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TOMATOES OR TOMATO PICKERS? FREE TRADE AND MIGRATION BETWEEN MEXICO AND THE UNITED STATES

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This paper examines the relationship between trade liberalisation and migration in the case of Mexico. The increasing bilateral trade between Mexico and the United States after signing the North American Free Trade Agreement (NAFTA) was supposed to stem the illegal Mexican migration flow by contributing to economic growth and job creation in both countries. Twelve years after the treaty has come into effect, questions emerge about the extent to which NAFTA was able to reduce the migration pressure: are trade and migration substitutes like the policy-makers had assumed or are they complements? Using monthly data from 1968 until 2004, we estimate a distributed lag model with the number of apprehensions at the US-Mexican border as a proxy for illegal migration. The results indicate that increasing trade flows cause larger illegal migration from Mexico to the United States.

JEL classification codes: C22; F00; F10; F22.
Key words: migration; international trade; distributed lag model; Mexico; NAFTA.

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I. Introduction

A reason for the United States to sign the North American Free Trade Agreement (NAFTA) in 1992 with Mexico and Canada was to reduce the illegal Mexican migration flow. This flow had increased steadily in the past decades in spite of restrictive US-immigration policies. Since the early 1980s, the number of illegal entries per year estimated by the United States Department of Homeland Security (2006) exceeded 1,000,000 individuals; in 1983 the number of illegal migrants apprehended by the US Border Patrol was 1,172,000 individuals; in 1993 it was 1,230,124; and in 2004 it slightly decreased to 1,085,006. Part of US public opinion was concerned about this development, as they believed that such influxes of Mexican workers could cause social and economic problems in the country. Even though the controversial problem of the illegal migration in the United States dominated the public discussion and the political rhetoric concerning NAFTA, this topic was not covered during the NAFTA-negotiations and no provision in the final version of the agreement deals with it.[1] Questions emerge about to what extent NAFTA is able to solve the migration problem and whether trade within a common free trade zone could help reducing the migration pressure from Mexico.

The theoretical and empirical analysis in this article makes a contribution in helping to understand the link between trade and migration in Mexico. To our knowledge, this is the first paper which investigates the effect of trade on migration in the US-Mexican case that uses time series data for such a long period (from 1968 to 2004).

According to the theory of regional integration, increasing trade can contribute to economic growth and job creation in the involved countries (Markusen and Zahniser 1999). By this means, the migrants from Mexico would not have an economic incentive to illegally cross the border to the USA looking for a job, but they would stay in their home country instead.[2] The US and the Mexican governments proceeded on this assumption of a substitution type relationship between trade and

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[1] There are just some rules about the entry of business and high qualified people in the country (CCH 1994).

[2] Based on micro-economic and sociological migration theories, the different motives to migrate are related to factors such as income, employment, relative deprivation, family and wider social networks, dissatisfaction with the place of living, social security provisions etc. According to Lee (1966) these different influence factors can be classified within a "push-pull" model. The International Organisation for Migration (1999) distinguishes five "pull" and two "push" main factors in motivation. The pull factors are: better living conditions and wages, other people's experience with migration, good employment prospects and more individual freedom. The push factors are: ethnic problems and economic conditions

migration when they decided to negotiate NAFTA. During the signing of NAFTA side agreements in September 1993 in the White House, former US President Bill Clinton declared: "[NAFTA] means an even more rapid closing of the gap between our two wage rates. And as the benefits of economic growth are spread in Mexico to working people...they'll have more disposable income to buy more American products and there will be less illegal immigration because more Mexicans will be able to support their children by staying home" (CIS 2000). On the Mexican side, President Salinas de Gortari shared Clinton's opinion and emphasised: "More jobs will mean higher wages in Mexico, and this in turn will mean fewer migrants to the United States and Canada. We want to export goods, not people" (Martin and Taylor 1996). Mexico should in his words export tomatoes and not tomato pickers (Cornelius and Philip 1993).

Twelve years after NAFTA has come into effect it should be noticed that the trade volume between Mexico and the USA has indeed grown. According to the United States Census Bureau (2006), the total volume of trade between Mexico and the United States was USD 25,858 million in 1983, in 1993 it increased to USD 81,497 million, and in 2005 it more than trebled to USD 290,245 million.

The aim of this paper is to identify the relationship between trade liberalisation and migration referred to the NAFTA case: are they substitutes like the policy-makers in the USA and Mexico assumed or are they on the contrary complements? In Section II, we outline eight different models that deal with this question and constitute the theoretical foundation of our analysis. Depending on the initial assumptions, the models come to different results concerning the relationship between trade liberalisation and factor mobility.[3] In a next step, some empirical studies dealing with this problem are considered. In Section III, we specify an econometric model and estimate multiple regression models by using distributed Almon lag models. Section IV describes our results and Section V concludes.

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in the country of origin. These factors hold for legal as well as for illegal migration. In our article we will focus on illegal migration. In fact, illegal migrants respond faster to changes in the economic situation in the country of origin and/or destination (e.g. they tend to arrive in larger numbers when the economy in the destination country is booming). In contrast, legal immigration is subject to arbitrary selection criteria and bureaucratic delays, which tend to disassociate legal inflows from the market conditions (Hanson 2007).

[3] The theoretical models refer to factor mobility of labour in general and do not distinguish between legal and illegal migration. However, especially models V, VII and VIII deal with labour mobility of skilled and unskilled workers, which can be linked to illegal migration since it is a well-known fact that a large proportion of unskilled workers migrate illegally from Mexico to the US (see, e.g., López and Schiff 1995).

II. Literature review

A. Theoretical framework

The relationship between trade and migration has been addressed by many researchers based on the classical models of Mundell (1957) who uses the Heckscher-Ohlin framework and Markusen (1983). This section gives an overview of different trade models and their implications about the interaction between trade and migration.

We initially consider the following set of assumptions following Markusen (1983):

1. we regard 2 countries, 2 goods and 2 factors (labour and capital);
2. countries have identical relative factor endowments;
3. countries have identical technologies;
4. countries have identical homothetic demand;
5. production is characterized by constant returns to scale;
6. production is characterized by perfect competition; and
7. there are no domestic distortions within the countries.

