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Implications of U.S. Immigration Policies for North American Economies

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We develop a four-sector (labor-intensive agriculture, capital-intensive agriculture, service & construction, and manufacturing) general-equilibrium model of North American countries to analyze the effects of tighter U.S. immigration policies. Results show that these policies erode the comparative advantage of U.S. labor-intensive agriculture, causing U.S. production and exports to fall and other countries to expand their exports to the United States. In Mexico, low-skilled labor demand in labor-intensive agriculture increases as production rises. The effectiveness of U.S. tighter immigration policies depends on the substitutability between U.S. domestic and undocumented workers. Immigration policies exacerbate the wedge between Mexican low-skilled wage rate and the undocumented wage rate, intensifying the underlying cause for unauthorized entry.

Key words: labor-intensive sectors, labor flow, trade

Introduction

In the 1960s, labor scarcity arising from the culmination of the bracero program, established migration routes, and high U.S. wages incentivized unauthorized migrants from Mexico to cross the border and seek employment in the United States. By the early 1980s, the number of undocumented migrants working in many U.S. sectors reached over 2 million (Passel, 1986). To assimilate these workers into the U.S. economy, the 1986 Immigration Reform and Control Act provided amnesty to unauthorized workers in the United States (Gunter, Jarrett, and Duffield, 1992). However, the amnesty provision of this law did not reduce unauthorized entry into the United States, because new migrants were hopeful of being granted citizenship (Orrenius and Zavodny, 2003). After September 11, 2001, the United States enforced tighter border security following the enactment of the Patriot Act. However, because of the large disparity in wages between Mexico and the United States, illegal border crossing continued to accelerate, and the number of undocumented workers in the United States peaked at 12 million in 2007 (Martin, 2005; Martin and Zürcher, 2008; Passel and Cohn, 2011; Luckstead, Devadoss, and Rodriguez, 2012). Most of these undocumented migrants are low-skilled workers and seek employment in labor-intensive sectors of the U.S. economy, including fruit and vegetable production, service, and construction (Boucher and Taylor, 2007; Taylor et al., 2012; Devadoss and Luckstead, 2008).

Migration intensified until the mid-2000s, then slowed and reversed because of the Great Recession and the resulting weaker U.S. job market, tighter border surveillance, heightened domestic enforcement, decline in Mexican birth rates, and improved economic conditions in Mexico

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(Passel, Cohn, and Gonzalez-Barrera, 2012). As a result, net flows reached 0 around 2012.[1] The downward trend in the number of undocumented workers continued through the Obama administration (Horsley, 2016). The Pew Research Center (2019) estimates that 1.550 million undocumented workers returned to Mexico between 2007 and 2016. The reverse migration further deepened under the Trump administration due to stricter border control, greater deportation through domestic enforcement (Dickerson, 2017), and continued improvement in economic conditions in Mexico (Jordan, 2015). U.S. government expenditures on the the Customs and Border Patrol and Immigration and Customs Enforcement agencies increased from $9.2 billion in 2003 to $28.1 billion in 2018, in 2003 dollars (American Immigration Council, 2017). The Trump administration has ratcheted up immigration enforcement to curb the unauthorized entry and to reduce the number of undocumented workers. This study examines the impacts of stricter immigration policies on the economies of North American countries by modeling key sectors and restrictive cross-border labor mobility.

Lower birth rates, better opportunities for education (particularly in rural areas), and greater job availability in nonfarm sectors in recent years have caused the rural farm labor supply in Mexico to dwindle from 1980 to 2010 (Charlton and Taylor, 2016). Consequently, the United States and Mexico are increasingly competing for this shrinking labor force, and U.S. growers continue to face chronic labor shortfalls. With the U.S. economic recovery and accelerated hiring in many sectors, the low-skilled labor shortage has become a serious problem,[2] partly because of the short supply of Mexican workers (Jordan and Pérez, 2016). The tightening of labor markets has caused wages to rise, particularly in the farm sector (Jordan, 2015). Because timely completion of farm operations, such as harvesting, are critical, insufficient labor has caused substantial crop loss (Luckstead, Devadoss, and Rodriguez, 2012).

A few studies have examined the implications of tougher immigration enforcement for the U.S. farm sector. Boucher and Taylor (2007) concluded that stricter immigration policies may limit the entry of undocumented workers into U.S. labor-intensive agricultural production but keep the existing workers from returning to Mexico. Consequently, the net effect on the number of undocumented workers is ambiguous. Devadoss and Luckstead (2008) found that, because 95% of farm-labor in the Californian labor-intensive agricultural sector are immigrants, one new immigrant does not cause any precipitable decline in the domestic workforce or wage rate. Devadoss and Luckstead's (2011) partial-equilibrium analysis of immigration policies showed that stricter domestic and border enforcement decreased unauthorized farm workers by 17,094 and reduced U.S. farm exports to Mexico by $360 million. A computable general-equilibrium analysis by Zahniser et al. (2012) found that a reduction in the number of unauthorized workers by 2.1 million decreased the output in several labor-intensive agricultural sectors by 1.7%–3.5%. Kostandini, Mykerezi, and Escalante (2014) used difference-in-difference econometric models to show that county-level enforcement of 287(g) contracts (which allows local authorities to enforce federal immigration law) reduced the undocumented population by more than the number of law-breaking immigrants. Their results also indicated that counties that enforced 287(g) contracts experienced higher per-worker costs and a reduction in farm income and vegetable acres relative to adjacent counties, providing evidence of potential farm labor scarcity. Devadoss and Luckstead (2018) developed a dynamic partial-equilibrium model of U.S. and Mexican labor markets to study the effects of stricter immigration policies and the use of guest-worker program on undocumented workers and labor-intensive U.S. agricultural production. Their findings indicated that the U.S. immigration policies, aimed at curbing the inflow of migrants and deporting undocumented workers, intensified the acute

[1] Annual inflows of unauthorized immigrants from Mexico peaked at half a million in the late 1990s and early 2000s and then started to decline, falling to 350,000 in the mid-2000s and again to 100,000 in 2014 (Jordan and Pérez, 2016). Furthermore, apprehensions at the southern border declined to 310,531 in 2017, the lowest since 1971, an indication of fewer migrants attempting to enter the United States (U.S. Customs and Border Protection, 2017).

[2] As reported by Jordan and Pérez (2016), many sectors experienced labor scarcity: There were 700,000 vacancies in the restaurant and accommodation sector in May 2015, and 86% of construction firms were not able to find workers for carpentry, electrical work, and other operations in 2015.

labor shortages, but the expanded use of the H-2A program helped to alleviate the labor shortfall.[3] Furthermore, they observed that immigration policies cost substantially more than implementing the guest-worker program.

