Gains from Trade with Heterogeneous Households

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Abstract

In this paper, I investigate the distributional consequences of international trade within countries by taking into account different dimensions of heterogeneity across households and allowing them to interact with each other. I consider the welfare consequences of differences between households' expenditures, the effect of trade costs on wages, and the impact of these costs on households' intertemporal consumption-saving decisions. I develop a two-country, multisector dynamic model of trade with households that are heterogeneous in wealth, earning abilities, and education (skill) level. The model features nonhomothetic preferences, idiosyncratic income shocks, endogenous consumption-saving decisions, and capital-skill complementarity. I calibrate the model to the United States and Mexico to analyze the distributional implications of the North American Free Trade Agreement. The results imply that considering three dimensions of heterogeneity—wealth, income, and education—and the interaction between the mechanisms they generate is crucial in order to measure gains from trade accurately. I find that in both countries, an unanticipated permanent elimination of import tariffs relatively favors the poor within each education level. However, the gap between the gains of the poor and the rich is larger for college graduates compared to non-college workers. In addition, I show that although college graduates experience larger gains than non-college workers at the same wealth level, poor non-college workers gain more than rich college graduates. Finally, I find that an anticipated permanent elimination of tariffs results in lower gains than an unanticipated fall, especially for the poor.

Keywords: welfare, consumption, saving, wealth, trade, factor price
JEL classification: E21, E24, F10, F16, F41, F62

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1 Introduction

Studies that demonstrate the evolution of international trade costs over time provide evidence for significant reductions in these costs. First, iceberg trade costs have decreased significantly. For example, air transport costs declined by 92 percent in the period 1955-2004 (WTO, 2008). Second, trade barriers that are determined by trade policies have fallen. For instance, developments such as the General Agreements on Tariffs and Trade (GATT) and free trade agreements (FTA) have led to reductions in tariffs for all countries (WTO, 2008).[1]

We do not expect these significant reductions in trade costs to affect individuals within a country uniformly. Thus, it is crucial that we understand the factors that cause changes in trade barriers to differently affect households' welfare and quantify their effects. The literature has mostly focused on the importance of heterogeneity on the labor side, such as different skill levels, for the distribution of gains from trade. When we focus only on this heterogeneity, we overlook the fact that households within a worker group, such as high-skilled workers, have different levels of wealth and income. Therefore, we assume that workers within each group have the same level of gains regardless of their wealth and income, and any gap between the gains of different worker groups is independent of their wealth and income levels. However, these two other sources of heterogeneity affect the distribution of gains through differences between households' expenditure patterns and intertemporal consumption-saving decisions.

Since changes in trade costs have an effect on households' expenditures, earnings, and intertemporal decisions, each household's gain from trade is jointly determined by their wealth, income, and education (skill) level. When we consider all three sources of heterogeneity together, we can measure welfare gains accurately by capturing the interaction between the mechanisms they generate. Hence, in this paper, I provide a comprehensive framework to answer the following questions: (i) How do trade costs affect the welfare of poor versus rich households within a country? (ii) How do the welfare gains/losses of agents with different wealth and income levels depend on their level of education?

I initially document how expenditure shares for agricultural goods, manufacturing goods, and services vary with wealth and income to provide motivating evidence for the importance of considering wealth and income as important determinants of the distribution of gains. I confirm that the poor and the rich consume different bundles of goods and services by using household expenditures data from the United States (U.S.) and Mexico. Considering this fact and other mechanisms that determine how gains are distributed across households that are heterogeneous in wealth, income, and education levels, I de-

[1]For example, the average import tariff for developed countries was 3.9 percent in 2005 while it was 14 percent in 1952 (WTO, 2008).

velop a two-country, multi-sector, dynamic, heterogeneous-agent model of trade. I use the model to quantify the welfare effect of changes in trade costs on households within a country.

My paper makes two important contributions to the literature. The existing studies mostly focus on the effect of changing trade barriers on workers (wage channel) and ignore heterogeneity in wealth and the role of dynamic mechanisms (households' intertemporal consumption-saving decisions and the effect of those decisions on the supply of capital and factor prices in the long run) in the distribution of gains. I develop a framework that provides an accurate measure for the distribution of gains from trade within a country by including dynamic mechanisms. Hence, first, I am able to show the importance of the intertemporal channel for the distributional consequences of trade. Second, I show how gains within each skill group and any gap between gains at different skill levels vary with income and wealth due to expenditure and intertemporal channels. I can make those two contributions because, unlike most of the existing studies, I consider transition dynamics instead of comparing steady states or computing the immediate (short-run) effect of trade costs.

I consider the role of heterogeneity in wealth and income in the distribution of gains because, first—as stated above—households' expenditure shares vary depending on their wealth and income; i.e., they have nonhomothetic preferences. This fact has crucial implications for the unequal distribution of gains through the effect of changing trade costs on households' expenditures. For example, if a fall in trade costs leads to a reduction in the relative price of goods consumed mostly by the rich, the expenditures of the rich become relatively lower compared with those of the poor, which renders their welfare relatively higher.

Changes in trade costs also lead to the unequal distribution of gains through the intertemporal channel. Even in the absence of differences between households' consumption baskets and education levels, trade costs affect the welfare of households with different wealth and income levels depending on their consumption-saving decisions. This is because, first, trade costs affect the price of investment in capital, which results in a difference between the gains of households that want to save and those that are willing to sell their savings. Second, changes in trade costs have an impact on the marginal product of capital and thus on the interest rate. As a result, the gains of borrowers differ from those of savers. Also, since the level of capital accumulated is determined by households' consumption-saving decisions, these decisions influence trade-induced changes in the skill premium as a result of capital-skill complementarity.

My other goal is to analyze how the welfare gains of the poor and the rich depend on their education levels (skills) because of the heterogeneous effect of trade on wages and the skill premium.[2] Trade costs have a direct effect on the skill premium due to differences in intensities of high-skilled and low-skilled workers in production across sectors (the Stolper-Samuelson effect).[3,4] Trade-induced changes in the relative prices of goods and services determine the effect of changing trade costs on the skill premium. For instance, if goods that use high-skilled workers more intensively become relatively more expensive following a change in trade costs, the price of high-skilled workers relative to that of low-skilled workers rises, which increases the skill premium. The other mechanism that causes changing trade barriers to have an effect on the skill premium is the complementarity between capital and skilled labor.[5] Since a change in trade costs affects capital accumulation and capital use in production through its impact on the price of capital and return on capital, demand for high-skilled workers is also affected. As a result, the relative wage of high-skilled workers changes.

I build a two-country, multi-sector dynamic model of international trade with heterogeneous households that incorporates the mechanisms and observations described above. The production side builds on Armington (1969)[6]: each country produces a distinct variety in each sector—manufacturing, agricultural, and non-tradable (services). Manufacturing and agricultural varieties are traded subject to iceberg trade costs and import tariffs. All goods are produced using capital, high-skilled and low-skilled labor, and intermediate inputs. The shares of factors and intermediate inputs differ across sectors.

On the household side, I consider a framework in which households are heterogeneous in their wealth, earning abilities, and education levels. It builds on Aiyagari (1994).[7] Households smooth their consumption over time by investing in capital, buying firm equities, and buying/selling bonds in international financial markets. In addition, preferences are nonhomothetic, which enables me to capture differences between the consumption baskets of households with different wealth levels. Households derive utility from consuming both domestic and foreign goods, and the elasticity of substitution between domestic and foreign goods (trade elasticity) varies across sectors.

There are also two skill (education) levels: high-skilled (college graduates) and low-skilled (non-college workers). The skill level of each household is exogeneously determined and the supply of each skill type is fixed. High-skilled and low-skilled workers are imperfect substitutes. In addition, the elasticity of substitution between capital and skilled

[2]The skill premium is the ratio of the real wage of a skilled labor to that of an unskilled labor.

[3]According to the Stolper-Samuelson theorem, there is a link between the relative prices of outputs and the relative prices of production factors. If the relative price of a good increases (decreases), then the relative price of the factor that is used intensively in the production of this good increases (decreases) as well.

[4]See, for example,Parro (2013) and Cravino and Sotelo (2019).

[5]See, for example, Griliches (1969) and Krusell et al. (2000).

[6]In the Armington (1969) model, each country produces a distinct variety in each sector and countries trade with each other, since consumers in each country want to consume varieties produced in other countries in addition to domestically produced goods.

[7]In the Aiyagari (1994) model, households face uninsurable idiosyncratic income risk.

labor is smaller than that between capital and unskilled labor, which implies capital-skill complementarity.

This model provides a measure that allows me to quantify the effect of a reduction in iceberg trade costs and changes in import tariffs on the welfare of households by taking into account the transition dynamics between steady states. In my framework, changes in trade costs affect households' welfare gains through the following channels. First, lower trade costs result in changes in the relative prices of consumption goods and services. Therefore, welfare gains vary across households at different wealth levels, depending on changes in the relative prices of the goods and services they consume intensively.[8] There are several differences between agricultural goods, manufacturing goods, and services that cause changing trade costs to have an unequal impact on their prices and that are incorporated in my model. The first difference is the fact that manufacturing goods and agricultural goods are more tradable than services. Second, trade elasticities for these goods differ from each other.[9] Third, factor shares and shares of the tradable and imported intermediate inputs used in their production vary across these goods. Finally, they have different income elasticities of demand.

Second, lower trade costs reduce the cost of investment in capital. A lower cost of investment leads to variation in gains, depending on households' willingness to save and their existing wealth and income levels—i.e., intertemporal consumption-savings decisions. Third, trade-induced changes in factor prices affect households' gains. Lower trade costs increase the marginal product of capital and thus the interest rate, due to the reduction in the cost of investment and rise in measured total factor productivity. Households that hold capital benefit from the rise in the interest rate, but this increase reduces the gains of households that borrow. As for wages, changes in the relative prices of goods and services affect the wage of college graduates relative to that of non-college workers—i.e., the wage premium—because the share of worker types varies across sectors (the Stolper Samuelson effect). Also, the capital used in production increases due to the rise in the marginal product of capital. Since capital and skill (high level of education) are complementary, the demand for skilled workers rises as well, which leads to an increase in the skill premium.

I calibrate the model to the U.S. and Mexico to analyze the distributional consequences of the North American Free Trade Agreement (NAFTA). I do not consider Canada—the other country that signed NAFTA—because, first, tariffs between the U.S. and Canada were low even before NAFTA due to a free trade agreement. Second, the trade volumes between Mexico and Canada are small.

I use the calibrated model to quantify the effect of eliminating import tariffs under

[8]For example, if a fall in trade costs leads to a reduction in the relative price of a good consumed mostly by the rich, the welfare of the rich becomes relatively higher compared with that of the poor.

[9]See, for example, Ossa (2015); Nigai (2016); and Fajgelbaum and Khandelwal (2016).

NAFTA on households' welfare. In the first quantitative exercise, tariffs are eliminated immediately: I analyze the effect of an unanticipated permanent reduction. Although tariffs are eliminated, iceberg trade costs remain the same. In the second exercise, I consider an anticipated permanent elimination of tariffs and compare the welfare consequence of this case with that of the unanticipated reduction. In this quantitative exercise, tariffs are eliminated in both countries after a pre-announced time lag. I assume that households in both countries know the future path of tariffs once the agreement is signed. Both of these scenarios capture realistic features of FTAs in general and NAFTA in particular.

The results suggest that all households gain from an unanticipated permanent elimination of import tariffs. However, in both countries, the poor gain more from eliminating tariffs compared to the rich within each skill group. This is because wage accounts for a larger share of the total income of poor households; that is, they benefit from any increase in wage more than the rich. In addition, the gains of the rich are lower, since the non-tradable good becomes relatively more expensive. I also show that the gap between the gains of the poor and the rich is relatively larger for high-skilled workers.

As for the distribution of gains across different skill groups, I find that the gains of high-skilled workers (college graduates) exceed the gains of low-skilled workers (non-college workers) at each wealth level. High-skilled workers benefit more from trade primarily because of the increase in capital accumulation. Since capital and skill are complementary, the demand for high-skilled workers rises as capital is accumulated, which renders their wage relatively higher than the wage of low-skilled workers. The results also imply that the gap between the gains of high-skilled and low-skilled workers depends on households' wealth levels because, first, not only poor high-skilled workers but also poor low-skilled workers experience higher gains than rich high-skilled workers. Second, this gap increases as wealth decreases, since any change in relative wages has a greater impact on the poor as mentioned above. Hence, we can say that the importance of the earnings channel for the distribution of gains across skill groups is not the same for all households and depends on households' wealth. The results of the second exercise indicate that the gains of all households are relatively lower when there is an anticipated permanent reduction in tariffs.

This paper is related to several strands of the literature. First, it is related to studies that investigate the distributional consequences of trade within countries by focusing only on differences between the consumption baskets of households—i.e. the expenditure channel. Nigai (2016); Fajgelbaum and Khandelwal (2016); and Hillrichs and Vannoorenberghe (2022) use static trade models, which overlook the effect of variation in households' wealth and intertemporal consumption-saving decisions on the distribution of gains.[10] I extend their models for the expenditure channel by allowing heterogeneity

[10]In static models, factors of production and technology in each country are held fixed and gains reflect the immediate change in consumers' real income.

in wealth. Therefore, I can capture the fact that expenditure shares vary with wealth. In addition, in my model, households can both consume and save endogenously depending on their wealth and income levels. As a result, the model can show the effect of households' intertemporal decisions on the distribution of gains, which cannot be investigated with static trade models. In this group of studies, Carroll and Hur (2020) is closely related to my paper in terms of considering heterogeneity in wealth and dynamic effects for the expenditure channel. Unlike this paper, Carroll and Hur (2020) categorize the goods in households' consumption baskets as tradables and non-tradables, while I consider the distinction between tradable goods (manufacturing versus agricultural goods). This distiction is important in order to calculate the gains correctly, because their shares in total expenditures vary with wealth differently and they have different characteristics that affect trade-induced changes in their prices—e.g. trade elasticities and the shares of inputs.

I also contribute to the literature that investigates the unequal effects of trade on labor markets. Some of the studies included in this literature consider the impact of trade on labor market dynamics (for example, Artuç et al. (2010); Dix-Carneiro (2014); Coşar et al. (2016); Dix-Carneiro and Kovak (2017); Ferriere et al. (2018); Caliendo et al. (2019)). Another group of studies analyzes trade-induced changes in the skill premium, which is closely related to this paper on the labor side (see, e.g., Parro (2013); Burstein et al. (2013); Dix-Carneiro and Kovak (2015); Burstein and Vogel (2017); Ferriere et al. (2018); Cravino and Sotelo (2019).) In this literature, Parro (2013) is the most closely related to this work, because, first, he measures the effect of trade costs on the skill premium by taking into account both the Stolper-Samuelson effect and capital-skill complementarity. Second, trade costs affect the skill premium through capital-skill complementarity due to their effect on the price of capital goods. That is, capital used in production increases following a fall in trade costs, since trade costs lead to a reduction in the price of capital goods. The demand for high-skilled workers rises as well due to capital-skill complementarity, which results in an increase in the skill premium. Unlike my study, he uses a static model in which households' intertemporal decisions play no role in determining the level of capital in the economy. Also, he doesn't capture the effect of capital accumulation on the skill premium over time.