If all of these assumptions hold, then the two countries have no incentives to trade. Relaxing some of the restrictions mentioned above leads to the following models:

Model I: Heckscher-Ohlin-Samuelson

If we relax assumption 2), we have the Heckscher-Ohlin-Samuelson model (HOS model). In the HOS model, under trade liberalisation a country exports the good where it has a comparative advantage, i.e. it will export the good that uses its relatively more abundant factor relatively more intensively in production (Feenstra 2004). Liberalised trade increases the relative price of the good that uses a country's relatively more abundant factor relatively more intensively and leads to the convergence of goods' prices (Razin and Sadka 2001). If both countries produce both goods and there are no factor intensity reversals, the equalisation of goods prices implies factor price equalisation following Samuelson's Factor Price Equalisation Theorem (Feenstra 2004). This can be explained intuitively by the fact that although the factors of production do not move from one country to the other, they move indirectly because they are embodied in the traded goods. The labour-abundant country will implicitly export labour and import capital (Razin and Sadka 2001). Trade in goods is then a perfect substitute for factor mobility.

By relaxing the remaining assumptions 3), 5), 6) or 7), Markusen (1983) shows that factor mobility and trade are rather complements.

Model II: Different technologies

In this model, following Markusen (1983) and Razin and Sadka (2001), assumption 3) is relaxed, and the difference in technology is considered as the basis for trade instead of the difference in relative factor endowments. It is assumed that one country has a more productive technology in one sector, e.g., in the labour-intensive sector. Under free trade it will then export the labour-intensive good and, without factor mobility, it will have a higher wage. If factor mobility is allowed alongside trade, then there will be a factor inflow of the factor intensively used in the export sector, because of the higher wage in the sector with the higher productivity. The increase in the labour-capital ratio will through Rybczynski effects strengthen the specialisation in the production of the labour-intensive good (Faini, De Melo and Zimmermann 1999).[4] Thus, factor mobility reinforces trade. In this setup factor mobility and trade complement each other.

Model III: Increasing returns to scale

Increasing returns to scale are considered in the standard model of the "new" trade theory with two countries and one factor, e.g., labour, as the only factor of production within two sectors. One sector of production has constant returns to scale and produces a homogeneous good. The other one has increasing returns to scale and produces a set of differentiated goods (therefore, assumption 5) is relaxed in this case). Before trade liberalisation, the wage in each country is pinned down by the assumption of constant returns to scale in the homogeneous good sector (Faini, De Melo and Zimmermann 1999). Thus, wages in both countries are equal. With free trade, monopolistic competition and increasing returns to scale, the bigger economy will specialize and be a net exporter in the increasing-returns-to-scale sector (Krugman 1995). Consequently, wages may diverge (they will be higher in the specialised region) and labour will have an incentive to move. This movement makes the factor endowment in both countries more unequal, so that the basis for trade increases (Faini, De Melo and Zimmermann 1999). Factor mobility and trade are in this case complements.

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[4] The Rybczynski theorem states that if relative good prices are constant and if both goods continue to be produced, an increase in the supply of a factor will lead to an increase in the output of the good using that factor intensively and a decrease in the output of the other good (Markusen et al. 1995).

Model IV: Ricardo-Viner specific factors

In the model of specific factors which was developed by Jacob Viner based on the Ricardian model, some factors of production are specific or immobile to a given sector (e.g. land or capital), while other factors (e.g., labour) are fully mobile across sectors (this means that they can be used in the production of both goods). With liberalised trade, a country will specialise in the production of the good that uses its abundant factor intensively and export it and will import the good that uses its scarce factor intensively (Markusen et al. 1995). The price of the imported good will decrease as production in the home country is substituted with more efficient foreign production. The assumption of increasing costs implies that the price of the exported good rises. The price of the immobile factor is determined by the value of its marginal productivity. Assuming that the productivity of one factor depends positively on the quantity of the other factor used in production, as the mobile factor moves out of production of the imported good and into production of the exported good, the price of the factor specific to the exported good will rise. The rise in the price of the exported good will also increase the value of this factor's marginal productivity. Thus, the owners of this factor will benefit from free trade. On the other side, the owners of the factor specific to the imported good will be worse off. The increased production of the exported good leads to an increase of the demand for the mobile factor. The decreased production of the imported good reduces the demand for the mobile factor. If the country is abundant in the mobile factor, there will be a net increase in the demand for the mobile factor. If the country is abundant in the immobile factor there will be a net decrease in the demand for the mobile factor. In the former case, the price paid to the mobile factor will rise, but by less than the increase in the price of the exported good. In the latter case the price paid to the mobile factor will fall, but by less than the price of the imported good. The effect on the mobile factor is uncertain and depends on whether the country is abundant in the mobile or immobile factor and on the weight of importable goods in the consumption basket. Contrary to the results of the HOS-model, trade does not equalize factor prices across countries in the specific factor model. Thus, the effect of free trade on factor mobility cannot be determined a priori (Faini, De Melo and Zimmermann 1999).

Model V: López-Schiff

López and Schiff (1995) investigated the effects of trade liberalisation on migration of skilled and unskilled labour, where migration is assumed to take place from a

labour-abundant sending country to a capital-abundant destination country, e.g., from a developing to a developed country. They add four further assumptions to the standard HOS-model: heterogeneity of labour skills, international labour mobility, migration costs and constraints on financing migration. Moreover migration costs for unskilled workers are supposed to be higher than for skilled ones since among other things a large fraction of the unskilled workers migrate illegally and in general illegal migration is more expensive than legal migration (López and Schiff 1995). Migration costs mean quite a huge limitation for the unskilled workforce to migrate since in many cases they cannot obtain a credit in their country to finance these costs. If trade liberalisation in the labour-abundant sending country increases the level of wages, like the HOS-model predicts, then the financial constraints will be relaxed and more unskilled workers are able to afford the migration costs (Faini, De Melo and Zimmermann 1999, López and Schiff 1995). In this case trade and migration of unskilled workers are complements. On the other hand, López and Schiff (1995) also show that trade liberalisation leads to a reduction of migration of the skilled labour force.