The studies that use a partial-equilibrium model of the agricultural sector to analyze domestic and border enforcement policies do not capture intersectoral impacts. With undocumented workers heavily employed in the agricultural, service, and construction sectors and the highly integrated U.S., Canadian, and Mexican economies, it is important to analyze the impacts of heightened domestic and border enforcement on the North American countries using a general-equilibrium framework. In contrast to previous general-equilibrium models, which examined the impacts of an exogenous reduction of the undocumented workforce, we model the endogenous decisions of low-skilled Mexican workers to work either in Mexico or in the United States as undocumented workers or spend time in leisure.

This article develops a general-equilibrium model consisting of labor-intensive agricultural, capital-intensive agricultural, service & construction, and manufacturing sectors of the North American countries' economies and the restrictive cross-border migration from Mexico to the United States. Our primary research question is to analyze the impacts of the immigration policy changes under the Trump administration on U.S. low-skilled labor markets, unauthorized entry, and the number of undocumented workers. The analysis also provides insight into the impacts on production, consumption, trade, and welfare. We draw policy implications from our findings.

Model

The model includes labor and commodity markets in the United States, Mexico, and Canada and incorporates the rest of the world (ROW) to capture the economic interdependence between North American countries and ROW through trade. With the North American economies having become increasingly integrated over the last 3 decades through trade and labor markets, Mexican immigrants have become an integral part of the U.S. workforce and are employed in many sectors.[4,5] To analyze the impacts of immigration policy, we consider key U.S. sectors that heavily employ immigrant labor and engage extensively in bilateral trade. Domestic low-skilled workers and immigrants are imperfect substitutes in the production processes of these sectors, which include labor-intensive agriculture,[6] capital-intensive agriculture, service & construction, and manufacturing. Each sector of the model consists of consumption, production, and market clearing. Further, the model incorporates restrictive cross-border labor mobility to capture the employment of undocumented workers in the labor-intensive agricultural and service & construction sectors.

Given the complex and lengthy nature of this general-equilibrium model, we present the detailed model structure and equations in the online supplement (available online at www.jareonline.org. Here, we describe the key parts of the overall model and elaborate on the components of the immigration and labor markets with equations.

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[3] For additional details related to policies and the increasing trend of H-2A guest workers, see Luckstead and Devadoss (2019).

[4] Several industries employ a significant number of immigrant workers, including private households (45%); textile, apparel, leather manufacturing (36%); agriculture (33%); accommodation (32%); and food manufacturing (29%) (Desilver, 2017). Numbers in parentheses are the percentage of immigrant workers in the industry.

[5] Jordan and Pérez (2016) report that 60% of the undocumented workforce is employed in the service, construction, and production sectors, twice the share of U.S. natives. Because of the physically demanding nature of these jobs, most U.S. workers are not willing to perform them.

[6] Some agricultural segments, such as fruits and vegetables, employ relatively more labor than others, such as grain, row crops, and livestock production. Consequently, we refer to the former group as the labor-intensive sector and the latter group as the capital-intensive sector.

Consumption

For North American countries, we consider two types of consumers: low-skilled and skilled workers. For each group, a representative consumer maximizes utility governed by constant elasticity of substitution (CES) preferences by choosing consumption of four sectoral goods (labor-intensive agriculture, capital-intensive agriculture, manufacturing, and service & construction) and leisure. The labor- and capital-intensive agricultural goods and manufacturing good are supplied domestically and imported, whereas the service & construction good is supplied only by the domestic market. We utilize the Armington assumption, implying that consumers differentiate goods by country of origin (i.e., each sectoral good is a CES nest of imperfect substitute of domestically produced and imported goods).

Skilled and low-skilled workers in the United States and Canada and skilled workers in Mexico work in their respective countries. In contrast, Mexican low-skilled workers have the opportunity to legally work in the United States through the guest-worker program or seek employment as undocumented workers in the United States. The income of skilled and low-skilled workers in the United States and Canada and skilled workers in Mexico consists of their share of profits from the four sectors, capital earnings, labor income, and net transfers from the government. The budget constraints of these groups of workers entail their income is spent on consumption of the four sectoral goods and also covers the opportunity cost of leisure. The income source for low-skilled Mexican workers includes their share of profits from the four production sectors in Mexico, earnings from capital, government transfers, labor income from work in Mexico, undocumented-worker earnings in the United States, and guest-worker earnings in the United States. The expenditures of these consumers include spending on four sectoral consumption goods, migration costs incurred for paying smugglers and forgone wages, and opportunity cost of leisure. Utility maximization subject to the budget constraint yields demand functions for commodities and leisure. Labor supply is derived from the identity that total time is allocated between leisure and work.

Production

In the three North American countries, the CES specifications of the production functions for the four sectoral goods are as follows: The manufacturing good in each North American country is produced by utilizing capital and skilled labor. The capital-intensive agricultural commodity is produced by employing capital and low-skilled labor. In Canada and Mexico, the labor-intensive agricultural commodity is produced using capital and low-skilled workers. However, the U.S. labor-intensive agricultural commodity is produced using capital, U.S. low-skilled workers, and temporary migrant workers consisting of undocumented workers and guest workers from Mexico.[7] The production for the service & construction sector in Canada and Mexico use capital, skilled labor, and low-skilled labor, but U.S. production of the service & construction good employs capital, domestic skilled labor, domestic low-skilled labor, and undocumented workers. In the labor-intensive agricultural and service & construction production process, U.S. domestic low-skilled labor and undocumented workers are treated as imperfect substitutes.

The model incorporates domestic enforcement policy, which imposes fines (FC) on producers of labor-intensive agricultural and service & construction goods if they are caught employing undocumented workers. These fines are

$$FC = dcL^{UI}, \tag{1}$$

[7] We assume the income earned by temporary workers in the United States is spent in Mexico, which is similar to remittances. In reality, the temporary workers also spend money in the United States, and the results of consumption could be a bit overstated for Mexico and understated for the United States.

where d is the probability of getting caught, c is the fine per worker, and L^{UI} is the number of undocumented workers employed. Profit maximization yields input demand, which is used to obtain supply functions.

Since the focus of the study is on the impact of immigration policies on North American countries' labor markets, commodity markets, and economies, we do not fully model the various components of ROW. Rather, we incorporate ROW into the model by introducing reduced-form supply and demand functions for the three trade goods: labor-intensive agriculture, capital-intensive agriculture, and manufacturing.