Carroll and Hur (2022); Borusyak and Jaravel (2018); and Egger and Nigai (2018) consider both the earnings and expenditure channels while analyzing the distributional consequences of trade. Borusyak and Jaravel (2018) provide evidence on how gains from trade vary across education groups through these two channels using U.S. data. They examine differences between the consumption bundles of individuals with different education levels and the characteristics of industries in which each education group works to show how gains are distributed within a country. Egger and Nigai (2018) build a model in which workers are heterogeneous in their skill levels and, workers' consumption patterns vary with their income—i.e. workers have nonhomothetic preferences. In their paper, the unequal effect of trade on wages is determined by capital-skill complementarity. Lower trade costs raise the trade of capital goods, which increases the relative price of high-skilled workers due to this complementarity. Compared to my paper, both of these studies abstract from heterogeneity in wealth and the dynamic mechanisms that affect the distribution of gains. Within this group of studies, Carroll and Hur (2022) is the most closely related paper to mine. They show how both households' consumption preferences and skill levels affect the distribution of gains across households that are heterogeneous in wealth, income, and skill. There are significant differences between their study and this paper. First, they have two types of goods: tradables and non-tradables. As stated above, categorizing tradable goods as manufacturing goods and agricultural goods is crucial to quantify the distributional effect of trade accurately. Second, Carroll and Hur (2022) overlook the effect of differences in factor shares across sectors on changes in the skill premium (the Stolper-Samuelson effect), whereas I take it into account. That is, they consider only capital-skill complementarity for trade-induced changes in the skill premium.

My study is also related to the literature that measures aggregate gains from trade with dynamic models. Ravikumar et al. (2017); Reyes-Heroles et al. (2016); and Dix-Carneiro et al. (2021) emphasize the importance of allowing for trade imbalances and highlight the gap between dynamic and static gains. Dix-Carneiro et al. (2021) specifically focus on the effect of trade imbalances on labor market dynamics. However, they don't explain how this gap is distributed across heterogeneous households within a country, because they assume there is a representative agent in each country.

Finally, this paper contributes to the literature on models of international trade that feature nonhomothetic preferences—e.g. Hallak (2006); Fieler (2011); and Fajgelbaum et al. (2011). Fajgelbaum et al. (2011) define nonhomothetic preferences over goods of different quality for households that are heterogeneous in income. Hallak (2006) highlights the relationship between income per capita in a country and demand for quality in that country with nonhomothetic preferences. Similarly, Fieler (2011) argues the effect of per capita income on consumption patterns. All of these studies mainly focus on explaining trade flows between countries. Although nonhomothetic preferences play a role in the determination of trade flows between countries in my model, I mainly contribute to this literature by considering nonhomothetic preferences for the effect of trade on the welfare of heterogeneous households within a country in a dynamic setting with capital accumulation.

2 Stylized Facts on Household Expenditures

It is well known that households' consumption bundles depend on their income and wealth. In this section, I confirm this fact by using Consumption Expenditure Surveys (CEX) published by the U.S. Bureau of Labor Statistics (BLS) and National Survey of Household Income and Expenditure (ENIGH) published by Mexico's National Institute of Statistics and Geography (INEGI). Borusyak and Jaravel (2018) also use the CEX by combining them with other datasets and show that workers' consumption patterns depend on their education levels. In addition, Carroll and Hur (2020) analyze the link between households' expenditures and their income and wealth by using the CEX published between 2004 and 2014. They show that the share of tradable goods in total expenditure is decreasing in income and wealth. I focus on a different period and disaggregate tradables further into agricultural and manufacturing goods while using the CEX. As for the ENIGH, there are studies examining the variation of expenditures across households in Mexico by using these surveys. However, there is no paper showing how the expenditures shares of goods and services with different levels of tradability varies with income in Mexico.

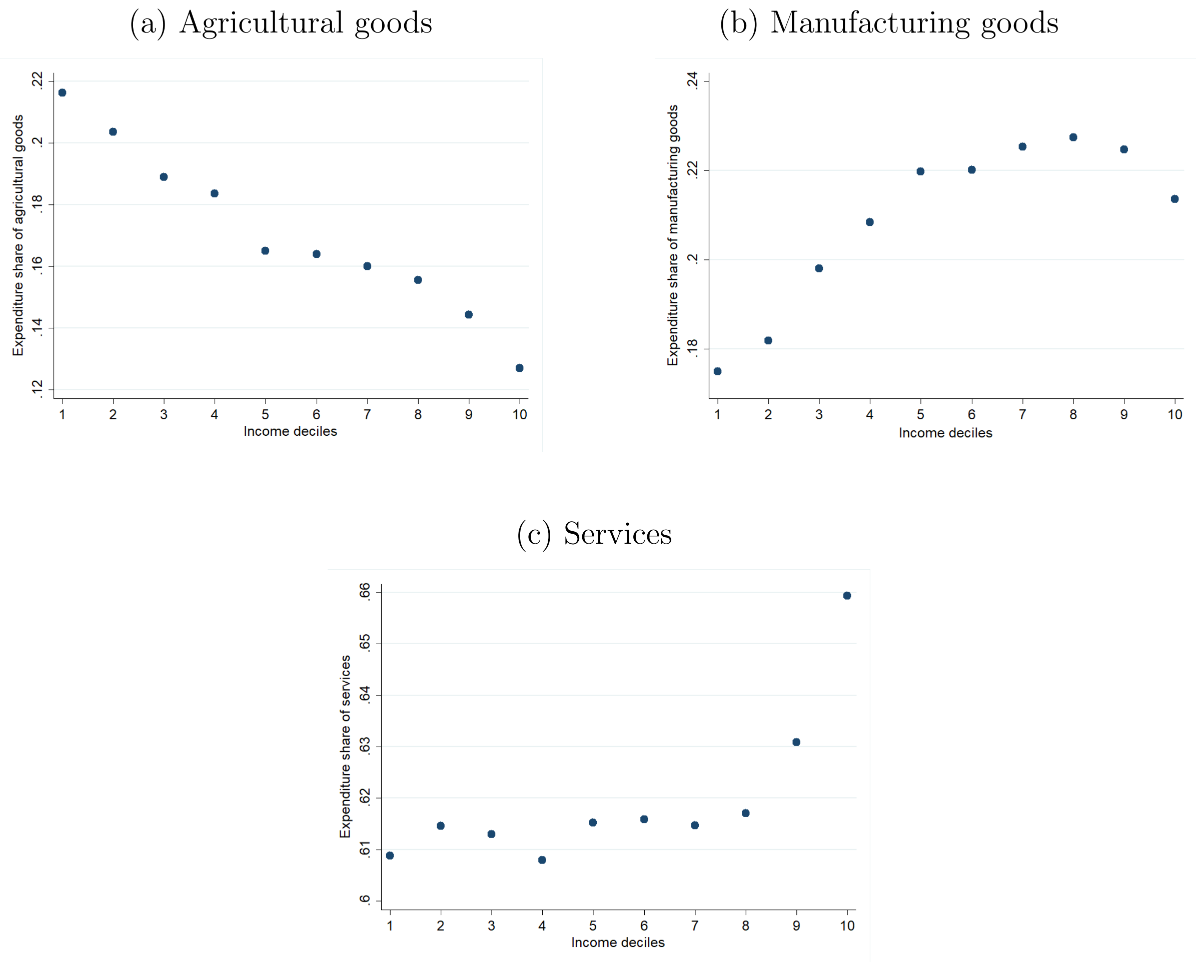
I use the CEX from the fourth quarter of 2014 to the first quarter of 2020 in order to document the variation in the consumption bundles of households with different income and wealth levels. Since the ENIGH does not provide information on households' wealth levels, I can show how households' expenditures vary only with income in Mexico by using the surveys published in 2014, 2016 and 2018.

The CEX provide very detailed information on households' expenditures. In the data set, there are more than 400 items. Similarly, the ENIGH includes Mexican households' expenditures on more than 700 items. I categorized these items into three groups: agricultural goods, manufacturing goods and services. The items in each category are shown in Table B.1 and Table B.2.

While constructing the data sets that I use for the analyses, only working-age households with the household head between 25 to 64 are included. In the CEX, each household's annual income is provided, whereas the ENIGH shows the quarterly income of each household. In both data sets, households with non-positive income are dropped. Also, income and wealth are adjusted using the Consumer Price Index (CPI).

In the U.S. data, I have 11,370 households with positive income. However, only 7,936 households report their wealth. For each household, I calculated the shares of agricultural good, manufacturing good, and services in their annual expenditure by combining information on their quarterly expenditures. Therefore, for each of them, I have one observation for the year they were interviewed. As for the ENIGH, there are 127,398 households that have positive income. It shows the expenditures of each household for seven consecutive days.

Figure 1: Annual Expenditure Shares for the US Consumers (Income)



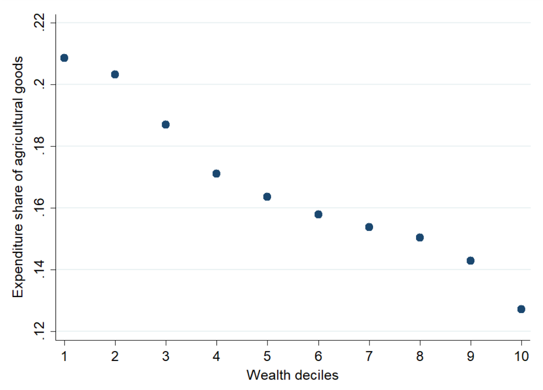
Notes: The data source is the CEX from 2014 (quarter 4) to 2020 (quarter 1) published by the BLS. See Table B.1 for the items included in each sector.

United States Figure 1 shows how expenditure shares vary across income deciles in the U.S. The expenditure share in each decile is the average of households' expenditure shares in that decile. The share of the agricultural good significantly differs across income groups. While this share is around 22% for the lowest decile, it is approximately equal to 12% for the top decile. The share of the manufacturing good is non-monotonic: it first increases as income rises and after the eight decile, it slightly goes down. The share of services in total expenditure is almost the same across the first eight income deciles. Then there is a sharp increase in this share. Hence, we see a significant difference between the services share of the top income deciles and that of lower deciles.

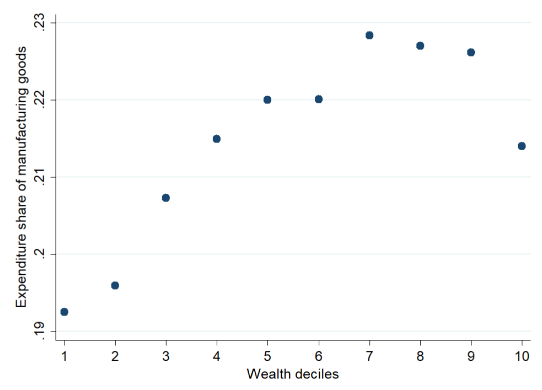
The expenditure shares also depend on households' wealth levels. The total value of checking, savings, money market accounts, certificates of deposit, retirement accounts, directly-held stocks, bonds, mutual funds and other financial assets gives wealth for each household. Figure 2 shows that the variation in the expenditure shares across wealth deciles is very similar to that for income deciles.

Figure 2: Annual Expenditure Shares for the US Consumers (Wealth)

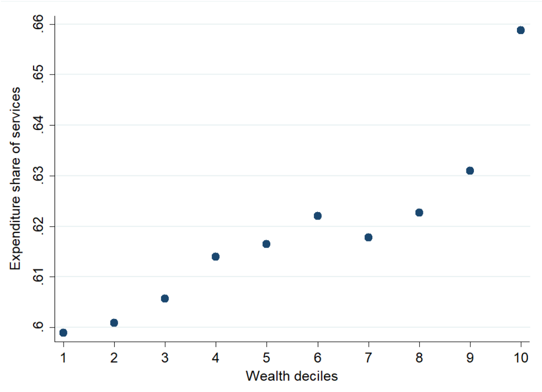
(a) Agricultural goods



(b) Manufacturing goods



(c) Services



Notes: The data source is the CEX from 2014 (quarter 4) to 2020 (quarter 1) published by the BLS. See Table B.1 for the items included in each sector.

The results are also robust to controlling for age, education level (college versus non-college) and sex of household head, household size and living in a rural or urban area. I also include year dummies in the regressions. Table 1 shows that as income and wealth increase, the share of agricultural good in total expenditure decreases while the shares of manufacturing goods and services rise. In the third and fifth columns, I use quadratic variables - square of the logarithm of income and square of the logarithm of wealth - because the expenditure shares of manufacturing good and services follow a non-monotonic pattern. The results suggest that although the share of manufacturing good is increasing in wealth, it goes down after some level of wealth due to the negative coefficient on the square of the logarithm of wealth. This finding is consistent with the hump-shaped pattern in Figure 2. Also, I find that the share of services rises more steeply as wealth or income increases, which is consistent with Figure 1 and Figure 2.

Table 1: Regression results for expenditure shares, US

	Agricultural	Manufacturing	Manufacturing	Services	Services
Income (log)	-0.0127***	0.0074***	-0.0104	0.0053***	-0.0206*
	(0.0009)	(0.0016)	(0.0087)	(0.0016)	(0.0088)
(Log(income))^2			0.00096*		0.0013**
			(0.0004)		(0.0005)
Wealth (log)	-0.0033***	0.0024***	0.0046***	0.0009*	-0.0027*
	(0.0002)	(0.0004)	(0.0012)	(0.0004)	(0.0012)
(Log(wealth))^2			-0.0002*		0.0003**
			(0.0001)		(0.0001)
Age	0.0005***	-0.0004**	-0.0003*	-0.0001	-0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
College graduate	-0.0193***	-0.0128***	-0.0130***	0.0321***	0.0291***
	(0.0018)	(0.0032)	(0.0032)	(0.0032)	(0.0033)
Female head	-0.0043*	-0.0025	-0.0023	0.0067*	0.0077**
	(0.0017)	(0.0029)	(0.0029)	(0.0029)	(0.0029)
Household size	0.0080***	0.0103***	0.0100***	-0.0183***	-0.0188***
	(0.0006)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Rural	0.0211***	0.0319***	0.0320***	-0.0530***	-0.0525***
	(0.0034)	(0.0060)	(0.0060)	(0.0060)	(0.0060)
Constant	0.298***	0.135***	0.210***	0.567***	0.707***
	(0.0114)	(0.0197)	(0.0452)	(0.0199)	(0.0457)
Observations	7936	7936	7936	7936	7936
Adjusted R^2	0.164	0.036	0.036	0.078	0.081