Model VI: "Migration hump"

The "Migration hump" model distinguishes between the short and the long term effects of trade liberalisation on migration between countries with different economic conditions. In the short-to-medium run, free trade is likely to increase pressures for migration from the developing country. Thus trade liberalisation and factor mobility are complements. The policies that accelerate economic growth through free trade, privatisation or land reform can lead to a temporarily increase in migration (migration hump) above the trend, because of the displacement and the disruptions that follow the economic development process (Martin and Taylor 1996). A migration hump is a part of the economic take-off-process when industrialisation occurs in a country that meets the following conditions: a long migration tradition, existence of migrant networks and programs for recruitment of migrant workers (Martin 1996). In the long run, if free trade brings an improvement of the economy in the developing country relative to the economy of the developed country, e.g., by narrowing the large wage and unemployment differentials, the economic incentives for migration will weaken and trade liberalisation and migration are then substitutes (Acevedo and Espenshade 1992). The duration and amplitude of the migration hump are relatively small since, when viewed over a long enough time period, there is less migration with free trade than without it (Martin and Taylor 1996). Although the

idea behind the migration hump model has a lot of merit, no rigorous model is presented (López and Schiff 1995).

Finally, there are two other models that question the wage convergence result of the HOS-model:

Model VII: Feenstra-Hanson

Contrary to the HOS-model predictions, Feenstra and Hanson (1995, 1997) show that trade and investment liberalisation do not lead to the convergence of wages between the countries (a developing and a developed country), at least in the short or medium run. In their model they distinguish between skilled and unskilled labour and assume that less-skilled-labour goods are produced in the developing country, which is unskilled-labour-abundant, and skilled-labour-intensive goods are produced in the developed country, which is skilled-labour-abundant. The goods are ranked in a continuum by their intensity in skilled labour. Investment and trade liberalisation lead to a shift of investment towards the developing country. The effect of trade and investment liberalisation is to move to the developing country the production of goods that are skilled-labour-intensive from the developing country's standpoint but that are unskilled-labour-intensive from the point of view of the developed country. Thus, the demand for skilled labour increases in both countries and the wage gap widens.[5] Trade and investment liberalisation and factor movements can be complements.

Model VIII: Markusen-Venables

Markusen and Venables (1998) come to the same conclusion as Feenstra and Hanson (1997) concerning the widening of the wage-gap between skilled and unskilled labour under trade and investment liberalisation in the involved countries, but they follow a quite different approach. The Markusen-Venables model deals with the role and structure of multinational firms and plant locations. The "unbundling" of activities permitted by trade and investment liberalisation raises the relative demand for skilled labour in both countries.

To sum up, a complementary relationship between trade and investment liberalisation and migration is possible. Table 1 summarizes the different conclusions of each theoretical model reviewed in this section in regard to that relationship.

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[5] Feenstra and Hanson (1997) show these results for the Mexican manufacture sector.

Table 1. Theoretical models

Model	Trade and migration are...
Heckscher-Ohlin-Samuelson	Substitutes
Different technologies	Complements
Increasing returns to scale	Complements
Ricardo-Viner-specific factors	Complements or substitutes
López-Schiff	Complements or substitutes
"Migration hump"	Complements in the short term, substitutes in the long term
Feenstra-Hanson	May be complements, there is no factor price convergence
Markusen-Venables	May be complements, there is no factor price convergence

B. Empirical results

As we have seen, the theory regarding the relationship between trade and factor mobility is quite ambiguous. This ambiguity invites to do empirical analysis, but surprisingly, only few econometric studies deal with the interaction of trade and factor mobility (Collins, O'Rourke and Williamson 1999).

In a descriptive approach, Richards (1994) examines the relationship between trade liberalisation and migration patterns in the experience of developing countries. She concludes that the more frequent relationship between freer trade regimes and migration flows is a complementary one, like in the case of South-East Asia (Taiwan, Singapore) or Latin America (Mexico).

Rotte and Vogler (1998) investigate empirically the link between trade, development and migration using a dataset based on total migration inflows from 86 African and Asian countries to Germany in the period from 1981 to 1995 and on asylum migration from these countries to Germany between 1984 and 1995. The estimation results show the existence of a U-shaped relationship between development and migration, as well as a significantly positive correlation between the total migration variable (number of registrations at local authorities) and the trade variable (sum of exports to and imports from Germany). Surprisingly, the results indicate a negative effect of trade on the asylum migration variable (number of asylum applications).

Collins, O'Rourke and Williamson (1999) use historical data for economies of the "Atlantic community" (three New World countries and seven Old World countries) between 1870 and 1940 to identify complementarity or substitutability between factor flows and international trade. Their empirical findings show that factor flows were rarely substitutes and often complements. Moreover, they conclude that policy makers apparently never acted as if they viewed trade and migration as substitutes either.

Girma and Yu (2002) investigate the link between migration and trade in the United Kingdom (UK) during the period from 1981 to 1993. They analyse the immigration to the UK from 48 countries, classified in Commonwealth (CW) and non-Commonwealth (NCW) countries. They show that immigration from CW-countries has a significant export-enhancing effect. If the stock of migration increases by 10 per cent, then UK's exports to those countries also increase by 1.6 per cent (Girma and Yu 2002). In contrast, the effect of migration from the NCW-countries on the exports from the UK to them is statistically insignificant. Regarding the imports, the study shows that migration from the NCW-countries has a pro-imports effect. A 10 per cent increase in the migrant stock from the NCW-countries is estimated to increase the UK imports from those countries by 1 per cent. However, immigration from the CW-countries seems to reduce the imports, a 10 per cent increase in the CW-migration stock reduces UK's imports by 1 per cent (Girma and Yu 2002). This result reveals a "trade-substitution" effect of migration possibly due to migrants' import-substituting activities.