Immigration and Undocumented Labor

This subsection focuses on economic forces that determine labor migration between Mexico and the United States. Low-skilled workers in Mexico endogenously choose to work in Mexico, to seek employment (as undocumented or guest workers) in the United States, and to partake in leisure. The supply of temporary workers is determined by the differences between the low-skilled wage rate in Mexico and the wage rate in the United States. The demand for temporary workers in the United States arises from input demand from profit maximization.

Because of the differences in wage rates between Mexican low-skilled workers (w^{MN}) and U.S. undocumented workers (w^{UI}), some Mexican low-skilled workers incur migration cost (g) to cross U.S. border illegally and seek employment in the labor-intensive U.S. agricultural and service & construction sectors. Of the workers (L^{I}) attempting to cross the border, a portion of them (b) are apprehended at the border and returned to Mexico, and only $(1-b)L^{I}$ successfully enter the United States and become part of the undocumented workforce (L^{UI}). Since they are unauthorized to work in the United States, U.S. Immigration and Customs Enforcement detains and deports some of these workers. As shown by Devadoss and Luckstead (2018), at equilibrium, given that the probability of getting caught is d,[8] the number of deported workers is equal to the number of successful entrants:

(2) $$dL^{UI} = (1-b)L^{I}.$$

At equilibrium, low-skilled Mexican workers will migrate until the undocumented worker wage rate (w^{UI}) is equal to the weighted average of the Mexican wage rate for low-skilled workers (w^{MN}) and migration cost (g) (Devadoss and Luckstead, 2018):

(3) $$w^{UI} = w^{MN}\left(1 + \frac{d}{1-b}\right) + \frac{d}{1-b}g.$$

The interpretation of these weights are as follows: Suppose the migration cost g is 0. Then, the wedge between the undocumented wage rate and Mexican wage rate is determined by the deportation and border apprehension rates. The higher the rates, the higher the wedges, implying that—given the larger risks involved in seeking unauthorized employment in the United States—migrants will attempt to enter only if the undocumented wage rate is significantly higher than the Mexican wage rate. Thus, the rate $\frac{d}{1-b}$ acts as a deterrent for migrants to cross the border, or it works similar to an *ad valorem* export tax. When g is not 0, stricter border apprehension and domestic deportation also require higher undocumented wage rates for migrants to incur these costs and enter the United States.

Low-skilled Mexican workers have the option of, instead of illegally migrating to the United States, working in the United States legally through the H-2A guest-worker program. These guest-workers are paid w^{UG}, which is equal to the wage rate earned by undocumented workers plus the potential fines incurred by employers:[9]

(4) $$w^{UG} = w^{UI} + dc.$$

[8] We assume the probability of employers getting caught and the deportation rate are equal.

[9] We assume the wage rates for H-2A workers and domestic workers are equal to AEWR which is the minimum wage that will not adversely impact the employment opportunities for U.S. workers.

Market Clearing

We close the model by specifying commodity and input market-clearing conditions. For traded goods, given the Armington assumption that goods are differentiated by region, the supply of each commodity from each North American country is equal to the demand by all labor types in all regions plus ROW demand. ROW exports are equal to demand by all labor types in North American countries. For the nontraded good, supply in each country is equal to demand by skilled workers and low-skilled workers.

Since capital is perfectly mobile across the three North American countries, the total capital endowment in all three countries is equal to capital used in all four sectors in these countries. In each country, the supply of skilled workers is employed domestically in the manufacturing and service & construction sectors. The supply of Canadian and U.S. low-skilled workers is employed in their respective labor-intensive agricultural, capital-intensive agricultural, and service & construction sectors. The supply of Mexican low-skilled workers is employed in the Mexican labor-intensive agricultural, capital-intensive agricultural, and service & construction sectors; the remaining workers work in the U.S. labor-intensive agricultural and service & construction sectors as undocumented or guest workers.

Empirical Analysis

Data and Calibration

The data for key variables were compiled from the GTAP 9 database (Aguiar, Narayanan, and McDougall, 2016), a global dataset covering 140 regions and 57 commodities. Of the 140 regions, we maintain Canada, Mexico, and the United States and aggregate all non–North American regions into the ROW. The 57 commodities are aggregated into the four sectors as defined in the theoretical model. For these country and commodity aggregations, we collect data on tariffs, sectoral inputs and outputs, consumption, and population. We obtain low-skilled worker wages from the National Agricultural Workers Survey and Marosi (2016). All value and price data are converted to U.S. dollars using exchange rates collected from International Monetary Fund (2016). Workers with high school education or above are considered skilled workers; data for these workers were compiled from the Organisation for Economic Co-Operation and Development (2018). We obtain data on guest workers from the U.S. Department of State (2015).

Following the CGE literature, we set prices to 1; consequently, quantities and values of inputs and outputs are measured in the same units (Burfisher, 2017). Given the above data, we follow Rutherford (2002) to calibrate the share parameters in the utility functions and the returns to scale, productivity parameters, and share parameters in the production functions. For the calibration of parameters in the labor-intensive agricultural commodity production function, we assume a CES parameter value of -1.85, which yields an elasticity of substitution of 0.35. This implies limited substitutability of U.S. low-skilled workers and undocumented workers, indicating the unwillingness of U.S. low-skilled workers to perform physical field labor. The deportation rate d of undocumented workers is 1.5% and the apprehension rate b at the border is 50%, which is consistent with Gonzalez (2015). Using the values of b, d, the U.S. undocumented wage rate, the Mexican low-skilled wage rate, and the wage-linkage equation, we calibrate the migration cost as

$$g = w^{UI}\frac{1-b}{d} - w^{MN}\left(1+\frac{1-b}{d}\right). \tag{5}$$

Using the undocumented wage and U.S. low-skilled labor wage, we calibrate the U.S. fine levied for hiring undocumented workers as

$$c = \frac{1}{d}\left(w^{UG} - w^{UI}\right). \tag{6}$$

The online supplement provides additional details on the calibration. To understand how the model reacts to the assumed parameter values, we undertake sensitivity analysis and report the results below.

Counterfactual Simulation

We solve the model numerically to analyze the impacts of stricter U.S. immigration enforcement on the North American economies. We run baseline and alternate scenarios. With the calibrated parameters, the baseline scenario replicates the data. In the alternate scenario, we increase the domestic deportation rate (d) by 10% and the border apprehension rate (b) by 15% to reflect the ramped-up immigration control under the Trump administration.[10] We compare the results of the alternate scenario to those of the baseline to quantify the impacts of tighter immigration policies on labor market, domestic prices, production, sectoral profit, consumption, trade, and welfare.

Table 1 reports the baseline values and impacts as percentage changes for undocumented workers, low-skilled and skilled workers, and capital. Similarly, Table 2 presents the results for bilateral trade volumes, Table 3 reports the impacts on total production and producer prices, and Table 4 documents the results for CES consumption and price indices, wage rate, and welfare. Tables S5–S8 in the online supplement report the results in absolute differences.