Standard errors in parentheses

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

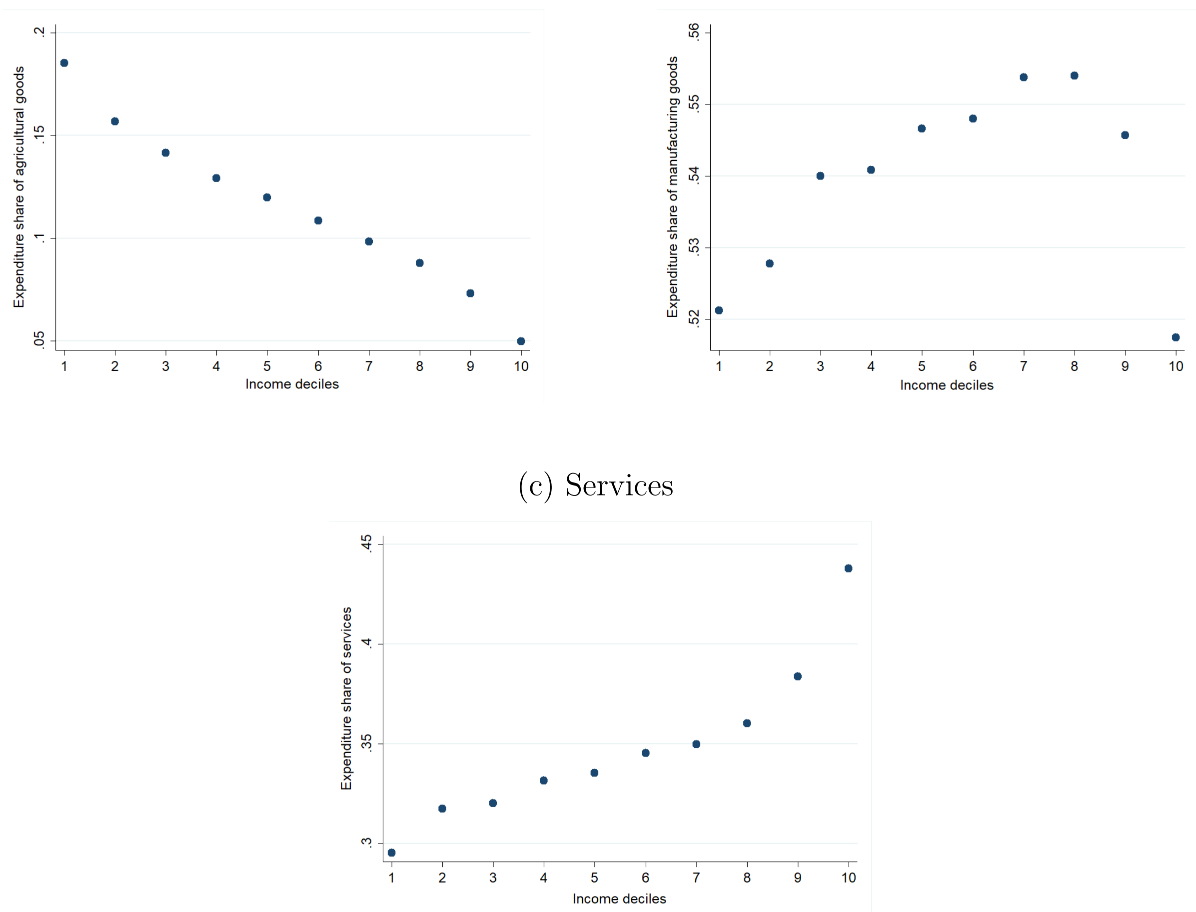
Mexico The variation in expenditure shares across income deciles in Mexico is shown in Figure 3. The share of agricultural goods in total expenditure falls as income rises whereas the services share is increasing in income. There is a steep reduction in the share of agricultural goods: it is approximately 20 percent for the lowest decile and 5 percent for the highest decile. The share of services also differs significantly from the lowest decile (around 3 percent) to the highest one (around 45 percent). As for manufacturing goods, their share initially goes up as income rises. There is a reduction in that share after the eight decile. The main difference between the consumption patters of the U.S. and Mexico is the level of expenditure shares. Households in the U.S. spend a smaller share of their income on manufacturing goods compared with Mexican households. In contrast, the share of services is much smaller in Mexico for all the income deciles.

Figure 3: Annual Expenditure Shares for the Consumers in Mexico (Income)

(a) Agricultural goods

(b) Manufacturing goods

(c) Services



Notes: The data source is the ENIGH published by the INEGI in 2014, 2016 and 2018. See Table B.1 for the items included in each sector.

In Table 2, I show that these results are robust to controlling for household characteristics by using the same variables as I use for the U.S. The regression results are consistent with the significant variation in the shares of agricultural goods and services across income deciles and the non-monotonic patterns that manufacturing goods and services follow (see columns 3 and 5).

Table 2: Regression results for expenditure shares, Mexico

	Agricultural	Manufacturing	Manufacturing	Services	Services
Income (log)	-0.0496***	0.0140***	0.1880***	0.0368***	-0.0782***
	(0.0004)	(0.0008)	(0.0118)	(0.0008)	(0.0117)
$(\text{Log(income)})^2$			-0.0084***		0.0056***
			(0.0006)		(0.0006)
Age	0.0007***	-0.0022***	-0.0021***	0.0014***	0.0014***
	(0.00002)	(0.00005)	(0.00005)	(0.00005)	(0.00005)
College graduate	-0.0151***	-0.0396***	-0.0344***	0.0573***	0.0539***
	(0.0009)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Female head	-0.0030***	-0.0111***	-0.0113***	0.0139***	0.0140***
	(0.0006)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
Household size	0.0033***	0.0148***	0.0146***	-0.0195***	-0.0194***
	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Rural	0.0042***	0.0571***	0.0584***	-0.0613***	-0.0622***
	(0.0006)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
Constant	0.583***	0.421***	-0.477***	-0.008	0.584***
	(0.0041)	(0.0085)	(0.0615)	(0.0084)	(0.0609)
Observations	127350	127344	127344	126634	126634
Adjusted R^2	0.159	0.065	0.066	0.115	0.115

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

These stylized facts on households' expenditure patterns motivate the framework that is used in this paper. In the following section, I present a quantitative trade model with households that are heterogeneous in wealth, income and skills to capture these facts and other mechanisms that affect the distribution of gains through these three sources of heterogeneity.

3 Model

I develop this model by embedding the model in Armington (1969) into a dynamic environment.[11] Consider an infinite horizon in which time is discrete and indexed by $t = 0, 1, 2, \ldots$ In the world there are 2 countries indexed by $i = H, F$: home and foreign countries.

Households in each country are heterogeneous in their earning abilities, wealth and educational levels. I call college graduate workers high-skilled workers and non-college workers low-skilled workers. Each country is endowed with S_i units of high-skilled workers and U_i units of low-skilled labor. In addition, households are endowed with different efficiency units of labor, ε_{it}, which are supplied inelastically to the domestic labor market. Finally, in each country there are three sectors indexed by $j = a, m, n$: agricultural, manufacturing and non-tradable (services) sectors, respectively.

3.1 Production

While categorizing the sectors, I take into account whether they are tradable or not across the countries. Agricultural and manufacturing goods are traded subject to finite trade costs, but services are not traded internationally. This difference between sectors plays a role in determining the effect of a change in trade costs on each sector.

Each country produces a distinct variety of each good. Each sector uses capital, labor (high-skilled and low-skilled) and intermediate inputs in the production. Labor is mobile across sectors within countries, so wages of high-skilled and low-skilled workers in each country are not sector dependent and the same for all three sectors. Additionally, total capital investment is freely allocated among sectors. While high-skilled and low-skilled workers are imperfect substitutes, capital complements high-skilled worker.

Agricultural and manufacturing goods are traded subject to sector-specific bilateral iceberg trade costs. Namely, $\tau^j_{ih,t} \geq 1$ for $j = m, a$ denotes the cost of shipping good j from h to i at time t. $\tau^j_{ii,t} = 1$ for $i = H, F$ and $j = m, a$, which implies that the cost of trade within countries is zero. These two goods are also subject to import tariffs. t^j_i denotes the tariff set by country i for the imported good j.

3.1.1 Technology

The technology which the representative firm in country i uses to produce good j is given by

[11] In the Armington model each country produces a different good and the consumers in each country consume at least some of the goods of the other countries, which is the reason behind the trade between countries.

$$Y_{it}^j = \left\{ (\Gamma^j)^{1-\Delta} (U_{it}^j)^{\Delta} + (1-\Gamma^j)^{1-\Delta} \left[(\Upsilon^j)^{1-\Lambda} (S_{it}^j)^{\Lambda} + (1-\Upsilon^j)^{1-\Lambda} (K_{it}^j)^{\Lambda} \right]^{\Delta/\Lambda} \right\}^{\beta^j/\Delta} \left[(A_{it}^j)^{\alpha^j} (N_{it}^j)^{\xi^j} (M_{it}^j)^{1-\alpha^j-\xi^j} \right]^{\zeta^j} \tag{1}$$

for $j = a, m, n$ and $i = H, F$. K_{it}^j, U_{it}^j and S_{it}^j are the amount of capital, unskilled and skilled labor used in the production of good j in country i, respectively. Similarly, A_{it}^j, N_{it}^j and M_{it}^j denote the amount of intermediate inputs used from agricultural, non-tradable and manufacturing sectors for the production of good j in country i, respectively. The representative firms hire labor and capital from households. I assume that if $\beta^j + \zeta^j < 1$, i.e. production function has decreasing returns to scale, then there is a fixed factor used in the production of good j.

The elasticity of substitution between capital and skilled labor in sector j is $1/(1-\Lambda) > 0$ while the elasticity of substitution between unskilled labor and capital/skilled labor is $1/(1-\Delta) > 0$. $\Lambda < \Delta$ must be satisfied in order for the production function to exhibit capital-skill complementarity.

The manufacturing and agricultural goods used in the production are a composite of domestic and imported varieties. This aggregation is in the form of CES. Let $1/(1-\Omega_j) > 0$ for $j = m, a$ be the elasticity of substitution between domestic and imported intermediate inputs. Then the aggregate manufacturing and agricultural inputs used by sector j in country i are respectively given by

$$M_{it}^j = \left((\chi_m^j)^{1-\Omega_m} (M_{ii,t}^j)^{\Omega_m} + (1-\chi_m^j)^{1-\Omega_m} (M_{ih,t}^j)^{\Omega_m} \right)^{1/\Omega_m} \tag{2}$$

$$A_{it}^j = \left((\chi_a^j)^{1-\Omega_a} (A_{ii,t}^j)^{\Omega_a} + (1-\chi_a^j)^{1-\Omega_a} (A_{ih,t}^j)^{\Omega_a} \right)^{1/\Omega_a} \tag{3}$$

for $j = a, m, n$ and $i = H, F$. χ_m^j (χ_a^j) denotes the share of domestic intermediate input m (a) in total use of this intermediate input for the production of good j. $M_{ih,t}^j$ ($M_{ii,t}^j$) is the amount of manufacturing good which is imported from h (produced domestically) and used in the production of manufacturing good in i while $A_{ih,t}^j$ ($A_{ii,t}^j$) denotes the imported (domestically produced) agricultural input used in the production of good j in country i. Aggregate capital, labor and intermediate inputs are allocated across sectors according to the static profit maximization problem of sectors.

3.2 Households

Each household in country i gets utility from consuming non-tradable, manufacturing and agricultural goods. The household's utility function is

$$u(c_{it}^n, c_{it}^m, c_{it}^a) = \frac{1}{1-\gamma}\left[(c_{it}^a)^{1-\lambda} + \kappa_1 \frac{1-\lambda}{1-\eta}(c_{it}^m)^{1-\eta} + \kappa_2 \frac{1-\lambda}{1-\psi}(c_{it}^n)^{1-\psi}\right]^{\frac{1-\gamma}{1-\lambda}} \tag{4}$$

where c_{it}^j is the amount of good j consumed by each household in country i. κ_1 and κ_2 are the utility weights on c_{it}^m and c_{it}^n, respectively. The utility function is similar to functional forms used in Fieler (2011) and Wachter and Yogo (2010) and allows for non-homotheticity. Namely, the share of each good in total consumption varies across households depending on their wealth level. Thus, I capture the differences between the consumption baskets of agents with different wealth levels via these preferences. The parameter restrictions determine how the expenditure shares differ across consumers.[12] If $\lambda = \eta = \psi$, this utility function collapses to the homothetic utility function with a constant elasticity of substitution, $1/\lambda$.

In addition, agricultural and manufacturing goods consumed by households are aggregate of domestic and foreign goods and this aggregation is in the CES form.

$$c_{it}^j = \left((\theta^j)^{1-\sigma_j}(c_{ii,t}^j)^{\sigma_j} + (1-\theta^j)^{1-\sigma_j}(c_{ih,t}^j)^{\sigma_j}\right)^{1/\sigma_j} \tag{5}$$

for $j = m, a$. $c_{ii,t}^j$ denotes the consumption of domestic good j, $c_{ih,t}^j$ is the consumption of good j imported from country h and $1/(1-\sigma_j) > 0$ denotes the elasticity of substitution between domestic and foreign goods.

Households can save by investing in capital, buying and selling one-period bonds available around the world and buying firm equities. The price of investment in capital in each country equals the price of the manufacturing good produced in this country. The value of equities in each country depends on the profits of agricultural and non-tradable sectors, which result from decreasing returns to scale, in that country. I assume that in each country, equities are provided by an intermediary that owns representative firms in these sectors.

All the saving vehicles pay the same rate of return, because all of them are safe assets. Hence, in the budget constraint below there is only one saving vehicle that consists of capital, bonds, and equities. These savings pay in units of numeraire good. The price of the manufacturing good produced in H is taken as the numeraire, i.e. $P_{Ht}^m = 1$. In the equilibrium the returns on the productive asset - capital - equities, and bonds are given

[12] For example, if $\gamma > 1$, $\lambda \geq \eta > 1$, $\lambda \geq \psi > 1$ and $\eta \approx \psi$, then the share of the agricultural good decreases whereas the expenditure shares for both manufacturing and non-tradable goods increase in total consumption.

as

$$1 + r_{t+1} = 1 + R_{Ht+1} - \delta = \frac{(1-\delta)P^m_{Ft+1} + R_{Ft+1}}{P^m_{Ft}} = \frac{V_{it+1} + D_{it+1}}{V_{it}} \quad \forall i \tag{6}$$

where $1 + r_{t+1}$ is the real return on savings, R_{Ht+1} (R_{Ft+1}) is the marginal product of capital in H (F), P^m_{Ft} is the price of the manufacturing good produced in F in period t, V_{it} is the price of the stock share and D_{it} is the dividend distributed by intermediaries in country i in period t. The real return on savings is the same across countries.

The efficiency units of labor, ε_{it}, changes according to a Markov process, which is independent across agents.

$$\ln \varepsilon' = \kappa \ln \varepsilon + \nu' \tag{7}$$

where primes indicate one-period leads and $\nu' \sim \mathrm{N}(0, \sigma^2_\nu)$. This process varies across skilled and unskilled workers.

Let $V(\varepsilon_{it}, s_{it}, e)$ denote the lifetime utility of a household in country i who has productivity ε_{it}, wealth s_{it} and education e at time t. For households who are (not) college graduates $e = c$ ($e = n$). Let $\beta \in (0,1)$ be the discount factor and $\underline{s}^i$ be the borrowing limit in country i. Then the problem which a household faces is given by

$$V(\varepsilon_{it}, s_{it}, e) = \max_{c^a_{it}, c^m_{it}, c^n_{it}, s_{it+1}} u(c^a_{it}, c^m_{it}, c^n_{it}) + \beta \mathrm{E}\big[V(\varepsilon_{it+1}, s_{it+1}, e)\big] \tag{8}$$

subject to

$$\varepsilon_{it} W^e_{it} + (1 + r_t)s_{it} = P^a_{it} c^a_{ii,t} + P^a_{ih,t} c^a_{ih,t} + P^m_{it} c^m_{ii,t} + P^m_{ih,t} c^m_{ih,t} + P^n_{it} c^n_{it} + s_{it+1}$$

$$s_{it+1} \geq \underline{s}^i \quad \text{and} \quad (5)$$

where $P^j_{ih,t}$ is the price of imported good j in country i, i.e. $P^j_{ih,t} = P^j_{ht} \tau^j_{ih}(1 + t^j_i)$ for $j = m, a$. In addition, $W^e_{it} = W^c_{it}$ for skilled workers and $W^e_{it} = W^n_{it}$ for unskilled workers in country i.