Bowen and Wu (2004) examine empirically, in a panel of OECD countries from 1980 to 2001, changes in either exports or services output in relation to changes in total migration and alternatively in net migration (immigration minus emigration). The results indicate that the output of services rises with the level of migration. In addition, they show that trade (exports) and migration are complements. Moreover, their model shows that trade liberalization would create incentives for illegal immigration and create disincentives for legal immigration. However, they find that the complementary relationship can be reduced by migration policies like guest-worker programs, so the likelihood that exports and immigration are substitutes is increased in this case.

Bruder (2004) also analyses the relationship between labour migration and trade focusing on German data from 1970 to 1998 from the main source countries for foreign workforce: Greece, Italy, Portugal, Spain and Turkey. The results indicate that there is a substitution type relationship between trade and the foreign labour force. Labour migration has no significant impact on trade (exports and imports), but an increasing trade volume has significantly negative effects on labour migration.

Bryant, Genc and Law (2004) use a panel data model within the framework of a standard gravity model of trade including an average of over 170 countries for the years 1981 to 2001 in order to examine the hypothesis that a greater stock of migrants in New Zealand from a particular country leads to more trade between that country and New Zealand. Their results suggest that larger migrant stocks lead to higher trade flows.

Mundra (2005) examines the effect of migration from 47 countries to the USA on the bilateral trade flows between them and the USA in the period from 1973 to 1980 using a semiparametric dynamic panel model. The empirical study shows that the migration effect on imports is positive for both finished and intermediate goods, but the effect on exports is positive only for finished goods. Thus, migration and trade seem to be complements.

To summarize, most of the studies lead to the result that migration and trade are complements, but broader analysis is needed to come to a conclusion. Table 2 summarizes the results of the empirical literature reviewed in this section.

Table 2. Existing studies and their results

Empirical study	Trade and migration are...
Richards (1994)	Complements
Rotte and Vogler (1998)	Complements for total migration, substitutes for asylum migration
Collins, O'Rourke and Williamson (1999)	Mostly complements, rarely substitutes
Girma and Yu (2002)	Complements for non-Commonwealth sender countries, partly substitutes for Commonwealth sender countries
Bowen and Wu (2004)	Complements, perhaps substitutes in the case of guest-worker programs in the destination country
Bruder (2004)	Substitutes
Bryant, Genc and Law (2004)	Complements
Mundra (2005)	Complements

III. Methodology and data section

We use monthly data from 1968 to 2004 to determine the relationship between illegal migration and economic and social factors, whereas the number of

apprehensions at the US-Mexican border is used as a proxy for illegal migration.[6] Since monthly data on legal migration was not available and the NAFTA treaty mainly addresses the reduction of illegal migration, using only the amount of the illegal influx seems quite appropriate. Trade data is from the US Department of Commerce and the Federal Reserve Economic Database. For sources of all variables, see Table 3.

Table 3. Definition and source of variables

Variable	Definition	Source
Y	Apprehensions by the US Border Patrol, no. caught attempting to cross US-Mexican border illegally	Hanson (2005), Orrenius and Coronado (2005)
T	Trade volume (exports + imports) between Mexico and the United States in millions of 2001 US dollars	US Department of Commerce (1966–1973), Federal Reserve Economic Data (2006)
WD	Wage differential in constant US dollars, i.e., (US federal minimum wage/US CPI) – (Mexican minimum wage/Mexican CPI)* exchange rate	US Bureau of the Census (2006), Banco de México (2006)
UR	US unemployment rate	Bureau of Labor Statistics (2006)
EXR	Real exchange rate index with respect to 111 countries	Banco de México (2006)
MN	Mexican-born population of the US in thousands	Mexican Migration Project (2006), Current Population Survey - CPS (1999-2005)
LW	Linewatch hours spent by the US Border Patrol policing the US border.	Hanson (2005), Orrenius and Coronado (2005)
IRCA	Dummy=1 if IRCA enacted, otherwise = 0	
NAFTA	Dummy=1 if NAFTA treaty effective, otherwise = 0	
GATT	Dummy = 1 if GATT effective, otherwise = 0	
IMACT	Dummy = 1 if the Immigration Act of 1990 enacted, otherwise = 0	
Policy	Dummy = 0 if immigration policy becomes less restrictive, 1 if immigration laws are tightened	Melchor del Río (2008)

[6] Data on a monthly basis collected by the US Department of Homeland Security were kindly provided by Pia M. Orrenius and Gordon H. Hanson.

A. Description of variables

The main problem is how to measure illegal immigration. Since the number of undocumented migrants crossing the US-Mexican border in a given period is not observable, the number of border apprehensions by the US Border Patrol is used as a proxy variable for illegal immigration.[7] This indicator is not a perfect measure of the number of undocumented migrants successfully entering the United States or even the number attempting to enter, because in addition to counting the number of failed attempted crossings instead of the number of successful crossings, the data includes repeated apprehensions for the same individual. Furthermore, illegal aliens who enter legally and then overstay their visas are not taken into account by the apprehension data. Since they represent approximately one-quarter of illegal immigrants present in the United States, this also yields a bias to this proxy (Orrenius and Coronado 2005). Nevertheless, the apprehension data has proved to be appropriate in several recent empirical studies (Bean et al. 1990, Borjas and Fisher 2001, Hanson and Spilimbergo 1999, Hanson 2005, Orrenius and Coronado 2005). Espenshade (1995) found an overall linear correlation of 0.90 between apprehensions and the volume of illegal immigration. His results also suggested that the estimated gross volume of undocumented migration exceed the level of the amount of apprehensions by a factor of 2.2. We assume that all apprehended individuals are of Mexican origin. Over the period 1977-1996, 99.2 per cent of apprehensions occurred at the US-Mexican border and the vast majority of those apprehended were Mexican residents (over a period of 1988-1996 this applied to 96.1 per cent). The same applies accordingly for the linewatch enforcement hours since in the same period 91.6 per cent occurred at the US-Mexican border (Hanson and Spilimbergo 1999).

Due to our theoretical framework, a trade variable is included to analyse the impact of trade liberalisation on the migration flow from Mexico to the United States.