Heightened border and domestic controls cause total supply of undocumented migrant workers in the labor-intensive agricultural and service & construction sectors in the United States to decline for two reasons. First is the direct effect: Heightened border surveillance (increase in b) curtails the number of migrants successfully crossing the border, and tighter domestic enforcement (increase in d) results in more undocumented workers being deported from the United States to Mexico. Second is the indirect effect: Due to stricter immigration controls, the probabilities of successfully entering and remaining in the United States decline; consequently, fewer low-skilled workers in Mexico are willing to incur the migration cost (g) and attempt to cross the U.S.–Mexican border. As a result, the number of working hours of undocumented workers in the labor-intensive agricultural and service & construction sectors declines by 10% (or 95 million hours) and 18% (or 2,318 million hours), respectively (Table 1), which causes the undocumented wage rate to rise by 24%, from \$9/hour to \$11/hour (Table 4).

With fewer undocumented workers and U.S. domestic workers unwilling to preform field work, U.S. labor-intensive agricultural production declines by 3% as labor becomes scarce and costs rise (Table 3). As explained above, we assume a low elasticity of substitution between domestic and undocumented workers. Because of this low substitution, this sector contracts, resulting in 3% (or 44 million hours) fewer U.S. domestic low-skilled working hours (Table 1). With higher labor costs, the U.S. labor-intensive agricultural sector loses comparative advantage and U.S. competitiveness in the export markets falls. By contrast, Mexican, Canadian, and ROW labor-intensive agricultural sectors are relatively more competitive, and production of these commodities expands, leading to an increase in exports to the United States by 2%, 2%, and 1%, respectively. With the loss of comparative advantage and more international competition, U.S. domestic sales decline by 2.85% and U.S. labor-intensive agricultural exports to Mexico, Canada, and ROW fall by 5%, 3%, and 1%, respectively (Table 2).

However, in the U.S. service & construction sector, the number of domestic U.S. low-skilled working hours rises slightly, by 0.05% (or 127 million hours) (Table 1) because, in contrast to the U.S. labor-intensive agricultural sector, this sector is not traded. Consequently, since imports do not enter the United States from the other countries, heightened foreign competition is not a factor, and domestic demand for this good has to be met by domestic production. Furthermore,

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[10] Previous studies have considered larger percentage changes for d and b. For example, Devadoss and Luckstead (2018) implemented percentage changes of 15% for d and 20% for b in their dynamic partial-equilibrium analysis of the effects immigration control on only U.S. labor-intensive agriculture.

Table 1. Impacts of Tighter Immigration Policies on Undocumented Workers, Low-Skilled and Skilled Workers, and Capital

		Labor-Intensive Agriculture		Service & Construction		Capital-Intensive Agriculture		Manufacturing	
		Baseline Values	**Percentage Change**	**Baseline Values**	**Percentage Change**	**Baseline Values**	**Percentage Change**	**Baseline Values**	**Percentage Change**
U.S.	Undoc. workers	939.73	−10.10	12,607.27	−18.39	n/a	n/a	n/a	n/a
	Low-skilled	1,273.29	−3.44	254,965.59	0.05	18,674.80	−0.01	n/a	n/a
	Skilled	n/a	n/a	147,769.54	0.05	n/a	n/a	46,973.15	0.00
	Capital	12,892.40	−3.45	2,933,848.00	0.02	151,779.00	−0.02	798,628.60	−0.03
ME	Low-skilled	4,218.47	2.29	83,357.53	0.23	14,180.40	0.13	n/a	n/a
	Skilled	n/a	n/a	11,864.72	0.08	n/a	n/a	6,092.30	0.06
	Capital	3,880.60	2.21	474,910.50	0.00	48471.90	0.05	151,673.40	−0.01
CA	Low-skilled	114.92	1.75	24,498.63	0.00	2619.65	−0.01	n/a	n/a
	Skilled	n/a	n/a	21,815.14	0.00	n/a	n/a	6,529.61	−0.01
	Capital	1,250.60	1.75	358,253.40	−0.01	29,255.20	−0.02	159,363.90	−0.02

Notes: Units for baseline values are million hours for labor and US$ millions for capital.

Table 2. Impacts of Immigration Policies on Bilateral Trade

		United States		Mexcio (ME)		Canada (CA)		ROW	
		Baseline Values	Percentage Change	Baseline Values	Percentage Change	Baseline Values	Percentage Change	Baseline Values	Percentage Change
U.S.	Labor-intensive agriculture	57,784.80	−2.85	1,210.10	−4.99	4,622.20	−3.46	10,018.44	−0.88
	Service/construction	18,848,775.90	−0.12	n/a	n/a	n/a	n/a	n/a	n/a
	Capital-intensive agriculture	1,104,832.90	−0.01	20,258.18	0.03	20,118.07	0.02	145,223.07	0.00
	Manufacturing	6,387,333.00	−0.01	156,732.80	0.04	207,869.90	0.01	959,293.71	0.00
ME	Labor-intensive agriculture	10,098.86	2.19	7,481.90	−0.07	978.20	1.55	746.34	−0.28
	Service/construction	n/a	n/a	1,068,322.00	0.04	n/a	n/a	n/a	n/a
	Capital-intensive agriculture	11,564.88	0.00	159,205.00	0.03	308.55	0.03	4,829.74	0.00
	Manufacturing	238,612.39	−0.02	388,862.20	0.02	13,821.00	0.00	68,915.19	0.00
CA	Labor-intensive agriculture	1,932.40	1.64	54.10	−0.60	2,087.60	1.01	2,944.04	−0.34
	Service/construction	n/a	n/a	n/a	n/a	1,983,587.10	0.00	n/a	n/a
	Capital-intensive agriculture	20,315.78	−0.03	1,994.07	0.00	145,108.70	0.00	21,956.18	0.00
	Manufacturing	268,574.70	−0.02	5,740.50	0.02	561,349.30	0.00	103,481.67	0.00
ROW	Labor-intensive agriculture	9,679.87	0.58	261.29	−1.64	1,084.77	−0.05	n/a	n/a
	Capital-intensive agriculture	70,510.59	−0.01	5,685.85	0.03	11,053.31	0.02	n/a	n/a
	Manufacturing	1,621,283.91	−0.01	114,113.53	0.04	137,828.85	0.01	n/a	n/a

Notes: Units for baseline values are US$ millions.