3.3 Government

Households pay tariffs when they buy imported manufacturing and imported agricultural goods. In each country the government collects the import tariffs and spends tariff revenues on non-tradable good, i.e. tariff revenues are wasted by the government. Transfers are measured in units of manufacturing good produced in home country. Hence, the budget constraint of the government is given by

$$G_{it} = T^a_{ih,t} + T^m_{ih,t} \tag{9}$$

where G_{it} denotes the government expenditure in country i at time period t and

$$T^a_{ih,t} = P^a_{ht}\tau^a_{ih,t}t^a_{it}\Big\{\sum_{e=n,c}\int_{\varepsilon,s} c^a_{ih,t}(\varepsilon,s,e)X_{it}(\varepsilon,s,e) + A^m_{ih,t} + A^n_{ih,t} + A^a_{ih,t}\Big\}$$

$$T^m_{ih,t} = P^m_{ht}\tau^m_{ih,t}t^m_{it}\Big\{\sum_{e=n,c}\int_{\varepsilon,s} c^m_{ih,t}(\varepsilon,s,e)X_{it}(\varepsilon,s,e) + M^m_{ih,t} + M^n_{ih,t} + M^a_{ih,t}\Big\}$$

Thus, $T^j_{ih,t}$ denotes the tariff revenues in country i coming from total expenditure by households and firms in this country on good j imported from country h. $X_{it}(\varepsilon,s,e)$ is the distribution of households over ε, s and e in country i at time period t.

3.4 Market Clearing Conditions

First, the labor market clearing conditions are satisfied in each country and every period. They are given by

$$S_{it} = S^a_{it} + S^m_{it} + S^n_{it} = \int_{\varepsilon,s} \varepsilon_{it}X_{it}(\varepsilon,s,c) \tag{10}$$

$$U_{it} = U^a_{it} + U^m_{it} + U^n_{it} = \int_{\varepsilon,s} \varepsilon_{it}X_{it}(\varepsilon,s,n) \tag{11}$$

for $i = H, F$ and $t = 0, 1, ...$

Also, the good markets must clear in every country and period. The market clearing conditions for agricultural, non-tradable and manufacturing goods are given by the following equations, respectively.

$$\begin{aligned} Y^a_{it} = \sum_{e=n,c}\Bigg(\tau^a_{hi,t}\int_{\varepsilon,s} c^a_{hi,t}(\varepsilon,s,e)X_{ht}(\varepsilon,s,g) + \int_{\varepsilon,s} c^a_{ii,t}(\varepsilon,s,e)X_{it}(\varepsilon,s,e)\Bigg) + \\ \tau^a_{hi,t}\Bigg(A^a_{hi,t} + A^m_{hi,t} + A^n_{hi,t}\Bigg) + A^a_{ii,t} + A^m_{ii,t} + A^n_{ii,t} \end{aligned} \tag{12}$$

$$Y^n_{it} = N^m_{it} + N^a_{it} + N^n_{it} + \sum_{e=n,c}\int_{\varepsilon,s} c^n_{it}(\varepsilon,s,e)X_{it}(\varepsilon,s,e) + G_{it} \tag{13}$$

$$\begin{aligned} Y^m_{it} = \sum_{e=n,c}\Bigg(\tau^m_{hi,t}\int_{\varepsilon,s} c^m_{hi,t}(\varepsilon,s,e)X_{ht}(\varepsilon,s,e) + \int_{\varepsilon,s} c^m_{ii,t}(\varepsilon,s,e)X_{it}(\varepsilon,s,e)\Bigg) \\ \tau^m_{hi,t}\Bigg(M^a_{hi,t} + M^m_{hi,t} + M^n_{hi,t}\Bigg) + K_{it+1} - (1-\delta)K_{it} + M^a_{ii,t} + M^m_{ii,t} + M^n_{ii,t} \end{aligned} \tag{14}$$

for all i, h and t. As seen in equation (12), there are two components of total demand for agricultural goods: consumers' demand and firms' demand for intermediate input. (13) implies that total demand for non-tradable goods includes government expenditures as well as households' demand and demand for intermediate non-tradable input by firms. Since the capital of each country is the manufacturing good produced in this country, the total demand for manufacturing goods is the sum of the consumers' demand, firms' demand and investment in capital by households as seen in equation (14).

Finally, households' total wealth satisfies the following condition.

$$K_{Ht+1} + P_{Ft}K_{Ft+1} + V_{Ht} + V_{Ft} = \sum_{e=n,c} \Big\{ \int_{\varepsilon,s} s_{Ht+1}(\varepsilon,s,e)X_{Ht}(\varepsilon,s,e) + \int_{\varepsilon,s} s_{Ft+1}(\varepsilon,s,e)X_{Ht}(\varepsilon,s,e) \Big\} \text{ for all } t \tag{15}$$

where $K_{it+1} = K^m_{it+1} + K^a_{it+1} + K^n_{it+1}$. Since net supply of bonds is zero, total savings in the world equal the value of equities and total demand for capital by the firms.

3.5 Equilibrium[13]

The recursive competitive stationary equilibrium of the world economy is (a) policies for households $\{\{c^j_{ii}(.), c^j_{ih}(.)\}_{j=m,a}, c^n_i(.), s'_i(.), e(.)\}$ (b) policies for firms $\{\{K^j_i, S^j_i, U^j_i, M^j_{ii}, M^j_{ih}, A^j_{ii}, A^j_{ih}, N^j_i\}_{j=m,n,a}\}$; (b) households' value functions (c) good and factor prices (d) households' distribution across their states $\{X_i(.)\}$; (e) a government policy $\{tr_{it}, \{t^j_i\}_{j=m,a}\}$ for $i = H, F$ such that (i) the households' policies solve their problem; (ii) factor demands by sectors solve the social planner's problem; (iii) all markets clear; (iv) the government budget constraint is satisfied; (v) households' distributions are stationary and consistent with households' policies.

3.6 Channels for the unequal distribution of gains from trade

I use the model in order to analyze the effect of changes in tariffs on households' welfare quantitatively. However, before discussing the quantitative results, I will explain the mechanisms in the model which determine how gains/losses from changes in trade costs are distributed across households with different wealth, income and skill levels.

Relative prices of goods and services From the cost minimization problem of sector j I find that the marginal cost of production in this sector is given by

$$C^j_{it} = \frac{1}{\beta^j + \zeta^j} (X)^j \left(P^{\nu,j}_{it}\right)^{\beta^j} \left[(P^{a,j}_{it})^{\alpha^j} (P^{n,j}_{it})^{\xi^j} (P^{m,j}_{it})^{1-\alpha^j-\xi^j} \right]^{\zeta^j} (Y^j_{it})^{\beta^j+\zeta^j-1} \tag{16}$$

where

$$P^{\nu,j}_{it} = \left[\Gamma^j (W^u_{it})^{\frac{\Delta}{\Delta-1}} + (1-\Gamma^j)(P^{s,j}_{it})^{\frac{\Delta}{\Delta-1}} \right]^{\frac{\Delta-1}{\Delta}} \tag{17}$$

[13]The main steps that are followed to find equilibrium and transition dynamics are explained in appendix A.

$$P_{it}^{s,j} = \left[\Upsilon^j (W_{it}^n)^{\frac{\Lambda}{\Lambda-1}} + (1-\Upsilon^j)(r_t)^{\frac{\Lambda}{\Lambda-1}} \right]^{\frac{\Lambda-1}{\Lambda}} \tag{18}$$

$$P_{it}^{k,j} = \left[\chi_k^j (P_{it}^k)^{\frac{\Omega_k}{\Omega_k-1}} + (1-\chi_k^j)(P_{ih,t}^k)^{\frac{\Omega_k}{\Omega_k-1}} \right]^{\frac{\Omega_k-1}{\Omega_k}} \tag{19}$$

$$P_{it}^j = C_{it}^j \tag{20}$$

$$\left(X\right)^j = (\beta^j)^{-\beta^j} (\zeta^j)^{-\zeta^j} (\alpha^j)^{-\alpha^j \zeta^j} (\xi^j)^{-\xi^j \zeta^j} (1-\alpha^j-\xi^j)^{(-1+\alpha^j+\xi^j)\zeta^j} \tag{21}$$

for $k = m, a$ and $\forall i, h, j$. Equation (20) implies that the marginal cost of production in a sector equals the price of the good/service produced by this sector in the model. Therefore, equation (16) gives the price of good j produced in country i. This equation shows that there is a link between input and good prices. Moreover, it points out the interaction across and sectors. Because the price of good j depends on the prices of intermediate inputs produced by the other country and those produced by the other sectors. In addition equations (16) and (19) imply that lower trade costs reduce the price of good j and the aggregate price of manufacturing and agricultural goods since $P_{ih,t}^k = P_{ht}^k \tau_{ih}^k (1 + t_i^k)$. The effect of trade costs on the aggregate prices depends on the trade elasticities of goods which is given by the elasticity of substitution between domestic and imported varieties of these goods as seen in equation (19). Lower trade costs lead to a rise in the relative price of the good with higher trade elasticity.

Changes in trade costs affect the relative prices of consumption goods and services depending on the factors explained above: the share of imported inputs, the share of capital, labor and domestic inputs and trade elasticities. These trade-induced changes in relative prices also depend on the income elasticities of goods and services as these elasticities determine how the demand for a good/service by households is affected following a change in its price. The effect of these changes in relative prices on welfare gains varies across households with different wealth levels, because they consume different bundles of goods and services. If goods which they consume intensively become relatively cheaper after a reduction in trade costs, they benefit more from it compared with the other households.

Cost of investment in capital Trade costs affect the price of capital which is produced by the manufacturing sector in the model. Changes in the cost of investment in capital leads to heterogeneity in gains depending on households' willingness to save and their existing wealth level. For instance, if the cost of investment declines, then households that want to save benefit from this reduction while it affects those willing to sell their capital negatively.

Interest rate Changes in trade costs have an impact on the marginal product of capital, i.e. interest rate, due to two reasons. First, the price of investment good is affected by a change in trade costs as mentioned above.

Second, trade costs affect measured total factor productivity (TFP). I consider a simple version of my model in which all the sectors in a country have the same production function and have constant returns to scale - i.e. $\zeta = 1-\beta$ - in order to explain the link between trade costs and measured TFP clearly. In this case measured TFP in country i is given by

$$TFP_{it} = \left[(P^a_{it}/\alpha)^{-\alpha} (P^n_{it}/\xi)^{-\xi} (P^m_{it}/(1-\alpha-\xi))^{\alpha+\xi-1} (1-\beta) \right]^{\frac{1-\beta}{\beta}} \tag{22}$$

where P^j_{it} for $j = a, m, n$ is the aggregate price of intermediate input j. Equation (22) implies that as intermediate inputs become cheaper, measured TFP increases. Lower trade costs make intermediate inputs cheaper as they can be imported from the other country. Therefore, measured TFP rises following a reduction in trade costs. Intuitively it increases since lower trade costs enable firms to produce more efficiently due to the smaller loss in imported intermediate inputs. As a result, marginal product of capital rises. Households that hold capital benefit from the increase in the interest rate whereas it reduces the gains of those borrowing.

Wages of college graduates and non-college workers Trade-induced changes in the relative prices of goods and services affect the wage of college graduates relative to that of non-college workers, i.e. skill premium, because the share of worker types varies across sectors in the model (Stolper-Samuelson effect). If the relative price of a good/service becomes relatively cheaper due to a change in trade costs, then the relative wage of the worker type that is employed intensively by the sector producing this good/service decreases while the relative wage of the other type increases.

Additionally, capital used in production increases following a fall in trade costs. Because capital is accumulated more due to the rise in the marginal product of capital. Since capital and skilled workers (college graduates) are complementary, the demand for skilled workers rises as well, which leads to an increase in skill premium. Equation (23) also shows that a rise in capital use leads to an increase in skill premium as $\Delta > \Lambda$ (capital-skill complementarity).

$$\frac{W^s_{it}}{W^u_{it}} = \left(\frac{1-\Gamma^j}{\Gamma^j}\right)^{1-\Delta} \left(\frac{S^j_{it}}{U^j_{it}}\right)^{1-\Delta} (\Upsilon^j)^{1-\Lambda} \left[(\Upsilon^j)^{1-\Lambda} + (1-\Upsilon^j)^{1-\Lambda} \left(\frac{K^j_{it}}{S^j_{it}}\right)^{\Lambda} \right]^{\frac{\Delta}{\Lambda}-1} \tag{23}$$

4 Calibration[14]

I use the model to quantify the distributional consequences of NAFTA for households in the U.S. and Mexico. The economy in the initial steady state is calibrated to match the U.S. data. Since NAFTA went into effect in 1994, I calibrate most of the parameters to 1995 the year that is closest to 1994 given the data available.

A period is considered to be one year. For the size of the countries, I use the share of working age population, i.e. those aged 15 to 64, in the total population. Based on the data provided by OECD for 1995, the US is approximately three times as big as Mexico. The fraction of college graduates in the US is roughly 25% while it is around 12% in Mexico according to the OECD Education at a Glance data for 1998.

Table 3: Parameters taken from the literature

Parameter	Value	Description	Source
Δ	0.4012	1/(1-Δ) is the elasticity of substitution between unskilled labor and capital	Krusell et al. (2000)
Λ	-0.49254	1/(1-Λ) is the elasticity of substitution between skilled labor and capital	Krusell et al. (2000)
δ	0.06	Depreciation rate	
Ω_a	0.73	1/(1-Ω_a) is the elasticity of substitution between domestic and imported agricultural input	Ossa (2015)
Ω_m	0.68	1/(1-Ω_m) is the elasticity of substitution between domestic and imported manufacturing input	Ossa (2015)
σ_a	0.73	1/(1-σ_a) is the elasticity of substitution between domestic and imported agricultural good	Ossa (2015)
σ_m	0.68	1/(1-σ_m) is the elasticity of substitution between domestic and imported manufacturing good	Ossa (2015)
γ	2	Risk aversion	
Earnings process parameters			Hubbard et al. (1994)
κ_c	0.955	Persistence for college graduates	
κ_n	0.946	Persistence for non-college workers	
ν_c	0.126	Standard deviation for college graduates	
ν_n	0.158	Standard deviation for non-college workers	

The parameters whose values are taken from the existing studies are shown in Table 3. Krusell et al. (2000) estimate that the elasticity of substitution between capital and skilled labor is equal to 0.67 and the substitution elasticity between unskilled labor and capital equals 1.67. According to these estimations, $\Delta = 0.401$ and $\Lambda = -0.492$. The depreciation rate for capital, δ, is set to 0.06. The elasticity of substitution between domestic and imported goods are calculated using the estimations provided by Ossa (2015). Ossa (2015) estimates the subtitution elasticities at the 3-digit level of the Standard International Trade Classification (SITC) Revision 3. I categorize these goods into two categories: agriculture and manufacturing. Then I calculate the simple average of the estimated elasticities after excluding outliers. I use the International Standard

[14] In Sections 4 and 5, I present the results for a previous version of the model in which households do not invest in equities. The results for the model with equities will be reported in the new draft that will be released soon.

Industrial Classification (ISIC) for the categorization of the goods into agriculture and manufacturing while calibrating some other parameters. Therefore, I use some concordances available to match the ISIC categories. The risk aversion parameter, γ, is set to 2, which is standar in the literature. Finally, I use the estimations provided by Hubbard et al. (1994) for the earnings process parameters. According to the estimations of Hubbard et al. (1994), the persistence parameter for those with a college degree is equal to 0.955 and it equals 0.946 for those with a high school degree. They also find that the variance for college graduates is 0.016 and the variance for high school graduates is 0.025. Thus, ν_c is set to 0.126 and ν_n is set to 0.158.