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[7] There are different approaches on how to estimate the number of illegal Mexican migrants in the USA. One of them is the calculation of the demographic development in Mexico in a certain year (population – deaths + births – legal emigrants + legal immigrants) and compare it with the Mexican National Population Council population data for that year. The difference gives an approximation for the illegal Mexican emigration from and the illegal immigration to Mexico. This method is however not appropriate, since data availability is problematical. Another approach is to consider the number of remittances sent from the Mexican migrants in the USA to their families in Mexico. This could give an approximation for the number of migrants living and working in the USA. But data concerning the remittances also may not be an appropriate proxy variable for the influx of illegal migrants, because many of them send the money through informal ways that cannot be registered (e.g., with the help of friends or relatives) and there are also legal migrants that send remittances to Mexico.

According to the Heckscher-Ohlin model, trade has a substitutional effect on migration flows due to factor price equalisation. However, as we have already shown in Section II, relaxing the assumptions of the neoclassical trade model leads to a complementary relationship between trade and migration. Furthermore, intensive bilateral trade indicates strong ties between two countries which could lead to a reduction of immigrants' transaction costs and therefore promote migration. It is expected that the latter two effects dominate the Heckscher-Ohlin assumption, since it rests on a set of narrow assumptions that are rarely satisfied in the real world (Martin 1996).

To account for the impact of the NAFTA agreement on the migration flow, a dummy variable is included. Since Mexico had already joined the General Agreement on Tariffs and Trade (GATT) in August 1986, which formed another milestone in the bilateral US-Mexican trade relationship, we also included a dummy variable for GATT.

A core conclusion of the neoclassical migration theory is that higher wage differentials result in a higher emigration from the low-wage into the high-wage countries. If free trade leads to factor price equalisation between Mexico and the USA following the HOS-theorem, i.e. wage difference equals zero, then people would not have the incentive to migrate according to this theory. If otherwise there is no wage convergence induced by free trade like Feenstra and Hanson (1995, 1997) and Markusen and Venables (1998) state for the NAFTA region, then people would continue to migrate looking for higher wages. Since it seems quite obvious that illegal migrants, after crossing the border successfully, will receive work only in the low-skill sector, the US average wage is not an appropriate measure for prospective earnings of undocumented immigrants. Although most illegal immigrants are earning even less than the federal minimum wage, this seems to be a highly appropriate measure and therefore the monthly US minimum wage as well as the Mexican minimum wage are used to calculate the wage differential between the two countries.

The US unemployment rate is implemented as a proxy for employment opportunities for migrants upon crossing the border. We do not include the Mexican unemployment rate since there is limited availability for monthly data on this variable. Additionally, data concerning the unemployment rate is not very reliable because the informal sector's share of employment is not considered.

The massive Mexican Peso crisis, also known as the so-called Tequila crisis, which occurred shortly after the NAFTA treaty became effective in 1994, led to a sharp spike in unemployment and a 25 per cent drop in wages. These likely have

induced migration flows to the United States that complicate modest effects that the NAFTA treaty might have had in the opposite direction (Aroca and Maloney 2005). Furthermore, Mexico suffered from high inflation during several years with high peaks especially during the 1980s (e.g., 98.8% in 1981 and 114.2% in 1988) (Melchor del Río 2008). To account for these two effects, the real exchange rate index is included in the estimation equation. Since an increase in the real exchange rate index represents a real depreciation of the Mexican currency, it is expected that this variable has a positive impact on the illegal migration flow.

As Massey et al. (1998) suggest, migrant networks are sets of interpersonal ties that connect migrants, former migrants, and non-migrants in origin and destination areas through ties of kinship, friendship, and shared community origin. Hence, it is expected that migration networks have a positive effect on migration. To account for this effect, the number of Mexican-born population in the USA is implemented in the model. Since data is only available on a yearly basis, monthly values have to be constructed. Our theory that the Mexican-born population may have the same trend as the total population of the United States is verified by the high correlation coefficient of 0.97 between these two variables. Observing monthly data of total US population leads to the conclusion that this time series tends to be linear. Therefore, a linear interpolation of missing values for the Mexican-born population variable seems to be adequate and reasonable.

To control the effect of Border Patrol enforcement on the illegal migration flow, we use Border Patrol linewatch hours as a proxy variable for enforcement intensity. Linewatch hours are the number of hours the Border Patrol officers spend each month patrolling the US-Mexican border. It is expected that increasing linewatch hours deter illegal immigrants from entering the United States.

The United States has made several attempts to control the influx of illegal immigrants from Mexico (see Table 4). To account for this effect, a dummy variable is included which equals 1, if immigration policy becomes more restrictive.

Another dummy variable included in the model accounts for the Immigration Act of 1990. It equals 1 after October 1991 when the law was implemented. The law recognizes the growing internationalisation of the world's labour market and it facilitates employment-related immigration in order to enable US employers to hire more experts in such fields as science, engineering, systems analysis or computer programming. The Immigration Act continued to favour people with family members already living in the United States and it provided for the admission of immigrants from "underrepresented" countries to increase the diversity of the immigrant flow.

Table 4. Implementation date and possible effects on migration of policy variables

Date	Policy	Possible effect on migrants
May-87	Immigration Reform and Control Act (IRCA) was implemented	Positive
Oct-91	Immigration Act was launched	Positive
Sep-93	"Hold the line"	Negative
Oct-94	"Gate-keeper"	Negative
Apr-97	Illegal Immigration Reform and Immigrant Responsibility Act (IIRIRA) became law	Negative
Aug-97	"Rio Grande"	Negative
Feb-99	"Saveguard"	Negative
Oct-01	US Patriot Act	Negative
Dec-01	US Canada Smart Border Declaration	Negative
Mar-02	US Mexican Smart Border Action Plan	Negative
May-02	Enhanced Border Security and Visa Entry Reform Act	Negative
Dec-04	Intelligence Reform and Terrorism Prevention Act	Negative

Source: Melchor del Río 2008.

The Immigration Reform and Control Act (IRCA) was passed in order to reduce illegal immigration to the United States. The law established a one-year amnesty program for illegal migrants who had already worked and lived in the US since January 1982. They could apply for the regularization of their status and eventually for full citizenship. Family reunification was also established as a key priority. Furthermore, the law mandated the intensification of Border Patrol activities. Under IRCA over 2.7 million illegal aliens and others not qualifying for visas were legalized. We include a dummy variable to account for this effect which equals 1 after May 1987, when IRCA was launched. The descriptive statistics of these variables are shown in Table 5.