Table 3. Impacts of Immigration Policies on Total Production and Producer Prices

		U.S.		Mexico (ME)		Canada (CA)	
		Baseline Values	**Percentage Change**	**Baseline Values**	**Percentage Change**	**Baseline Values**	**Percentage Change**
Total production	Labor-intensive agriculture	73,635.54	−2.65	19,305.30	1.19	7,018.14	0.60
	Service/construction	18,848,775.90	−0.12	1,068,322.00	0.04	1,983,587.10	0.00
	Capital-intensive agriculture	1,290,432.22	0.00	175,908.17	0.03	189,374.73	0.00
	Manufacturing	7,711,229.41	0.00	710,210.78	0.00	939,146.17	−0.01
Producer Prices	Labor-intensive agriculture	1	2.99	1	0.93	1	1.15
	Service/construction	1	0.15	1	−0.02	1	0.00
	Capital-intensive agriculture	1	−0.01	1	−0.01	1	0.00
	Manufacturing	1	−0.01	1	−0.01	1	−0.01

Notes: Units for baseline values for total production are US$ millions and producer prices are normalized to 1.

Table 4. Impacts of Immigration Policies on Leisure, Wage Rates, and Welfare

		United States		Mexico		Canada	
CES labor-intensive agriculture price index	Baseline values	3.25		2.55		3.86	
	Percentage change	2.48		1.22		2.12	
CES capital-intensive agriculture price index	Baseline values	2.47		2.65		2.64	
	Percentage change	−0.01		−0.01		−0.01	
CES manufacturing price index	Baseline values	2.94		3.22		3.26	
	Percentage change	−0.01		−0.01		−0.01	
		Low-Skilled	**Skilled**	**Low-Skilled**	**Skilled**	**Low-Skilled**	**Skilled**
CES labor-intensive agriculture price index	Baseline values	7,905.91	17,055.87	1,507.83	2,027.06	778.04	1,548.79
	Percentage change	−1.64	−1.64	−0.68	−0.86	−1.39	−1.39
S/C construction (US$ millions)	Baseline values	5,969,797.03	12,878,978.87	455,700.76	612,621.24	663,263.40	1,320,323.70
	Percentage change	−0.12	−0.12	0.14	−0.04	0.00	0.00
CES capital-intensive agriculture consumption index	Baseline values	157,213.73	339,166.03	30,251.36	40,668.40	22,528.12	44,845.55
	Percentage change	−0.01	−0.01	0.13	−0.04	0.00	0.00
CES manufacturing & consumption index	Baseline values	923,978.44	1,993,350.65	88,391.77	118,829.46	94,680.87	188,476.26
	Percentage change	−0.01	−0.01	0.13	−0.05	0.01	0.00
Leisure (million hours)	Baseline values	1,297,345.14	962,614.49	773,346.77	138,934.59	116,476.36	121,230.49
	Percentage change	−0.01	−0.01	0.27	−0.01	0.00	0.00
Undocumented wage ($/hour)	Baseline values	8.98	n/a	n/a	n/a	n/a	n/a
	Percentage change	24.46	n/a	n/a	n/a	n/a	n/a
Wage ($/hour)	Baseline values	10.33	31.61	1.50	11.43	10.33	19.76
	Percentage change	−0.01	−0.01	−0.22	−0.07	0.00	0.00
Welfare	Baseline values	2,101,547.96	2,872,625.80	516,682.24	206,520.66	222,189.00	352,081.09
	Percentage change	−0.04	−0.04	0.21	−0.02	0.00	0.00

producers in this sector do not lose comparative advantage and market shares in foreign countries. As a result, the production decline of 0.12% in this sector (Table 3) is considerably less than that in the labor-intensive agricultural sector. With fewer undocumented workers and only a slight decline in production, more low-skilled domestic workers are employed. In addition, U.S. low-skilled domestic workers come out of leisure to work in this sector—despite the U.S. low-skilled wage rate falling minimally (0.01%), which implies a decline in the opportunity cost of leisure—to make up for some of the income lost as demand for low-skilled labor in both the labor-intensive and capital-intensive agricultural sectors falls.[11]

Under heightened border control and domestic enforcement, the number of low-skilled workers available in Mexico increases, which causes the wage rate to decrease slightly by 0.22%. With the number of working hours of low-skilled workers in the labor-intensive agricultural sector expanding by 2% (or 97 million hours) and lower wage rates, production expands by 1%. Mexico uses this increase in supply of the labor-intensive agricultural commodity to expand exports to the United States (2%) and to Canada (2%). In doing so, Mexico meets the U.S. demand for this commodity because the U.S. supply falls as domestic workers do not replace the displaced undocumented workers in this production sector and international competition expands. Despite more working hours and lower production costs, sales in the domestic market decline slightly, by 0.07% (Table 2), because the 2% increases in the CES composite price for the labor-intensive agricultural commodity in the United States and Canada are more than the CES 1% price increase in Mexico (Table 4).[12] Consequently, with more opportunities to sell in the United States and Canada than in Mexico, it is more profitable for Mexican producers to export to the United States and Canada than to sell in their domestic market. As more low-skilled workers are available in Mexico, production in the nontraded service & construction sector expands and the price falls modestly, increasing consumption. Because the U.S. undocumented wage rate rises, the remaining undocumented workers in the United States earn more wage income. This, coupled with the fall in the Mexican low-skilled wage, lowers the opportunity cost of leisure and low-skilled workers spend more time in leisure, leading to a reduction in the total labor supply. We model leisure endogenously, which moderates the effect on wages and labor supply.

As elaborated previously, stricter immigration policies reduce the number of undocumented workers and U.S. labor-intensive agricultural production, and U.S. demand for this commodity must be met by exports from other countries. Part of this demand is met by Mexican and ROW exports, and the remainder is met by Canadian exports, as evident from the 2% increase in Canadian exports of the labor-intensive agricultural product to the United States (Table 2). As a result, Canadian production of this commodity expands by 1% (Table 3), which requires more low-skilled Canadian labor. Consequently, low-skilled working hours in this sector rise by 2% as labor moves from capital-intensive agriculture to this sector (Table 1).

The capital-intensive agricultural and manufacturing sectors in all three North American countries are indirectly impacted. In the United States, with fewer undocumented workers, low-skilled domestic workers move from the capital-intensive agricultural sector to the service & construction sector. This, coupled with a decline in demand as income declines, leads to a small decline in production of the capital-intensive agricultural product (see Table s7 in the online supplement). Manufacturing production also falls minimally because of lower demand resulting from the decline in income. In Mexico, returned undocumented workers are employed in the labor-intensive agricultural, capital-intensive agricultural, service & construction sectors; consequently, production in these sectors expands modestly. Furthermore, these workers substitute for the skilled

[11] Li and Reimer (2019) found that border surveillance lowers the wage rate of undocumented workers slightly (by $0.29). This finding is consistent with our results, even though our results are based on a general-equilibrium model, which accounts for interaction among the sectors and leisure.