Table 4: Parameters observed in the data

Parameter	Value	Description	Data Source
Tariffs			UNCTAD - TRAINS 1991
t^a_{US}	0.054	Tariff for agricultural sector in the US	
t^m_{US}	0.047	Tariff for manufacturing sector in the US	
t^a_{MX}	0.153	Tariff for agricultural sector in Mexico	
t^m_{MX}	0.131	Tariff for manufacturing sector in Mexico	
Value added shares			WIOT 1995 - WIOD
β^a	0.3	Value added share for agricultural good	
β^m	0.35	Value added share for manufacturing good	
β^n	0.64	Value added share for non-tradable good	
Intemediate input shares			ICIO 1995 - OECD
α^a	0.46	Agricultural input share for agricultural sector	
α^m	0.012	Agricultural input share for manufacturing sector	
α^n	0.027	Agricultural input share for non-tradable sector	
ξ^a	0.38	Services share for agricultural sector	
ξ^m	0.33	Services share for manufacturing sector	
ξ^n	0.74	Services share for non-tradable sector	

The parameters which are directly observed in the data are given in Table 4. The tariffs are obtained from the United Nations Statistical Division, Trade Analysis and Information System (UNCTAD-TRAINS). In the UNCTAD-TRAINS data set, tariffs are provided at the 2-digit level of ISIC Revision 3. There are four types of tariffs in this data set: most favored nation (MFN) tariff, bound (BND) tariff, effectively applied (AHS) tariff and preferential (PRF) tariff. I use the effectively applied tariffs between the U.S. and Mexico, as they are the tariffs actually applied. I choose 1991 for the initial tariffs, because in that year, the AHS tariffs are available for both the U.S. and Mexico. I categorize the 2-digit industries into three categories: agriculture, manufacturing and services. Then I calculate the simple average of the tariffs applied in agricultural and manufacturing sectors for both the U.S. and Mexico. I find that the tariffs applied by the U.S. on Mexican goods, i.e. $t^a_{US} = 0.054$ and $t^m_{US} = 0.047$, are lower than those applied by Mexico on the goods imported from the U.S,i.e. $t^a_{MX} = 0.153$ and $t^m_{MX} = 0.131$. Additionally, the tariffs in the agricultural sectors are higher than those in the manufacturing sectors.

I calculate the value added shares using the 1995 World Input-Output Table (WIOT) of the World Input-Output Database (WIOD) (Timmer et al. (2015)) and the intermediate input shares using the OECD Inter-Country Input-Output (ICIO) Table for 1995. Both data sets use the two-digit ISIC Revision 3. After categorizing the two-digit industries into three sectors, I calculate the weighted averages of the shares. Weights are given by production in each two-digit industry. I use the following values for ζ^a and ζ^n due to computational reasons: $\zeta^a = 0.64$, $\zeta^n = 0.32$. That is, agricultural and non-tradable sectors have a decreasing returns to scale, which enables me to allocate aggregate capital and two types of labor across sectors. As for manufacturing sector, it has constant returns to scale, i.e. $\zeta^m = 1 - \beta^m$.

Table 5: Parameters calibrated to match data moments

Parameter	Description	Value
β	Discount factor	0.965
$\underline{s}$	Borrowing limit	-0.07
θ^a	Weight on domestic agricultural good	0.995
θ^m	Weight on domestic manufacturing good	0.97
χ_a^a	Weight on domestic agricultural input for agricultural sector	0.988
χ_a^m	Weight on domestic agricultural input for manufacturing sector	0.995
χ_a^n	Weight on domestic agricultural input for non-tradable sector	0.995
χ_m^a	Weight on domestic manufacturing input for agricultural sector	0.987
χ_m^m	Weight on domestic manufacturing input for manufacturing sector	0.97
χ_m^n	Weight on domestic manufacturing input for non-tradable sector	0.98
Γ^a	Weight on low skilled labor for agricultural sector	0.47
Γ^m	Weight on low skilled labor for manufacturing sector	0.44
Γ^n	Weight on unskilled labor for non-tradable sector	0.41
Υ^a	Weight on high skilled labor for agricultural sector	0.28
Υ^m	Weight on high skilled labor for manufacturing sector	0.30
Υ^n	Weight on high skilled labor for non-tradable sector	0.28
Utility function parameters		
κ_1		31.19
κ_2		125.24
λ		2.0
η		1.30
ψ		1.43

Table 5 shows the parameters which are calibrated to match some data moments. In Table 6, I compare the model and data moments. As seen in the table, the model fits the data well. I calibrate the discount factor, β, to match the average net worth over mean income income in the U.S. in 1995, which is approximately equal to 4.24. I obtain the average net worth from Current Population Reports and the mean income from Federal Reserve Economic Data (FRED). I select the borrowing limit, $\underline{s}$, to match the fraction of households with negative net worth. According to the U.S. Census Bureau's Current Population Reports, it is around 10 percent.

The weight on agricultural (manufacturing) good produced in the U.S. in the aggregate agricultural (manufacturing) consumption, which is in the CES form, θ^a (θ^m), is calibrated to match the ratio of expenditure on domestic good to expenditure on good imported from Mexico. Similarly, I select the weight on domestic agricultural (manufacturing) input in the aggregate agricultural (manufacturing) input function for sector j, χ_a^j (χ_m^j), to match expenditure on domestic input over expenditure on input imported from Mexico. I calculate these ratios by using the 1995 OECD ICIO Table. I categorize the two-digit industries into three sectors. Then I calculate the weighted average of the expenditure ratios of two-digit industries for both manufacturing and agricultural sectors. I use production in each two-digit industry as weight.

Table 6: Model vs. Data Moments

Parameter	Description of Target	Data	Model
β	Mean wealth/annual income	4.24	4.3
$\underline{s}$	Fraction of households with negative net worth	0.10	0.15
θ^a	Expenditure on imported/domestic agricultural good	0.004	0.004
θ^m	Expenditure on imported/domestic manufacturing good	0.018	0.004
χ_a^a	Expenditure on imported/domestic agricultural input for agricultural sector	0.0093	0.0093
χ_a^m	Expenditure on imported/domestic agricultural input for manufacturing sector	0.004	0.004
χ_a^n	Expenditure on imported/domestic agricultural input for non-tradable sector	0.004	0.004
χ_m^a	Expenditure on imported/domestic manufacturing input for agricultural sector	0.009	0.009
χ_m^m	Expenditure on imported/domestic manufacturing input for manufacturing sector	0.02	0.02
χ_m^n	Expenditure on imported/domestic manufacturing input for non-tradable sector	0.013	0.013
Γ^a	Low/high skilled labor compensation (agricultural sector)	2.75	2.76
Γ^m	Low/high skilled labor compensation (manufacturing sector)	2.32	2.32
Γ^n	Low/high skilled labor compensation (non-tradable sector)	2.15	2.16
Υ^a	Capital/high skilled labor compensation (agricultural sector)	3.98	2.19
Υ^m	Capital/high skilled labor compensation (manufacturing sector)	2.04	1.96
Υ^n	Capital/high skilled labor compensation (non-tradable sector)	5.06	2.19
κ_1	Manufacturing expenditure share for the 2nd decile of wealth distribution	0.19	0.19
κ_2	Agriculture expenditure share for the 2nd decile of wealth distribution	0.20	0.20
λ	Agriculture expenditure share for the 8th decile of wealth distribution	0.15	0.16
η	Manufacturing expenditure share for the 8th decile of wealth distribution	0.23	0.22
ψ	Manufacturing expenditure share for the top decile of wealth distribution	0.21	0.23

The weight on unskilled labor for sector j, Γ^j, is chosen to match the ratio of unskilled labor compensation to skilled labor compensation, whereas the weight on skilled labor, Υ^j, is calibrated to match capital compensation over skilled labor compensation. I use the WIOD Socio Economic Accounts data (Timmer et al. (2015)) to calculate these ratios for the U.S. and 1995. Unskilled labor compensation is the sum of medium-skilled and low-skilled labor compensation. The ratio in each sector is the weighted average of the ratios for two-digit industries. The weights are given by the production in each industry.

Finally, I select utility function parameters, κ_1, κ_2, λ, η, and ψ, to match the shares of agricultural and manufacturing goods in total expenditure in the 2nd, 8th and top deciles. I calculate these expenditure shares by using the CEX data.

4.1 Estimation of Iceberg Trade Costs

I estimate the iceberg trade costs for manufacturing and agricultural goods between the U.S. and Mexico by following Coşar et al. (2021). I estimate the following specification.

$$\ln Y_{ih}^{j} = \alpha_i + \alpha_h + \beta_j \ln \tau_{ih}^{j} + \epsilon_{ih} \tag{24}$$

for $j = m, a$. In that specification, i represents the destination, whereas h is the origin of the imports. Y_{ih}^{j} is the value of imports from h to i for good j and α_i and α_h are destination and origin fixed-effects, respectively. Since τ_{ih}^{j} can not be observed, I assume that it is a function of the distance between i and h. Namely, $\tau_{ih}^{j} = D_{ih}^{\rho_j}$, where D_{ih} is the distance between i and h and ρ_j is the trade cost elasticity of distance for good j. As for β_j, it is the elasticity of trade to trade costs. In my model, $\beta_j = \sigma_j/(\sigma_j - 1)$ Hence, Equation (24) can be written in the following form.

$$\ln Y_{ih}^{j} = \alpha_i + \alpha_h + \frac{\sigma_j}{\sigma_j - 1}\rho_j \ln D_{ih}^{j} + \epsilon_{ih} \tag{25}$$

Equation (25) shows that σ_j and ρ_j can not be estimated separately. Therefore, after estimating this equation, I calculate ρ_j by using the value of σ_j given in Table 3. estimate Equation (25) using the The Freight Analysis Framework (FAF) data. This dataset includes the trade flows between the U.S. states.

Table 7: Estimation of Iceberg Trade Costs

	Agricultural	Manufacturing
$\ln D_{ih}$	-1.299***	-0.861***
	(0.0340)	(0.0181)
Observations	19057	71690
Adjusted R^2	0.175	0.121

Standard errors in parentheses

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

The estimation results are given in Table 7. For agricultural goods, $\rho_a\sigma_a/(\sigma_a - 1) =$

-1.299. Since $\sigma_a = 0.73$, $\rho_a = 0.48$. For manufacturing goods, $\rho_m \sigma_m/(\sigma_m - 1) = -1.861$ and $\sigma_m = 0.68$. Thus, $\rho_m = 0.405$.

In the next step, I calculate $D_{MX,US}^{\rho^j}$, where $D_{MX,US}$ is the distance between Mexico and the U.S. Since, this value is very large, I normalize it to find the iceberg trade cost. For the normalization, I, first, calculate the internal distance for both Mexico and the U.S. by following Mayer and Zignago (2006). The internal distance of country i is given by

$$D_i = 0.67\sqrt{\text{area}_i/\pi} \tag{26}$$

I find that $D_{MX} = 329.89$ and $D_{US} = 735.24$. I assume that iceberg trade costs equal 1 within a country, i.e. $\tau_{ii}^j = 1$. Then I calculate iceberg trade costs between two countries relative to domestic trade costs, i.e. $\tau_{ih}^j = (D_{ih}/D_i)^{\rho_j}$. The results are given in Table 8.

Table 8: Estimated Iceberg Trade Costs

Parameter	Description	Value
$\tau_{MX,US}^a$	Iceberg cost from US to Mexico for agricultural good	1.71
$\tau_{US,MX}^a$	Iceberg cost from Mexico to US for agricultural good	1.17
$\tau_{MX,US}^m$	Iceberg cost from US to Mexico for manufacturing good	1.57
$\tau_{US,MX}^m$	Iceberg cost from Mexico to US for manufacturing good	1.14

5 The Welfare Effect of NAFTA

In this section, I investigate the welfare consequences of the elimination of the import tariffs between the US and Mexico under NAFTA. Table 9 shows the import tariffs before NAFTA. t_{MX}^j represents the import tariffs for good j produced in the US. Similarly, t_{US}^j is the tariff which the U.S. imposes on good j imported from Mexico.

Table 9: Tariffs before NAFTA

	U.S.	Mexico
Agriculture	0.054	0.153
Manufacturing	0.047	0.131

The tariffs reached their lower levels in ten years after NAFTA went into effect in 1994. Some of them dropped immediately, whereas some of them declined either several years later or gradually. In the first quantitative exercise, the tariffs are eliminated immediately in both countries at $t = 1$, while iceberg trade costs remain the same as before NAFTA. Hence, the results of this exercise show the effect of an unanticipated permanent reduction in tariffs on households.

I also compare the effect of an anticipated permanent elimination of tariffs with that of the unanticipated elimination mentioned above. In the second quantitative exercise, I compute the transition dynamics and the gains following an anticipated permanent elimination of tariffs at $t = 10$ to do so. I assume that households in both countries know the future path of the tariffs once the agreement is signed.

5.1 The Implications of an Unanticipated Permanent Elimination of Tariffs

5.1.1 Transition Dynamics

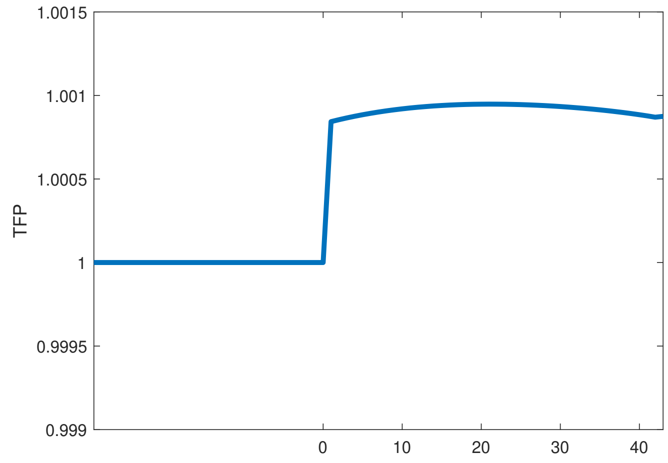
As seen in Table 9, the tariffs for the Mexican goods imported to the U.S. were low even before NAFTA. Only Mexico experienced significant reductions in the tariffs. Therefore, in this section, I will discuss the results by focusing on Mexico. The transition dynamics for the U.S. can be found in appendix C.

I compute the steady state for high and low (zero) tariffs separately and the transition path from high tariffs to low tariffs. There are some differences between the transition paths across countries. These differences result from different changes in the tariffs, the heterogeneity in factor abundance across countries and the variation in the shares of the factors in production across sectors. In this section, my goal is to explain the mechanisms which lead to a variation in households' gains within countries rather than the differences between countries.

The elimination of tariffs led to an increase in measured total factor productivity (TFP) once they went down at $t = 1$ as seen in Figure 4. As tariffs decline, intermediate inputs become cheaper since they can be imported from the other country. Therefore, measured TFP rises following a reduction in tariffs. Intuitively it increases, because lower tariffs enable firms to produce more efficiently due to the smaller loss in imported intermediate inputs during transportation.