Table 5. Descriptive statistics

Variable	Pre-NAFTA (1968M01-1993M12) – 299 observations				
	Mean	Median	Maximum	Minimum	Std. dev.
Y (border aprehensions)	40,580	39,730	100,480	2,670	22,810
T (trade, in millions US dollars)	3,620	3,580	8,880	720	2,060
WD (wage differential, dollars per day)	44.69	45.18	54.72	25.3	5.33
UR (US unemployment rate)	6.62	6.60	11.40	2.90	1.50
EXR (real exchange rate index)	83.31	81.81	139.29	57.85	19.20
MN (migrant network, in thousands)	2,445	2,288	5,357	722	1,343
LW (linewatch hours)	169,660	172,620	300,630	70,000	49,900
	Post-NAFTA (1994M01-2004M07) – 127 observations				
	Mean	Median	Maximum	Minimum	Std. dev.
Y (border aprehensions)	85,220	80,450	179,740	24,890	32,560
T (trade, in millions US dollars)	15,820	16,570	23,550	8,320	4,140
WD (wage differential, dollars per day)	36.32	37.01	40.80	24.46	4.16
UR (US unemployment rate)	5.16	5.30	7.30	3.60	0.82
EXR (real exchange rate index)	80.63	76.51	138.07	55.58	17.00
MN (migrant network, in thousands)	7,629	7,137	10,376	5,391	1,499
LW (linewatch hours)	597,260	708,960	870,500	258,590	207,430

Note: Dummy variables are not presented.

B. Empirical model

First it has to be considered whether the time series are stationary, i.e., they do not contain unit roots. To test this hypothesis the augmented Dickey-Fuller (ADF) test is carried out. Regarding the ADF test the apprehensions time series follows a deterministic as well as a stochastic trend. To obtain a stationary time series the apprehension variable is therefore regressed on a time trend. The obtained residuals will be stationary and are known as the (linearly) detrended time series. The ADF test (without trend) is also conducted for the other time series and in all cases (except for the real exchange rate index) the hypothesis is not rejected, which means that they are not stationary (see Table 6).

Table 6. Results obtained by checking for unit roots with the (augmented) Dickey-Fuller test

Level			Difference		
Variable	t-statistic	Lag length #	Variable	t-statistic	Lag length #
Y (border aprehensions)	-3.648 **	17			
T (trade)	-1.704	14	ΔT	-5.208 ***	17
WD (wage differential)	-2.018	0	ΔWD	-4.443 ***	17
UR (US unemployment rate)	-2.328	3	ΔUR	-5.297 ***	17
EXR (real exchange rate index)	-2.876 ***	17			
MN (migrant network)	-0.457	3	ΔMN	-5.689 ***	17
LW (linewatch hours)	-0.913	10	ΔLW	-5.072 ***	17

Notes: # The optimal number of lagged differences is based on the modified Schwarz information criterion; * significant at 10%; ** significant at 5%; *** significant at 1%.

The time series suffering from a random walk are integrated of order 1 and consequently enter the regression as first differences. Since the dependent variable is trend-stationary and is therefore not integrated of any order, testing for a cointegration relationship is not necessary. For our estimations we used multiple regression models with lagged independent variables. In general, lagged explanatory

variables can be included explicitly in the model when a substantial period of time may pass between the economic decision-making period and the final impact of a change in a policy variable. More generally, one would specify that economic changes can be distributed over a number of time periods, which provides the basis for the distributed lag model, in which the series of lagged explanatory variables accounts for the time-adjustment process (Pindyck and Rubinfeld 2000). The estimation equation takes the following form:

$$Y_t = \beta_0 + \beta_1 \Delta LW_{t-1} + \sum_{q=0}^{m} \alpha_q \Delta T_{t-q} + \sum_{q=0}^{m} \delta_q \Delta WD_{t-q} + \sum_{q=0}^{m} \gamma_q \Delta UR_{t-q} + \sum_{q=0}^{m} \lambda_q EXR_{t-q} + \beta_2 \Delta MN_t + \sum_{i=1}^{n} \mu_i D_{i,t} + \varepsilon_t, \quad (1)$$

where Y_t describes the apprehensions at the US-Mexican border attempted by the US Border Patrol at time t. ΔLW_{t-1} are the first differences of linewatch hours. Since they may be simultaneously determined with apprehensions, the linewatch hours variable enters the estimation equation with a one-period-lag. ΔT_{t-q} is the distributed lag of trade which also enters the equation as first differences. ΔWD_{t-q} is the distributed lag of the wage differential, ΔUR_{t-q} is the distributed lag of the US unemployment rate and EXR_{t-q} is the distributed lag for the real exchange rate index.

A next issue is ΔMN_t, which is a proxy variable for the migrant networks. We assume that the networks have already been so expanded since the beginning of the Mexican migration process to the USA in the middle of the 19th century that the new migrants do no longer (strongly) react to past increasing or decreasing numbers of Mexicans in the USA. Therefore, the variable is not lagged. $D_{i,t}$ stands for a vector of five dummy variables, namely NAFTA, GATT, policy, IRCA and Immigration Act, which also enter the equation without any lags since they do not receive a value of one until their point of implementation. Thus, it can be assumed that they affect the apprehension variable immediately. $\beta_0, \beta_1, \beta_2, \alpha_q, \delta_q, \gamma_q, \lambda_q$ and μ_i are the estimation coefficients, where β_0 is the intercept.

Our main hypothesis is that trade, the wage differential, the unemployment rate and the real exchange rate index affect illegal migration in the long run. To reduce the effect of multicollinearity a rather popular method is proposed by Almon. In this technique it is assumed that the q coefficients of the regressor lie on a polynomial curve. In this paper the finite distributed lags are restricted to lie on a 2nd degree polynomial.[8] Across time, the estimated lag coefficients may foster (positive lag

[8] Higher order polynomial terms did not improve the results.

coefficient) or hinder (negative lag coefficient) illegal migration. The long-run effect is calculated as the sum of the statistically significant lag coefficients.