[12] Given the Armington trade assumption, the CES price is a composite of the prices of domestic and foreign-produced goods paid by consumers.

workers, and some of the skilled workers move to manufacturing, which causes manufacturing production to increase slightly.

These results highlight the importance of the interconnections between the Canadian economy and the U.S. and Mexican economies through international trade, particularly in the labor-intensive agricultural sector. Even though Canada is not directly impacted by U.S. immigration policy on the southern U.S. border, stricter U.S. immigration policy improves the competitive advantage of the Canadian labor-intensive agricultural sector relative to the U.S. labor-intensive agricultural sector, which boosts Canadian exports to the United States, domestic sales, and production. Without an interlink through bilateral trade, the Canadian service sector is largely unaffected by changes in U.S. immigration policy. Also, the Canadian capital-intensive agricultural and manufacturing sectors do not experience significant changes, because the indirect effect of U.S. immigration policy has only very minimal impacts.

Next, we discuss changes in consumption and welfare in the North American countries due to stricter U.S. immigration policies. As these policies reduce production in the U.S. labor-intensive sector, it causes distortions not only in the United States but also in Mexico and Canada because of the cross-country interconnectedness of the labor markets and commodity markets. In the United States, consumption of all three composite goods, the service & construction good, and leisure of both low-skilled and skilled workers fall for two reasons: Income declines, and the increase in the CES price of the labor-intensive agricultural commodity and the price of the service & construction good are considerably more than the decrease in the CES price of capital-intensive agricultural and manufacturing products. Consequently, the welfare of both low-skilled and skilled workers falls. Not surprisingly, consumption for the labor-intensive agricultural commodity declines the most (2%) as the composite price rises by 2%, followed by a 0.12% fall in consumption of the service & construction good (Table 4) as the price increases by only 0.15% (Table 3) because tighter immigration control directly impacts these sectors. Trade plays a key role in how these policy changes impact consumption. For example, the decline in consumption of the traded labor-intensive agricultural commodity is significantly more than that of the nontraded service & construction sector because the price of the former rises, whereas the price of the latter increases only slightly.

In Mexico, the stringent U.S. immigration policies cause greater production of labor-intensive agricultural and service & construction goods, which augments the employment of low-skilled workers and raises their incomes. Mexican imports of U.S. capital-intensive agricultural and manufacturing goods increase as Mexican low-skilled workers consume more of these goods. Also, Mexican exports of the labor-intensive agricultural commodity expand to the United States and Canada, which raises prices in Mexico and lowers consumption by low-skilled workers. Since production of the nontraded service & construction good increases, price declines and consumption rises. The increase in consumption of capital-intensive agricultural, manufacturing, and service & construction goods offsets the decline in the consumption of the labor-intensive agricultural commodity, and the overall welfare of Mexican low-skilled workers rises. This result may seem counterintuitive, but a closer examination reveals that the increase in labor-intensive agricultural production in Mexico displaces U.S. production in this sector, thereby creating more employment for Mexican low-skilled workers, benefiting them. Mexican skilled workers' income declines and they work more, despite the lower wage rate, to make up a portion of the lost income. Consequently, their leisure falls. In addition, consumption of the four sectoral goods declines, leading to a small welfare decrease.

In Canada, the welfare of both low-skilled and skilled workers is minimally impacted. Though wage rates increase and consumption of capital-intensive, manufacturing, and service & construction increases negligibly, these increases are offset by reduced consumption of the labor-intensive agricultural commodity.

Sensitivity Analysis

We undertake four sensitivity analyses for key parameters.[13] First, we lower the Armington elasticity of substitution of domestically produced and imported goods from 2.5 to 1.5 and rerun the simulations. The reduction in this parameter implies that consumers substitute less between domestically produced and imported goods. The results show that changes in most of the variables are less pronounced in response to the lower elasticity of substitution. A notable exception is in the U.S. labor-intensive agricultural sector, where changes in the U.S. producer price and CES composite price are slightly more pronounced (i.e., the producer price increases by 3.21% vs. 2.99% in the main analysis and the CES composite price increases by 2.51% vs. 2.48%). This is because consumers are less willing to substitute for imports of the labor-intensive agricultural commodity as production costs and prices of domestically produced labor-intensive agricultural good rise. Consequently, the shortage in supply has a larger price effect in this sector.

Second, we lower the elasticity of substitution between U.S. low-skilled and undocumented workers in the U.S. labor-intensive agricultural sector from 0.35 to 0.21 (this corresponds to a doubling of the CES parameter from −1.85 to −3.70). The reduction in this parameter implies that producers in this sector are more limited with substitutability between these two groups of workers. Consequently, producers may not be able to find enough domestic workers (i.e., the number of domestic working hours decline by 4.25% vs. 3.44% in the main analysis) and have to rely on undocumented workers, which mitigates the effectiveness of stricter immigration policies (i.e., the number of undocumented working hours falls by only 8.31% vs. 10.10% in the main analysis). As a result, labor-intensive agricultural production decreases more compared to that in the main analysis. Labor-intensive agricultural production in Mexico expands slightly more than in the main analysis, and more Mexican low-skilled workers are now employed in this sector. With fewer undocumented workers returning to Mexico and production expanding, low-skilled Mexican workers increase their working hours by spending less time in leisure as wage rises.

Third, we examine the effects of increasing the elasticity of substitution between U.S. domestic and undocumented workers from 0.35 to 1.59, implying substantially greater substitutability between U.S. low-skilled and undocumented workers. In this case, U.S. producers of the labor-intensive agricultural commodity readily substitute domestic workers for undocumented workers in response to tighter immigration policies. Consequently, the decline in the number of undocumented workers is more pronounced (−25.17% vs. −10.10% in the main analysis) and the number of U.S. low-skilled workers employed in this sector increases to 3.42% (rather than declining by 3.44% as in the main analysis) because more domestic workers now replace undocumented workers. As a result, the production loss in the labor-intensive agricultural sector is less pronounced (−2.43% vs. −2.65% in the main analysis). Though the results of this sensitivity analysis provide key insights of the inner working of the model, they are likely unrealistic, as U.S. low-skilled workers are not keen to work in the labor-intensive agricultural sector.