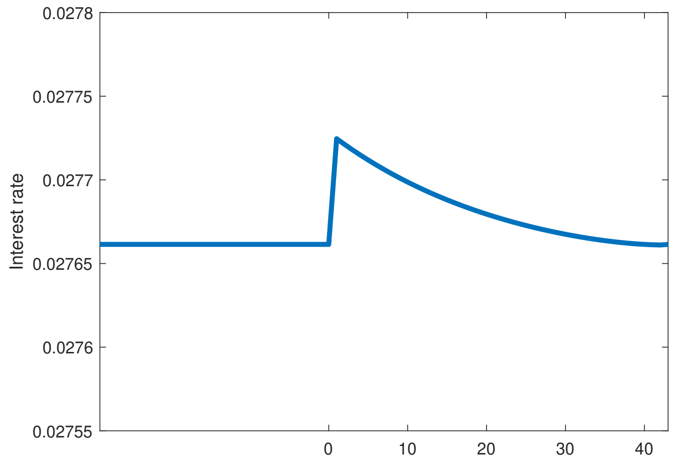
Figure 5 shows that lower tariffs increase the world interest rate. The interest rate is the same for both countries, because bonds are sold in international markets and capital can flow between countries. Changes in tariffs have an impact on the marginal product of capital and so on interest rate due to two reasons. First, the price of the investment good, which is produced by the manufacturing sector, declines following a reduction in tariffs. Second, the rise in the measured TFP increases the marginal product of capital. Since the interest rate is higher and the cost of investment is lower, capital is accumulated over time (see Figure 6). As capital is accumulated, the interest rate declines. Its value in the new steady state is slightly smaller compared to the initial steady state.

Figure 4: Transition path for the measured total factor productivity, Mexico



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

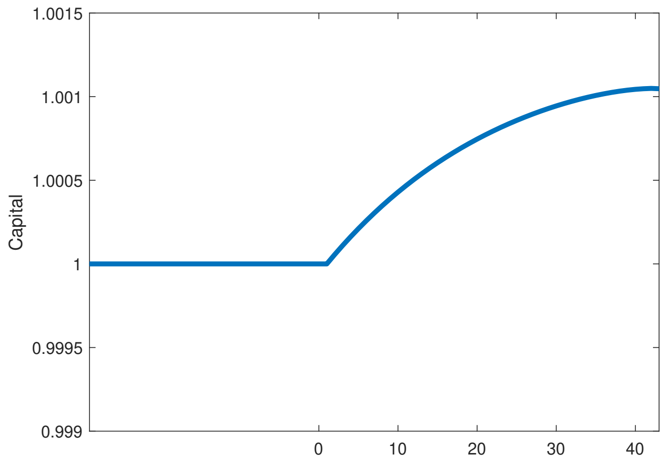
Figure 5: Transition path for the interest rate



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1.

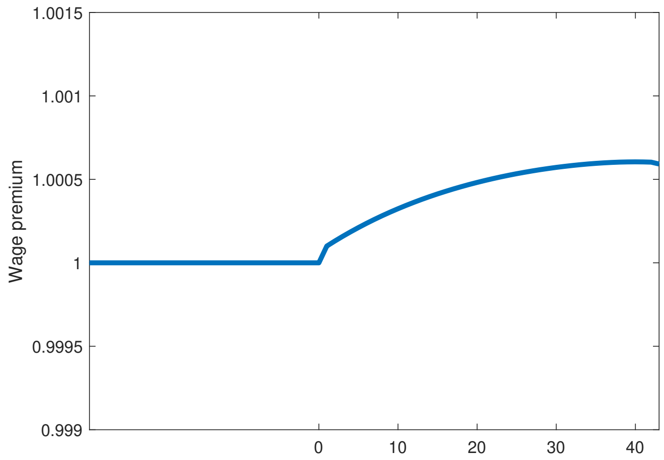
As seen in Figure 7, lower trade tariffs increase the wage premium. Trade-induced changes in the relative prices of goods and services (see Figure 8 and Figure 9) affect the wage of college graduates relative to that of non-college workers, i.e. wage (skill) premium, because the share of worker types varies across sectors in the model (Stolper-Samuelson effect). In addition, the wage premium goes up, because capital used in production increases. Since capital and skilled workers (college graduates) are complementary, the demand for skilled workers rises as well, which leads to a rise in the skill premium.

Figure 6: Transition path for capital



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1. This figure shows the path for total capital accumulated by two countries.

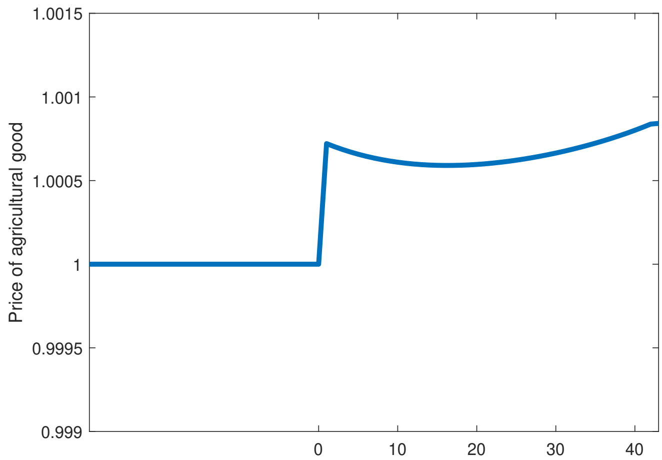
Figure 7: Transition path for wage premium, Mexico



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

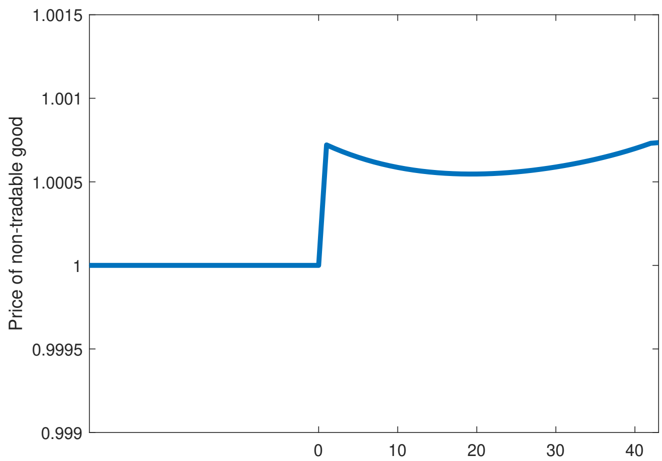
The marginal cost of production in a sector equals the price of the good/service produced by this sector in the model. Since the marginal cost is a function of input prices, there is a link between input and good prices. Moreover, each sector uses inputs produced by the other sectors and inputs imported from the other country. Thus the price of a good depends on the prices of intermediate inputs produced by the other country and those produced by the other sectors. Trade-induced changes in relative prices also depend on the income elasticities of goods and services as these elasticities determine how the demand for a good/service by households is affected following a change in its price. To summarize changes in trade costs affect the relative prices of consumption goods and services depending on the following factors: the share of imported inputs, the share of capital, labor and domestic inputs and income elasticities.

Figure 8: Transition path for the price of agricultural good, Mexico



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

Figure 9: Transition path for the price of services, Mexico

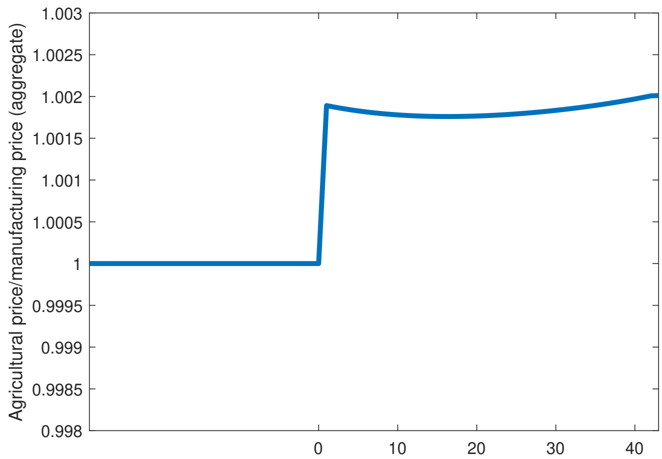


Notes: Transition path following an unanticipated and permanent elimination of tariffs tariffs in period 1. Initial steady state is normalized to 1.

Figure 8 and Figure 9 show that the agricultural good and services become more expensive than the manufacturing good after the elimination of tariffs. The agricultural sector uses agricultural good, which becomes relatively more expensive, more intensively.

Similarly, the non-tradable sector uses more intensively non-tradable good whose price becomes more expensive relative to the manufacturing good. The increase in the price of non-tradable goods can be also explained by the fact that households become wealthier following a reduction in trade costs. Since they become wealthier, their consumption increases and the demand for non-tradables rises due to the nonhomothetic preferences.

Figure 10: Transition path for the price of aggregate agricultural good, Mexico



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

Figure 10 indicates that the aggregate agricultural good becomes more expensive compared with the aggregate manufacturing good. The effect of tariffs on aggregate prices depends on the trade elasticities of goods which is given by the elasticity of substitution between domestic and imported varieties of these goods. Since the trade elasticity for the agricultural good is relatively higher, its price is not affected so much by a change in the trade costs. On the other hand lower tariffs make the manufacturing goods cheaper.

5.1.2 Gains From Trade

I measure the welfare gains as the percentage increase in the aggregate consumption good that a household in the initial steady state would have to receive in order to be indifferent between remaining in the high tariffs and shifting to the case with low tariffs (consumption-equivalent variation). Let $(c^n_{it})^{HI}$, $(c^m_{it})^{HI}$ and $(c^a_{it})^{HI}$ denote consumption of non-tradable, manufacturing and agricultural goods in country i under steady state for high tariffs. $(c^n_{it})^L$, $(c^m_{it})^L$ and $(c^a_{it})^L$ represent consumption of non-tradable, manufacturing and agricultural goods when tariffs decrease in period 10, starting from the steady state for high tariffs. For each household k identified by initial states (ε, s, e), where ε is productivity, s is wealth and e is the level of education, ω_k is the welfare gain from trade liberalization and it solves the following equation:

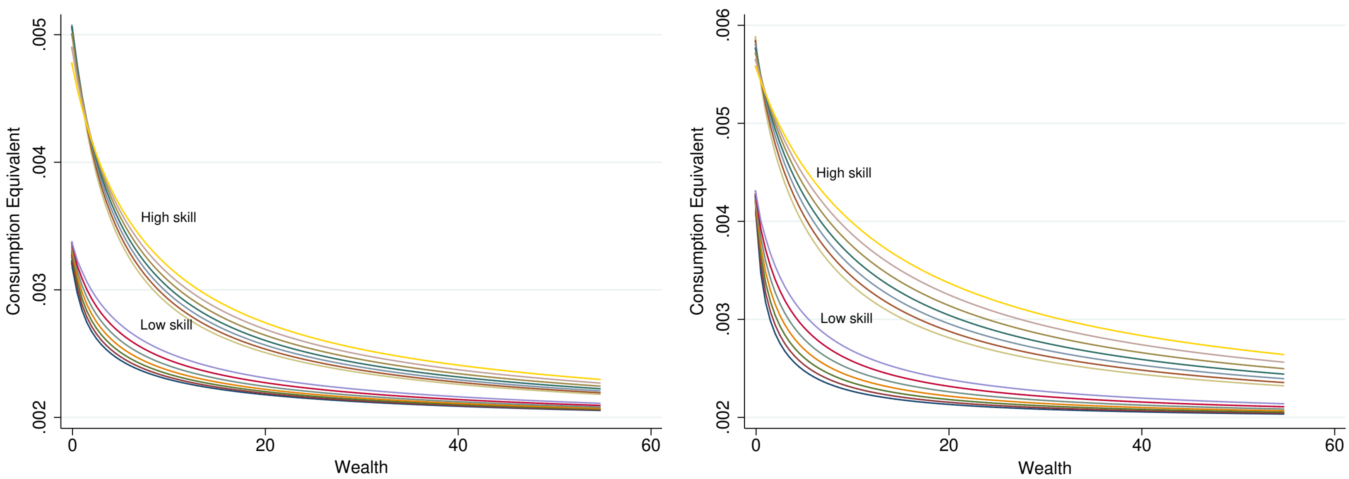
$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{1}{1-\gamma} \left[c_{it}^{HI} (1+\omega_k) \right]^{1-\gamma} = E_0 \sum_{t=0}^{\infty} \beta^t u((c_{it}^n)^L, (c_{it}^m)^L, (c_{it}^a)^L) \tag{27}$$

where

$$c_{it}^{HI} = \left[(c_{it}^{a,HI})^{1-\lambda} + \kappa_1 \frac{1-\lambda}{1-\eta} (c_{it}^{m,HI})^{1-\eta} + \kappa_2 \frac{1-\lambda}{1-\psi} (c_{it}^{n,HI})^{1-\psi} \right]^{\frac{1}{1-\lambda}} \tag{28}$$

Figure 11: Welfare gains from NAFTA

(a) US (b) Mexico



I calculate the welfare gains for both high and low skilled workers with different wealth and income levels. Figure 11 how gains vary with wealth for high-skilled and low-skilled workers. Different lines drawn for each skill level indicate the gains of households with different productivities (ε). As seen in Figure 11, the poor benefit more from NAFTA compared with the rich in both countries. Also, lower tariffs relatively favor high-skilled workers at each wealth level in both the U.S. and Mexico. However, poor low-skilled workers gain more than rich high-skilled workers.

There are three channels which explain the gap between the gains of households. The first one is the expenditure channel. Rich households are affected negatively by the reduction in trade costs due to the rise in the relative price of services while the lower price of manufacturing goods relatively favors them. As for the poor, their expenditures are affected negatively by the increase in the price of agricultural good. The increase in the relative price of services explains why the rich gain less than the poor. This result shows the importance of the expenditure channel in determining gains.

The second channel is the intertemporal channel. Households that are willing to save, i.e. those with high productivity and wealth, benefit from the reduction in the relative price of investment. However this leads to a reduction in the gains of households who are willing to sell their savings. According to Figure 11, at almost each wealth level gains rise as productivity increases, which shows the effect of intertemporal channel. As productivity increases, households' willingness to save rises too because of the probability of facing a low income shock in the future. Therefore, those with higher productivity benefit from the lower cost of investment in capital.

Finally, factor prices channel plays a role in determining households' gains. Higher interest rate relatively favors savers. In addition, high-skilled workers gain more than low-skilled workers since wage premium increases following the reduction in trade costs. In Figure 11, we also see that the gap between the gains of two skill levels becomes smaller as wealth increases. This result can be explained with wages. Since the share of wage in income is larger for the poor compared with the rich, the poor benefit more from the trade-induced increase in wages. The higher gains of the poor relative to the gains of the rich can be also explained with this greater importance of wages for the poor.

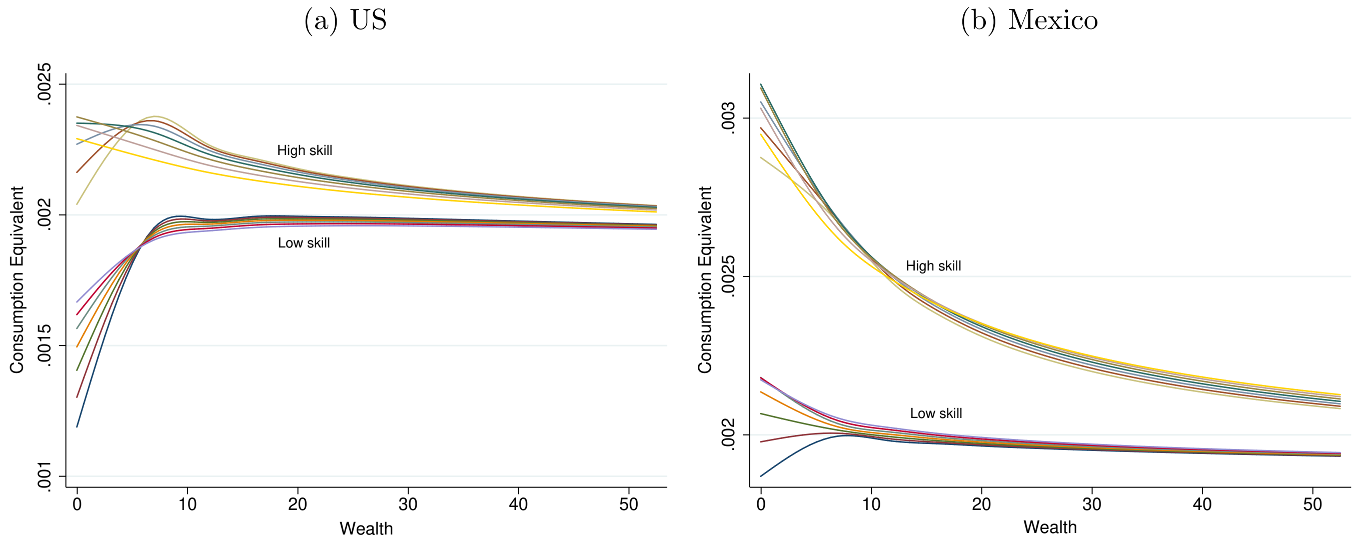
5.2 The Implications of an Anticipated Permanent Elimination of Tariffs

The anticipated elimination of tariffs produces different results for both the transition dynamics and the welfare gains. First, the transition path becomes longer compared to the unanticipated fall. In addition, the path which the variables follow until the shock hits and their initial reaction to the shock in this case differ from the initial effect of the unanticipated fall on the variables (See Figure D.1-D.6). These differences between two cases has an impact on welfare gains.