We run five different specifications for which the appropriate lag length has to be determined. This is done by using an iterative process with the Akaike and the Schwarz information criterion where we allowed for a maximum lag length as proposed by Schwert with $q_{max} = int\left[12\left(T/100\right)^{1/4}\right] = 17$ months prior to the apprehension variable, where *T* denotes the sample size and *int* denotes the integer part in brackets. For every specification we seek that lag length which minimizes the Akaike as well as the Schwarz information criterion. Table 7 shows that for specification 1 and 5 a lag length of 13 has to be applied and for specifications 2, 3 and 4 a lag length of 12 give the lowest values for the Akaike and Schwarz information criterion.

Since autocorrelation in the residuals was detected through the Durbin-Watson statistic, ordinary least squares does not lead to efficient estimators. A solution is provided by Newey and West (1987), who developed an estimator whose standard errors are robust to autocorrelation as well as to heteroskedasticity.

IV. Estimation results

Table 8 presents the regression results for the period from 1968 until 2004. The trade variable has a significant positive impact on illegal migration, contrary to the results of the neoclassical trade theory. The estimated coefficient varies between 54 and 71 depending on the model specification. This means that if the trade volume between Mexico and the United States increases by one billion US dollars, the number of border apprehensions and thus, the influx of illegal migrants will rise up to 71,000. This can be traced back to the different technologies in both countries. In the presence of free trade the labour intensive production in Mexico (e.g., crop production) cannot compete with the capital intensive US production that has a comparative advantage. Thus, employees in the labour intensive sector of Mexico were laid off, which lead to rise of migration pressure (Martin and Taylor 1996). Furthermore, the different factor productivity in both countries may lead to an increase of migration. If labour is more productive in the US due to better infrastructure and qualification, then manufacturing of labour intensive goods can decline in Mexico and rise in the United States. Consequently, Mexican migration would also increase. An example is the enlargement of the shoe industry by hiring Mexican workers in Los Angeles in the 1980s, whereas production of shoes suffered from heavy losses in Mexico. Hence, the big supply of labour as well as the wage gap

Table 7. Selection of appropriate lag length for Almon distributed lag model with Akaike's (AIC) and Schwarz' (BIC) information criterion

	(1)		(2)		(3)		(4)		(5)	
Lags	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC	AIC	BIC
1	-	-	-	-	-	-	-	-	-	-
2	8.5524	8.7438	8.3415	8.6190	8.3462	8.6332	8.3829	8.6508	8.3396	8.6362
3	8.5335	8.7252	8.3063	8.5843	8.3104	8.5980	8.3467	8.6151	8.3094	8.6066
4	8.5320	8.7241	8.2851	8.5636	8.2876	8.5757	8.3280	8.5968	8.2901	8.5878
5	8.5334	8.7258	8.2866	8.5656	8.2886	8.5772	8.3296	8.5989	8.2906	8.5888
6	8.5377	8.7304	8.2929	8.5724	8.2955	8.5846	8.3351	8.6049	8.2947	8.5935
7	8.5298	8.7229	8.3081	8.5881	8.3117	8.6013	8.3440	8.6143	8.314	8.6133
8	8.5468	8.7402	8.3282	8.6086	8.3325	8.6227	8.3675	8.6383	8.3293	8.6291
9	8.5749	8.7687	8.3662	8.6472	8.3710	8.6617	8.3986	8.6699	8.3625	8.6629
10	8.5396	8.7337	8.3119	8.5934	8.3164	8.6076	8.3361	8.6079	8.3125	8.6134
11	8.4854	8.6798	8.2562	8.5382	8.2594	8.5511	8.2924	8.5647	8.2571	8.5586
12	8.4617	8.6565	**8.2209**	**8.5034**	**8.2245**	**8.5167**	**8.2631**	**8.5359**	8.2266	8.5286
13	**8.4596**	**8.6548**	8.2299	8.5129	8.2339	8.5267	8.2742	8.5475	**8.213**	**8.5155**
14	8.4987	8.6943	8.2759	8.5594	8.2796	8.5730	8.2999	8.5736	8.2743	8.5774
15	8.5005	8.6964	8.2890	8.5730	8.2916	8.5855	8.3141	8.5884	8.283	8.5866
16	8.4907	8.6870	8.2727	8.5572	8.2743	8.5687	8.2992	8.5740	8.2663	8.5705
17	8.5231	8.7197	8.3155	8.6006	8.3195	8.6144	8.3398	8.6151	8.3107	8.6154

between Mexico and the US is not sufficient for obtaining a comparative advantage in the labour intensive sector. Returns to scale which arise in the production of labour intensive goods in the United States, mainly manufactured by Mexican migrants, lead to declining marginal costs with increasing production. Since more employees are needed for the expanding industry, migration is rising. The negative effects on formerly protected sectors such as agriculture occur immediately, whereas positive effects need time for adaptation. For example, there is a time lag between the investments made and the creation of jobs. Furthermore, some production factors are specific for one sector and cannot be used immediately in another sector. In this adaptation period an increase of migration can happen in terms of a migration hump (Martin and Taylor 1996). A further reason for the complementary between free trade and migration could be the market failure in Mexico; there is no credit- and social insurance system. According to the theory of new migration economics, migration means a risk diversity strategy for lots of Mexican families, since they can secure their income in the case of unemployment, diseases, poor harvest, etc., by obtaining remittances from Mexican emigrants (Martin and Taylor 1996).

Due to the economic openness of Mexico, the trade between Mexico and the United States underwent some structural changes especially in the late 1980s. Before that period, most of the Mexican goods exported to the US were oil-related (55 percent in 1985), whereas in the subsequent years, Mexican exports came basically from the Maquiladora sector and from the manufacturing industry (Melchor del Rio 2008).[9] To account for this effect an interaction terms, namely GATT*Trade was added into the model. However, this covariate turned out to be insignificant in every specification. Thus, it was dropped in our final model.