Fourth, because farmers tend to adapt labor-saving technology to mitigate the adverse impacts of labor scarcity, we undertake a sensitivity analysis to ascertain the impact of immigration policies if we augment capital-specific technology by 10% in U.S. labor-intensive agricultural sector. The results show that stricter immigration policies cause farmers in labor-intensive agriculture to employ fewer workers as a result of this technological change. Undocumented working hours decline by 8.15% (vs. 10.10% in the main analysis) and low-skilled domestic working hours fall by 1.34% (vs. 3.44%). Thus, expanding capital-specific productivity lessens the impacts of immigration policy on low-skilled worker employment, which leads to a labor-intensive agricultural production decline of 1.03% (vs. 2.65% in the main analysis). Because of the smaller decline in production, U.S. exports to Mexico and Canada fall only by 1.96% and 1.33% (vs. 4.99% and 3.46%, respectively). The spillover effects in Mexico and Canada are also dampened, in that Mexican and Canadian

[13] We only report key results here, but the complete set of results is available upon request.

labor-intensive agricultural production increases only by 0.57% and 0.23% (vs. 1.19% and 0.60%, respectively). Other sectors, including undocumented workers in the service & construction sector, are largely unaffected by an increase of 10% in capital-specific technology in U.S. labor-intensive agriculture.

Conclusion

This study develops a four-sector general-equilibrium model of North American labor and commodity markets to analyze the effects of tighter U.S. immigration policies under the Trump administration. The four sectors modeled are labor-intensive agriculture, capital-intensive agriculture, service & construction, and manufacturing. The three North American economies are also linked to the rest of the world through trade. The general-equilibrium model incorporates the Armington imperfect substitutability of goods based on the origins and intersectoral linkages, which captures the direct and indirect effects of the policy changes. For example, if not for intersectoral labor mobility, the increase in the U.S. domestic low-skilled wage rate would have been more pronounced.

The stricter immigration control has a direct effect on U.S. and Mexican labor markets, particularly on low-skilled workers, as the number of undocumented workers falls and the supply of low-skilled workers in Mexico increases. Consequently, the undocumented wage rate in the United States rises, but the low-skilled wage rate in Mexico falls. The indirect effects of these immigration policies impact trade across the North American countries and ultimately feeds back into the labor markets. For instance, with U.S. labor-intensive agricultural production declining, Mexico and Canada increase production of this good to export to the United States. In that process, Mexico and Canada employ more low-skilled workers in labor-intensive agricultural production.

The impact of tighter border and domestic policies on a sector depends on whether the sector's commodity is traded. The results show that these policies erode the comparative advantage of the U.S. labor-intensive agricultural sector, causing production to decline. The implications are two-fold: First, the United States exports less of this commodity as the relative U.S. price rises. Second, producers face more competition at home because other countries export more to the United States. Our results show that the increase in domestic deportation and border apprehension rates reduces U.S. labor-intensive agricultural production by 2.65%. This result is comparable to the findings of Zahniser et al. (2012), who found that an exogenous reduction of 2.1 million undocumented workers in the overall economy causes output in labor-intensive crop production to decline by 1.7%–3.5%. In Mexico, the implication is that the adverse effects of immigration policies on low-skilled Mexican workers are mitigated because labor demand in labor-intensive agricultural production rises as production expands to export to the U.S. market. Although the U.S. service & construction sector suffers from fewer undocumented workers, the production decline in this sector is not as severe as in the U.S. labor-intensive agricultural sector because the service & construction sector does not face import competition or export reallocation.

Our modeling approach generates new results. Because of tighter U.S. immigration policies, the undocumented wage rate rises by 24.46%, with significant adverse implications for the labor-intensive agricultural and service & construction sectors; production in these two sectors fall significantly. Consequently, the United States expands its import of labor-intensive products from Mexico and Canada. The employment of undocumented workers in the service & construction sector declines by 18.39%, which is higher than the 10.10% fall in the labor-intensive agriculture. The reason for this result is that since this sector is nontraded, there are no imports to replace the lower production. Consequently, this sector takes a larger hit in the employment of undocumented workers. We endogenously model the decision of Mexican low-skilled workers to illegally migrate to the United States as they allocate their time between work in Mexico, work in the United States, migrating to the United States, and spending time on leisure. This modeling approach generates unique results. For instance, when Mexican low-skilled workers return to Mexico, they have the option of spending time on leisure. This, along with higher wages earned in the United States, causes the welfare of low-skilled Mexican workers to increase slightly in response to tighter immigration policies.

The effectiveness of tighter U.S. immigration policies hinges upon the unwillingness of U.S. domestic low-skilled workers to perform farm work. Our sensitivity analysis shows that a reduction in the elasticity of substitution between these two groups of workers leads to fewer undocumented workers being deported as a result of the stricter immigration controls. Consequently, producers' heavy reliance on undocumented workers in the labor-intensive agricultural sector is not solved by U.S. immigration policy.

Given the small decrease in Mexican low-skilled workers' wage rate and the large increase in undocumented workers' wage rate (24.46%), stricter immigration policies are counterproductive in solving the root cause of unauthorized migration (i.e., wage disparity). If anything, these policies make the matter worse by exacerbating the wage wedge, which only intensifies future potential for unauthorized entry. Consequently, the U.S. government will need to continue to spend resources to secure the border. However, if Mexico continues to improve its economy through further market reform and engage in free trade with the United States and other countries, then Mexican workers will earn higher wages in Mexico, which will eliminate the incentive for them to trek across the border.[14] But the Mexican economic reform is slower and the U.S. stance of not fully liberalizing trade hinders the wage-equalization process.

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[14] For instance, Canadians do not illegally cross the border in droves to seek employment in the United States as Mexicans do, despite the border between Canada and the United States being much longer than the border between Mexico and the United States. This is because U.S.–Canadian wage differences are not as pronounced as U.S.–Mexican wage differences.

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Online Supplement: Implications of U.S. Immigration Policies for North American Economies

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Model

The model consists of consumers, producers, and market clearing conditions. Below, the superscript $i = U,M,C$ denotes the three countries: United States, Mexico, and Canada. The superscript $k = U,M,C,R$ denotes the four countries: United States, Mexico, Canada, and ROW. The superscript $j = N,E$ indexes low-skilled and skilled workers.