As seen in Figure 12, almost at all productivity levels the poor benefit more from NAFTA compared with the rich in Mexico. In the U.S., while the rich low skilled gain relatively more than the poor low skilled, the poor benefit more than the rich except very low levels of wealth within high skilled workers. Also, the anticipated reduction yields much lower gains, especially for the poor in both countries relative to the unanticipated fall.

Why do poor households gain less than rich households within low skill group in the U.S.? In the case of the anticipated fall, the capital in the economy falls until the shock hits. (See Figure D.2). The interest rate rises during this period because of the reduction in the capital (See Figure D.2). We can say that this higher increase in the interest rate harms the poor in the U.S. Additionally, when the fall is anticipated, the increase in the relative price of the agricultural good is bigger than the unanticipated fall (See Figure D.4 and Figure D.6). The poor are affected negatively by this more expensive agricultural good as well.

Figure 12: Welfare gains from an anticipated, permanent elimination of tariffs



6 Conclusion

This paper studies how welfare gains from eliminating import tariffs are distributed across heterogeneous households within a country. The quantitative framework I construct can be used to analyze the distributional consequences of changes not only in tariffs but also in other types of trade costs, such as iceberg trade costs. I build a two-country, multi-sector dynamic model of trade with households that are heterogeneous in their levels of wealth, income, and education. The model enables me to make two important contributions to the literature. First, it considers the impact of households' intertemporal consumption-saving decisions on the distribution of gains from trade. It introduces heterogeneity in wealth as well as income and education levels in order to capture that effect. Second, it shows that we cannot accurately assess the welfare effect of changing trade costs on different education levels without taking into account heterogeneity in wealth. This is because it indicates that households' nonhomothetic preferences and intertemporal consumption-saving decisions, which can be captured only by introducing wealth heterogeneity, cause gains to be distributed unequally within each education level. Also, most of the existing studies assume that any gap between the gains at different education levels is constant. However, my model shows that this gap is not independent of households' income and wealth levels and, the welfare gain of each household is jointly determined by their wealth and education level.

I use the theoretical framework I construct to quantify households' welfare gains from NAFTA in the U.S. and Mexico. After calibrating the model to those countries and computing the initial steady state, I eliminate import tariffs that were imposed before NAFTA and compute the steady state with no tariffs and the transition dynamics between the two steady states. I consider two cases: (i) an unanticipated permanent elimination and (ii) an anticipated permanent elimination of tariffs.

The results suggest that in both countries, high-skilled workers (college graduates) gain more from an unanticipated permanent elimination of tariffs compared with low-skilled (non-college) workers at the same wealth level. However, the gains of poor low-skilled workers exceed those of rich high-skilled workers. In addition, the gap between the gains of college graduates and those of non-college workers falls as wealth increases. I also find that eliminating tariffs relatively favors the poor within each skill group.

The results demonstrate the importance of considering heterogeneity in wealth and income, the expenditure channel, and the intertemporal consumption-saving decisions of households while measuring gains from trade. The interaction between the mechanisms generated by heterogeneity in wealth, income, and skill determines how gains are distributed. The existing studies show that high-skilled workers benefit more from trade compared to low-skilled workers and all the workers within each skill group experience the same level of gains. In this paper, first, we see that a low-skilled worker can benefit relatively more from trade depending on their wealth level. In addition, welfare gains from trade significantly vary with wealth within skill groups. The results also imply that the earnings channel has little importance for the distribution of gains at high levels of wealth.

Finally, I show that an anticipated permanent elimination of tariffs results in lower gains compared with an unanticipated fall, especially for the poor. This result implies that a shorter transition path is better for all households. All findings indicate that it is crucial to take into account transition dynamics. When we compare only steady states or focus on the immediate effect of trade costs, we cannot see how gains vary with wealth and the difference between the anticipated case and the unanticipated case.

My model can be extended to incorporate endogenous education decision, which allows the supply of high-skilled and low-skilled workers to change over time. As stated above, the elimination of tariffs results in an increase in the wage premium. A higher wage premium can affect households' education decisions, since it raises the value of going to college. Thus, labor supply changes over time and a changing supply of high-skilled and low-skilled workers determines how the wage premium evolves over the transition.

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A Solution Algorithm

The main steps that I follow to solve the model:

1. First, I compute the initial steady state with high trade costs. I define the main steps required below.
   (a) I provide initial guesses for the prices of agricultural, manufacturing and non-tradable goods of both countries. (b) Given prices, I solve the dynamic program of households. (c) I compute the stationary distribution of households over their state variables, ε, s and e, by using households' policy functions for savings. (d) I compute aggregate capital and labor, and then allocation of capital, labor and intermediate inputs across sectors by solving social planner's problem. (e) I compute the aggregate agricultural, manufacturing and non-tradable good production, consumption by households and intermediate input use by firms. (f) I use the Powell's hybrid method to compute the prices which clear markets.

2. An unanticipated, permanent reduction in trade costs for both agricultural and manufacturing goods occurs (counterfactual). After this reduction, since firms' intermediate input prices are affected, prices change.

3. Before the transition, I compute the steady state with lower trade costs by following the steps as in (1).

4. To compute the transition path (a) I guess a length of transition path, T. (b) I guess a path of prices for goods. (c) Starting from the last period T, given the sequence of prices, households' problem is solved at each period (from T to 0) and households' decision rules for consumption of each good and savings are computed.(d) I go back to time 0 and update the initial distribution of households at time 0 by using households' decision rules. Namely, I compute households' distribution over their state variables from 0 to T. (f) While computing households' distributions in each period as defined in the previous step, I also compute the aggregate capital, labor and the allocation of capital, labor and intermediate inputs across sectors. By using aggregate consumption, intermediate input use and production, market clearing prices for all the sectors are computed. (g) After obtaining market clearing prices, these prices are compared with the sequence of prices taken as given at the beginning. If they don't converge, sequence of prices taken as given is updated and these steps are repeated until market clearing prices converge to guesses.

B Categorization of Expenditure Items

Table B.1: The items in each sector, US

Agricultural Sector	**Manufacturing Sector**	**Non-tradable Sector**
Food at home	Major appliances	Food away from home
Alcoholic beverages at home	Household textiles	Alcoholic beverages away from home
Tobacco products	Apparel products	Life and other personal insurance
	Vehicles	Rent (dwelling)
	Fuel oil	Lodging on out-of-town trips
	Bottled gas	Housing while attending school
	Gasoline and motor oil	Ground rent
	Coal, wood, and other fuels	Homeowners insurance
	Phone cards	Maintenance and repair services (dwelling)
	Maintenance and repair commodities (housing)	Property management and security
	Furniture	Electricity
	Audio and visual equipment	Natural gas
	Floor coverings	Telephone services
	Miscellaneous household equipment	Water and other public services
	Housewares	Audio and visual services
	Small appliances	Flooring installation, repair, replacement (dwelling)
	Miscellaneous supplies and equipment	Personal services (babysitting, care for elderly etc.)
	Termite/pest control products	Housekeeping services

Agricultural Sector	Manufacturing Sector	Non-tradable Sector
	Maintenance products for vehicles	Gardening, lawn care service
	Drugs	Water softening service
	Medical supplies	Moving, storage, freight
	Reading (newspapers, books etc.)	Household laundry and dry cleaning
	Unmotored recreational vehicles	Appliance repair, including service center
	Motorized recreational vehicles	Reupholstering, furniture repair
	Toys, hobbies, and playground equipment	Other home services
	Sports, recreation and exercise equipment	Repairs/rentals of lawn and garden equipment, hand or power tools, other household equipment
	Photographic equipment and supplies	Rental of furniture
	Pet supplies and medicine	Appliance rental
	Personal care products	Rental of office equipment
	School books, supplies and equipment	Services for termite/pest control
		Home security system service fee
		Tenant's insurance
		Apparel services
		Vehicle rental, leases, licenses, and other charges
		Maintenance and repairs (vehicles)
		Vehicle finance charges
		Entertainment services
		Public and other transportation
		Medical services

Agricultural Sector	Manufacturing Sector	Non-tradable Sector
		Rental of medical equipment
		Health insurance
		Fees and admissions (entertainment)
		Pet and vet services
		Personal care services
		Education
		Repair of computer systems
		Internet services
		Installation of computer
		Miscellaneous (membership fees, bank service charges, funeral expenses etc.)

Notes: The table shows how I categorize the expenditure items in the Consumer Expenditure Surveys (CEX) published by The Bureau of Labor Statistics (BLS).

Table B.2: The items in each sector, Mexico

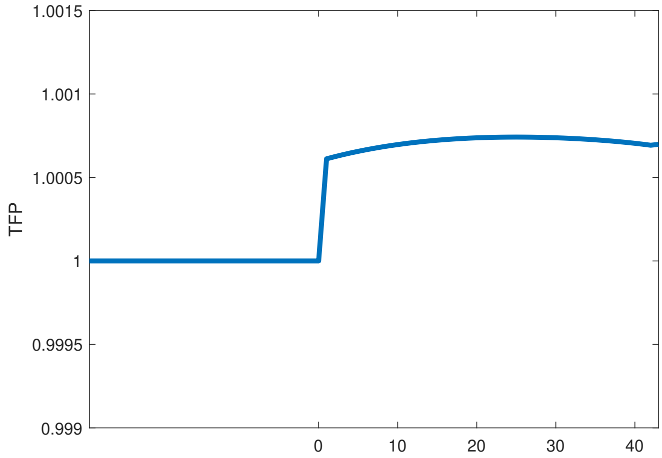
Agricultural Sector	Manufacturing Sector	Non-tradable Sector
Food at home	Home care and cleaning products	Food away from home
Alcoholic and non-alcoholic beverages	Personal care products	Transportation
Tobacco products	School books, materials and equipment	Home care and cleaning services
	Encyclopedia, books, newspapers, magazines etc.	Repair and maintenance of personal care products
	Cell phones and equipment	Personal care services
	Gasoline, diesel, oil, lubricant, carbon, firewood, liquefied petroleum gas, other fuels	Education
	Apparel, footwear and accessories	Recreation services
	Products for maintenance and repair of footwear	Repair and maintenance of school equipment
	Glassware, linens, dishware, household utensils, mattresses, household textile, haberdashery etc.	Communication services
	Drugs, alternative medicine and materials for healing	Maintenance and services for vehicles
	Orthopedic and therapeutic appliances	Housing services
	Household appliances and appliances for home maintenance	Electricity
	Furniture	Natural gas
	Materials for repair, maintenance, remodeling and extension of dwelling	Water services
	Audio and visual equipment	Internet services
	Photography and video equipment	Television services
	Other recreational equipment	Alarms for house
	Vehicles	Maintenance and repair of footwear and accessories

Agricultural Sector	Manufacturing Sector	Non-tradable Sector
	Spare parts and accessories for vehicles	Repair and maintenance of glassware, linens, dishware, household utensils
		Healthcare and medical services
		Alternative medicine services
		Repair and maintenance of orthopedic appliances
		Health insurance
		Repair and maintenance of household appliances
		Maintenance, repair, remodeling and extension of dwelling
		Rental, repair and maintenance of audio and visual equipment
		Repair and maintenance of photography and video equipment
		Repair and maintenance of other recreational equipment
		Maintenance of vehicles
		Miscellaneous (car insurance, lodging, funeral expenses etc.)
		Public sector services: issuance of passport etc.
		Procedures for vehicles: plates, licenses etc.

Notes: The table shows how I categorize the expenditure items in the National Survey of Household Income and Expenditure (ENIGH) published by National Institute of Statistics and Geography (INEGI).

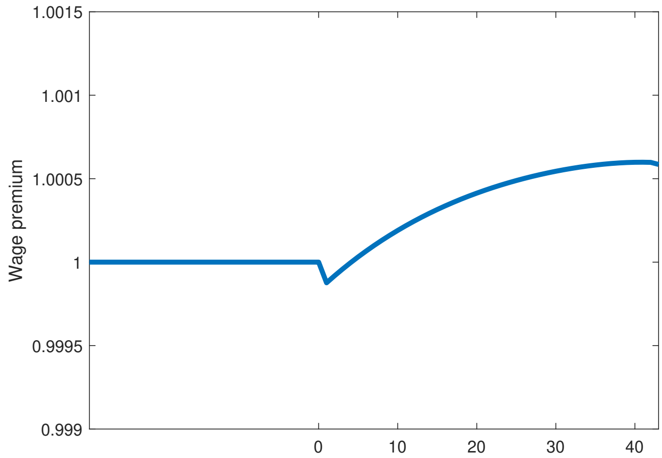
C Transition Dynamics for the U.S.

Figure C.1: Transition path for measured TFP, US



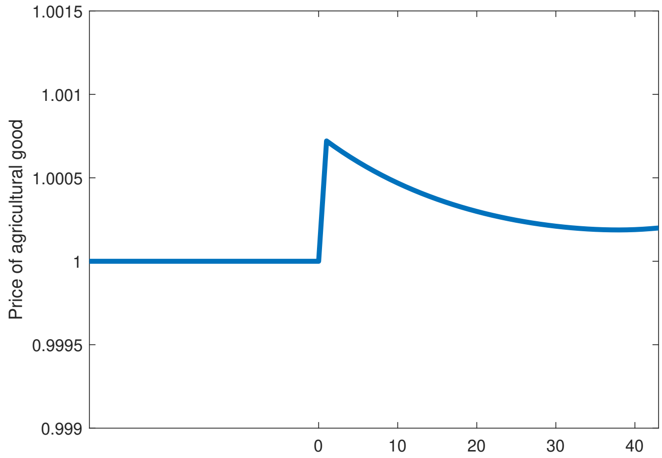
Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

Figure C.2: Transition path for wage premium, US



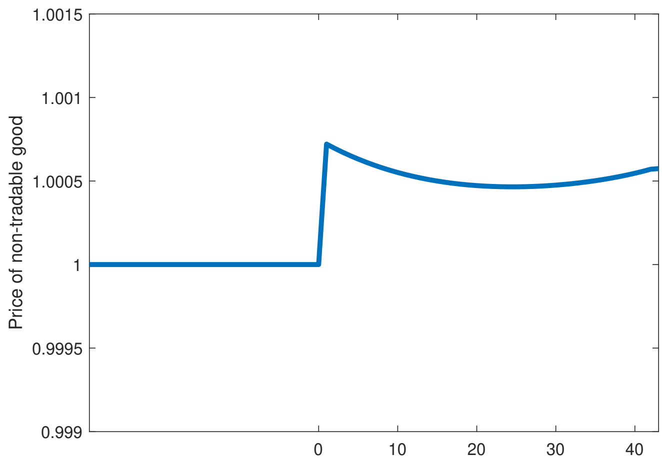
Notes: Transition path following an unanticipated and permanent elimination of tariffs in period . Initial steady state is normalized to 1.