Interestingly, we also find that neither the GATT nor the NAFTA agreement seemed to have a significant influence on the illegal migration flow from Mexico to the United States. However, the GATT has a significant effect only in the first specification as well as the IRCA variable. Furthermore, the wage differential and the unemployment rate also do not show any significant effect on the influx of undocumented migrants.

The real exchange rate index has a positive sign and is highly significant in every specification. This confirms our hypothesis that economic instability fosters migration. Our results show that a positive change in the real exchange rate leads to an increase

[9] Maquiladora or maquila are assembly plants in Mexico, especially along the border to the United States, that imports materials and equipment on a duty-free and tariff-free basis for manufacturing and then re-exports the assembled product usually back to the USA.

Table 8. Border apprehensions: regression results

Dependent variable	(1)	(2)	(3)	(4)	(5)
ΔT_{t-q}	71.436 ***	53.658 **	55.496 *	54.455 **	68.050 **
	(0.023)	(0.025)	(0.029)	(0.025)	(0.029)
$NAFTA_t$	-2.666	0.538	0.155	0.175	-1.646
	(4.1639)	(4.042)	(4.677)	(3.932)	(4.359)
$GATT_t$	15.241 *	-17.339	-17.788	-17.214	-15.233
	(8.690)	(10.599)	(10.621)	(10.693)	(10.414)
ΔWD_{t-q}	-	-0.250	-0.266	-0.171	0.507
		(2.915)	(2.928)	(2.886)	(3.052)
ΔUR_{t-q}	-	2.153	2.053	3.112	0.688
		(10.762)	(10.652)	(10.773)	(11.292)
EXR_{t-q}	-	0.568 ***	0.571 ***	0.565 ***	0.537 ***
		(0.120)	(0.120)	(0.119)	(0.123)
ΔMN_t	-	-	0.032	-	0.028
			(0.129)		(0.127)
ΔLW_{t-1}	-	-	-	0.096 *	-0.142 **
				(0.053)	(0.063)
$IRCA_t$	-26.484 ***	-10.794	-10.772	-10.756	-12.625
	(9.749)	(10.579)	(10.626)	(10.722)	(10.287)
Immigration Act$_t$	6.206 *	19.025 ***	18.844 ***	18.730 ***	18.210 ***
	(3.446)	(4.790)	(4.895)	(4.845)	(5.045)
$Policy_t$	0.694	0.147	-0.090	1.822	6.287
	(7.228)	(6.13)	(6.35)	(6.341)	(8.099)
Constant	7.412 **	-42.558 ***	-42.992 ***	-43.113 ***	-33.121 ***
	(3.247)	(10.604)	(10.704)	(10.642)	(10.754)
Newey-West truncation parameter	5	5	5	5	5
Max. number of q lags included	13	12	12	12	13
Joint significance of seasonal dummies	$X^2(11)$	$X^2(11)$	$X^2(11)$	$X^2(11)$	$X^2(11)$
	= 154.00 ***	= 135.57 ***	= 134.42 ***	= 139.44 ***	= 127.39 ***
Observations	412	413	413	413	412
Adjusted R-squared	0.443	0.569	0.568	0.603	0.575

Notes: Newey-West estimates. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

of illegal migration by around 5,000 people. Surprisingly, we also find no significant effect for Mexican migrant networks. Regarding the results of the linewatch hours, the effect on the apprehension variable is ambiguous as we find a significant positive and a significant negative effect in our different specifications.

The Immigration Act variable has a positive effect on the apprehensions variable. Although the law only concerned legal immigration to the United States (it was primarily thought to attract qualified migrants that where needed in the US-market), it may also have had a "call-effect" on the illegal migrants. Our coefficients show that the launching of the Immigration Act increases the yearly flow of illegal migrants from Mexico to the United States by around 19,000 people (depending on the specification this coefficient ranges between 6,000 and 19,000). Contrary to that result, the IRCA dummy variable turns out to be negatively significant only in the first specification.

The policy variable remains insignificant in every specification. This seems to be revealing of the fact that illegal immigration has not declined as a result of tighter border controls. Moreover, the reported F-test shows that the seasonal dummy variables are jointly significant, which indicates that seasonal effects are present in our model.

V. Concluding remarks

In our theoretical framework we have reviewed several trade models which pointed in different directions. First and foremost the classical approach by Heckscher-Ohlin and Mundell (1957) to show that factor movements and international trade are substitutes and the work by Markusen (1983) who shows the opposite, namely that trade and migration are complements if trade has causes other than different factor supplies, e.g., different technologies or scale effects in production. However, there are several other aspects and models which do not lead to an unambiguous conclusion at all.

Our results indicate that increasing bilateral trade flows cause larger illegal migration from Mexico to the United States. Therefore, trade and migration are complements in the Mexican case. Surprisingly, the US immigration policy seems to have no effect on the illegal migrant flow. To stem the illegal migration, it would rather be necessary to create more jobs and to reduce the prevailing poverty and high income inequality in Mexico, which are not adequate for a middle-income country. Thus, within our theoretical framework we are able to reject the approach of Heckscher-Ohlin that trade and migration are substitutes and confirm the underlying

theories of those models which point into the direction of a complementary relationship between international trade and factor movements.

However, this analysis also has some constraints. In order to empirically prove the validity of some of the theoretical models (e.g. López-Schiff, different technologies or increasing returns to scale), it would be necessary to consider variables for the skills of the Mexican workforce, the migration costs and for the productivity in both countries. It would also be interesting to investigate the effect of the US-Official Development Assistance in Mexico and of the number of young Mexicans in working age on Mexican migration to the United States. But again, missing monthly data from 1968 onwards did not allow us to extend the analysis in this paper.

Furthermore, it is quite reasonable to assume that Mexico shows regional differences regarding the links to the US economy. This unequal distribution across regions may also imply differences in the change of incentives to migrate due to trade liberalisation. This means that regions which are more integrated with the US show a decreasing migration flow than before the NAFTA treaty and vice versa. However, due to data constraints we were not able to address this problem.

In future research it may be interesting to investigate the effect of the trade flows by commodity groups on illegal migration.

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