sectors. This will create cross-industry variation in wages and the skill premium, again allowing for more external checks of the theory.

This paper provides a model for beginning to think about technological transfer and the impact that this transfer has both upon countries that adopt it and upon the firms who invest in it. I have demonstrated that technological transfer can play a big role in determining the skill premia of countries that liberalize to one another. An interesting issue that remains is identifying the reasons that technological transfer occurs to a lesser extent when certain countries open to trade and the implications that this has for inequality.

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