Figure C.3: Transition path for the price of agricultural good, US



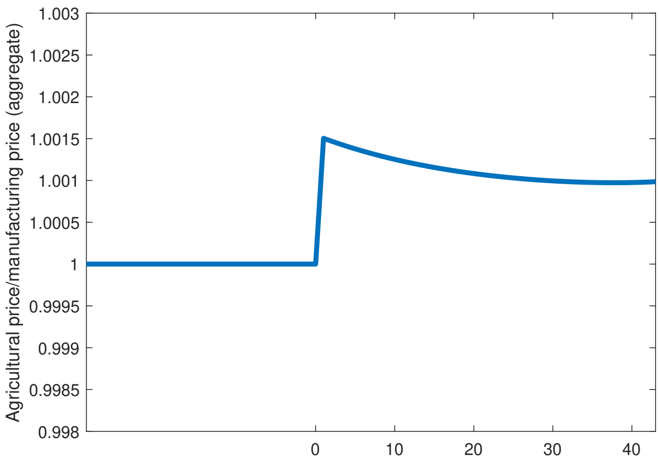
Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

Figure C.4: Transition path for the price of services, US



Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. Initial steady state is normalized to 1.

Figure C.5: Transition path for the price of aggregate agricultural good, US

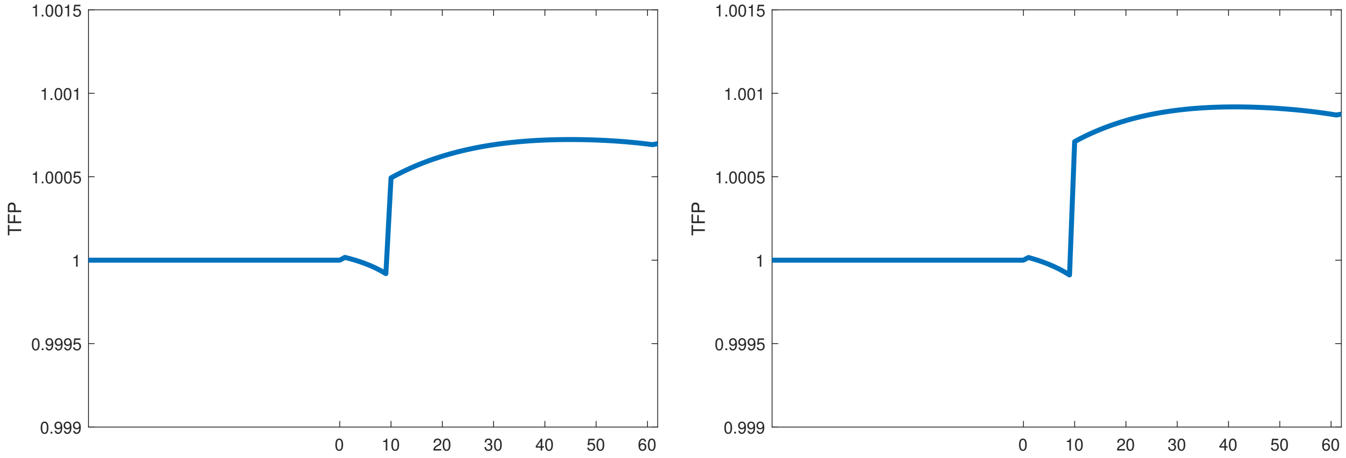


Notes: Transition path following an unanticipated and permanent elimination of tariffs in period 1. The graph shows the path for the ratio of the aggregate price of agricultural good to that of manufacturing good. Initial steady state is normalized to 1.

D Transition Dynamics for an Anticipated Permanent Elimination of Tariffs

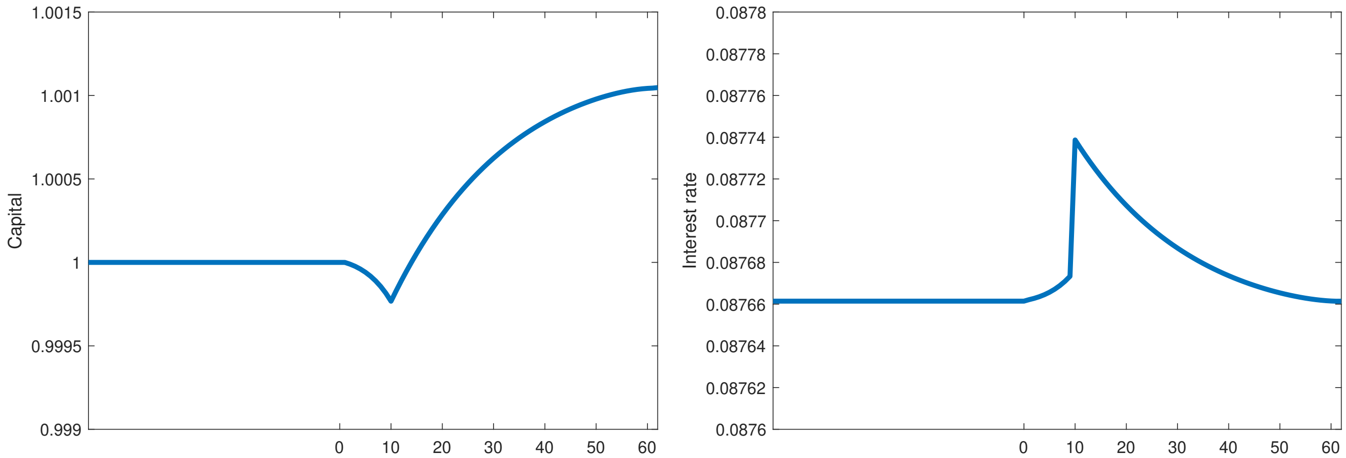
Figure D.1: Transition path for measured TFP

(a) US (b) Mexico



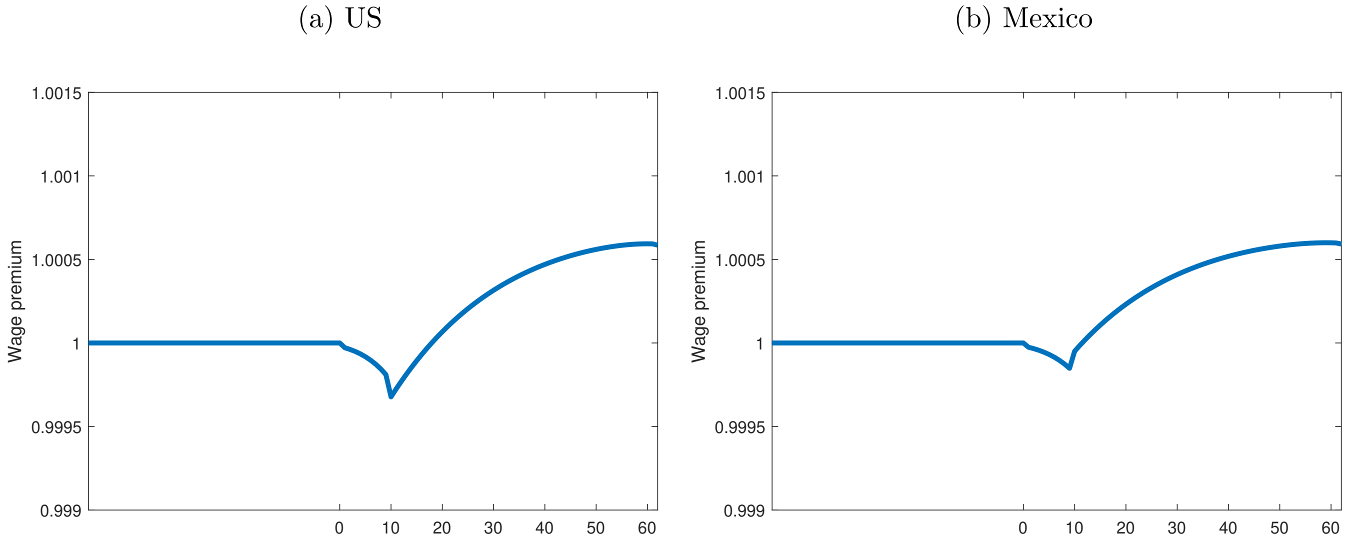
Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1.

Figure D.2: Transition path for capital and interest rate



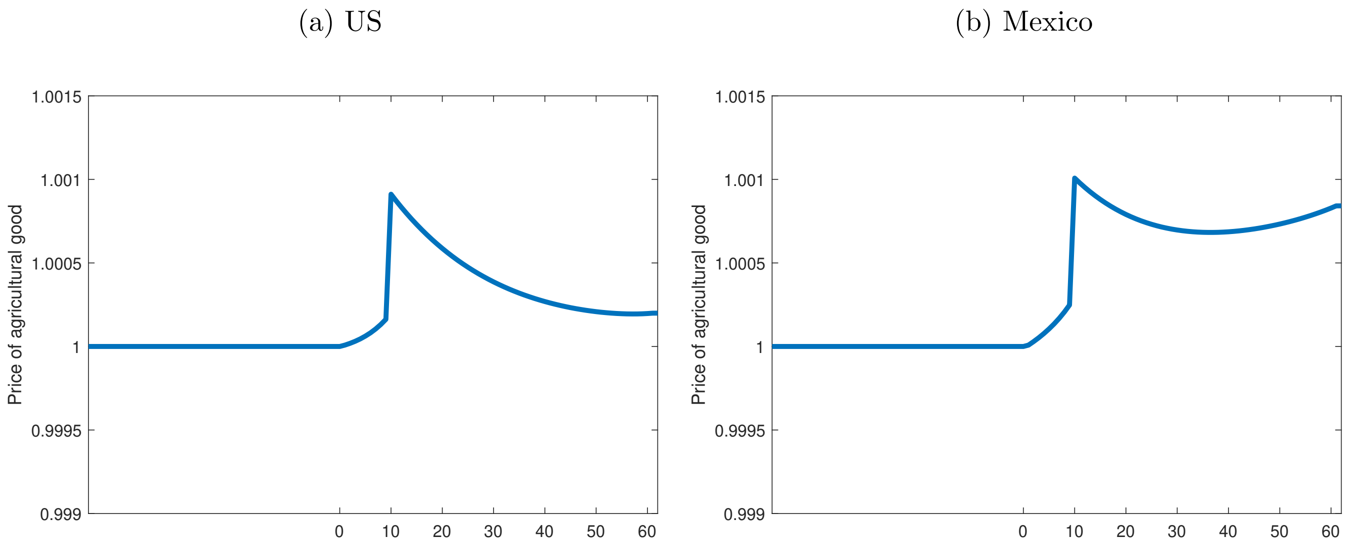
Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1 for capital.

Figure D.3: Transition path for wage premium



Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1.

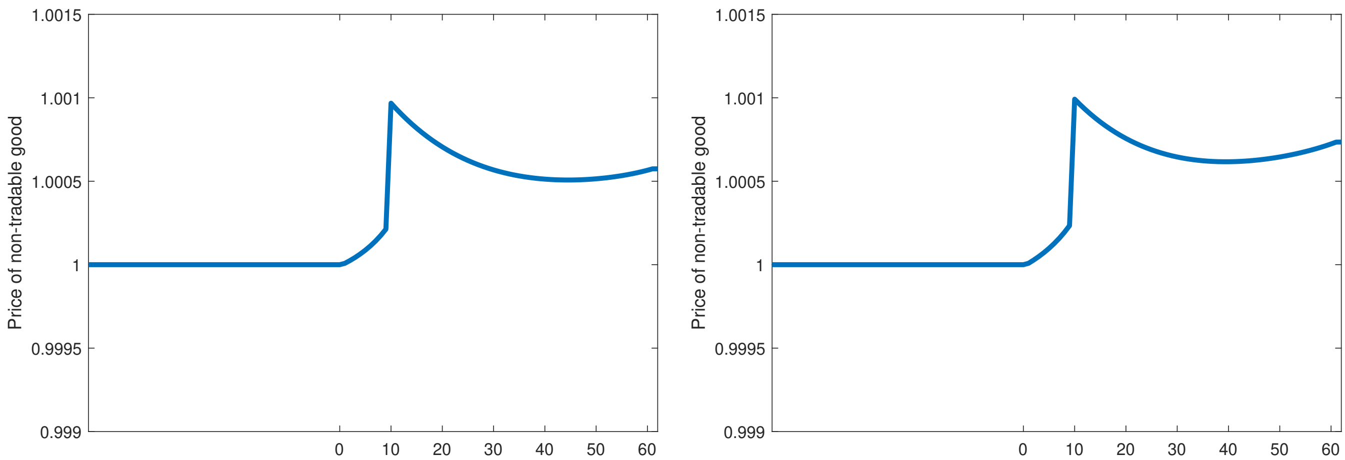
Figure D.4: Transition path for the price of agricultural good



Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1.

Figure D.5: Transition path for the price of services

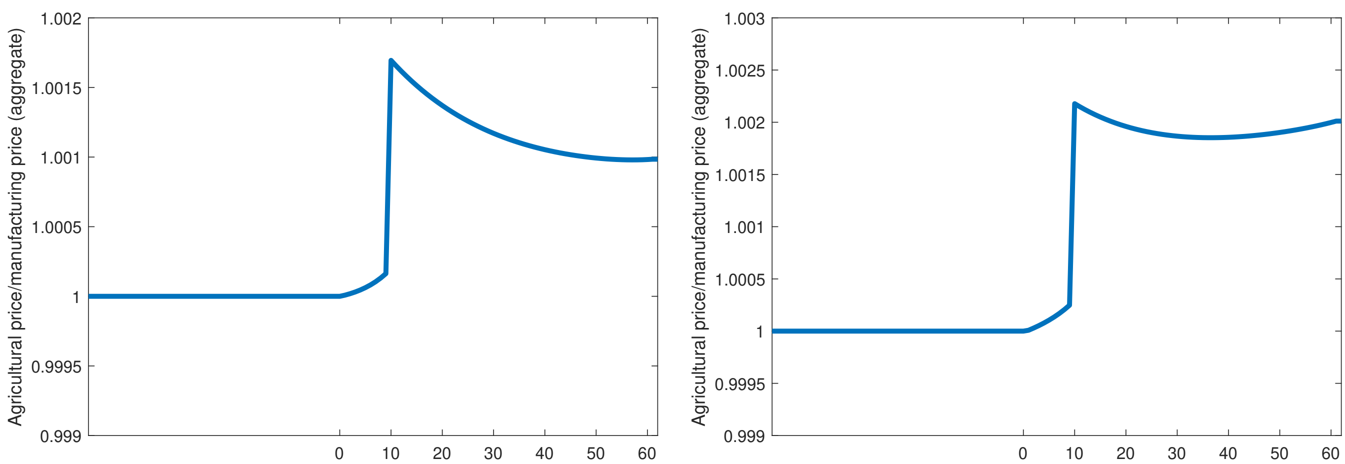
(a) US (b) Mexico



Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1.

Figure D.6: Transition path for the price of aggregate agricultural good

(a) US (b) Mexico



Notes: Transition path following an anticipated and permanent elimination of tariffs in period 10. Initial steady state is normalized to 1.