Consumer

Utility is represented by the constant elasticity of substitution (CES) functions:

$$U^{ij} = [\beta_{DY}^{ij}\left(DY^{ij}\right)^{\rho^{ij}} + \beta_{DX_1}^{ij}\left(DX_1^{ij}\right)^{\rho^{ij}} + \beta_{DX_2}^{ij}\left(DX_2^{ij}\right)^{\rho^{ij}} + \beta_{DV}^{ij}\left(DV^{ij}\right)^{\rho^{ij}} + \beta_{DL}^{ij}\left(DL^{ij}\right)^{\rho^{ij}}]^{\frac{1}{\rho^{ij}}} \tag{S1}$$

where β^{ij}s are share parameters that sum to one and ρ^{ij} is the CES parameter with elasticity of substitution $\sigma^{ij} = \frac{1}{1-\rho^{ij}}$. The traded goods ($DY^{ij}$, DX_1^{ij}, and DX_1^{ij}) are Armington composites consisting of domestic and imported commodities by source country:

$$DY^{ij} = \left[\sum_k \beta_{DY}^{ijk}\left(DY^{ijk}\right)^{\rho_{DY}^{ij}}\right]^{\frac{1}{\rho_{DY}^{ij}}},$$

$$DX_1^{ij} = \left[\sum_k \beta_{DX_1}^{ijk}\left(DX_1^{ijk}\right)^{\rho_{DX_1}^{ij}}\right]^{\frac{1}{\rho_{DX_1}^{ij}}},$$

$$DX_2^{ij} = \left[\sum_k \beta_{DX_2}^{ijk}\left(DX_2^{ijk}\right)^{\rho_{DX_2}^{ij}}\right]^{\frac{1}{\rho_{DX_2}^{ij}}}.$$

Here, the superscript i denotes consumption location, k signifies production location, and β^{ijk}s are the share parameters for the Armington composites.

Consumers' income comes from firms' profits, returns to capital, wage income, and government transfers. The budget constraints for low-skilled workers in the United States and Canada are

$$\Psi^{iN}\left(\Pi_Y^i + \Pi_{X_1}^i + \Pi_{X_2}^i + \Pi_V^i + r^i\bar{K}^i\right) + G^{iN} + w^{iN}L_S^{iN} = P_Y^i DY^{iN} + P_{X_1}^i DX_1^{iN} + P_{X_2}^i DX_2^{iN} + P_V^i DV^{iN}, \tag{S2}$$

where Ψ^{iN} is the portion of profits and capital returns belong to low-skilled consumers, G^{iN} is the total government transfers, w^{iN} is wage rate, and L_S^{iN} is labor supply of low-skilled consumers. The budget constraints for skilled workers in the United States, Mexico, and Canada are

$$\text{(S3)}\quad \Psi^{iE}\left(\Pi_Y^i+\Pi_{X_1}^i+\Pi_{X_2}^i+\Pi_V^i+r^i\bar{K}^i\right)+G^{iE}+w^{iE}L_S^{iE}= P_Y^iDY^{iE}+P_{X_1}^iDX_1^{iE}+P_{X_2}^iDX_2^{iE}+P_V^iDV^{iE},$$

where Ψ^{iE}, G^{iE} , w^{iE} , and L_S^{iE} are defined similar to above.

We set up the low-skilled Mexican consumers' budget constraint with endogenous choice between working in Mexican industries that employ low-skilled workers or in the United States as undocumented workers or guest workers. As such, these workers are considered as Mexican nationals where undocumented and guest workers' wage earnings originate from US industries, but expenditures occur in Mexico. Consequently, undocumented and guest workers wage earnings are akin to remittances. The cost of migration to the United States is g, which account for both payments to coyotes to cross the border and opportunity cost of traveling. After entering the United States, these undocumented workers (L^{UI}) earn the unauthorized wage w^I, which is greater than the wage rate w^{MN} paid to low-skilled workers (L_S^{MN}) in Mexico. Mexican low-skilled workers' budget constraint is defined as

$$\text{(S4)}\quad \Psi^{MN}\left(\Pi_Y^M+\Pi_{X_1}^M+\Pi_{X_2}^M+\Pi_V^M+r\overline{K}^M+G^M\right)+w^{MN}L_S^{MN}+w^IL^{UI}+w^{UG}L^{UG}= gL^I+P_Y^MDY^{MN}+P_{X_1}^MDX_1^{MN}+P_{X_2}^MDX_2^{MN}+P_V^MDV^{MN}.$$

Variable definitions are as follows: L^{UG} is the number of Mexican workers that enter the United States legally through the H-2A guest-worker program, w^{UG} is the guest-worker wage rate, L^I is the number of workers attempting unauthorized entry into the United States, b is the portion of workers caught at the border and returned back to Mexico, implying $1-b$ is the proportion of unauthorized workers that successfully cross the US-Mexican border, d is the proportion of unauthorized workers in the United States that are caught by US ICE and returned to Mexico. Consequently, at the equilibrium, the number of deported undocumented workers and the number of successful entrants are equal, as given by $dL^{UI}=(1-b)L^I$. This equation links the number of undocumented workers residing in the United States to the number of undocumented workers entering the United States through border and domestic enforcement.

From utility maximization, we obtain the linkage between the Mexican wage rate and the US undocumented wage rate:

$$\text{(S5)}\quad w^{UI}=w^{MN}\left(1+\frac{d}{1-b}\right)+\frac{d}{1-b}g.$$

Equation S5 shows that the undocumented wage rate is a weighted average of the Mexican wage rate and the migration cost. We also establish the wage linkage between the guest workers and the undocumented workers:

$$\text{(S6)}\quad w^{UG}=w^{UI}+dc,$$

where c is the fine for hiring unauthorized workers.

From the utility maximization, we derive the demand function for the composite traded goods DY^{ij}, DX_1^{ij}, and DX_2^{ij}, service & construction goods DV^{ij}, and leisure (DL^{ij}):

$$DY^{ij} = \frac{I^{ij}}{\left(\frac{\beta_{DY}^{ij}}{P_Y^{ij}}\right)^{\frac{1}{\rho^{ij}-1}} P^{ij}}, \qquad DX_1^{ij} = \frac{I^{ij}}{\left(\frac{\beta_{DX_1}^{ij}}{P_{X_1}^{ij}}\right)^{\frac{1}{\rho^{ij}-1}} P^{ij}},$$

$$DX_2^{ij} = \frac{I^{ij}}{\left(\frac{\beta_{DX_2}^{ij}}{P_{X_2}^{ij}}\right)^{\frac{1}{\rho^{ij}-1}} P^{ij}}, \qquad DV^{ij} = \frac{I^{ij}}{\left(\frac{\beta_{DV}^{ij}}{P_V^{ij}}\right)^{\frac{1}{\rho^{ij}-1}} P^{ij}},$$

$$DL^{ij} = \frac{I^{ij}}{\left(\frac{\beta_{DL}^{ij}}{w^{ij}}\right)^{\frac{1}{\rho^{ij}-1}} P^{ij}}.$$

where $I^{ij} = \Psi^{ij}\left(\Pi_Y^i + \Pi_{X_1}^i + \Pi_{X_2}^i + \Pi_V^i + r^i\bar{K}^i + G^i\right) + w^{ij}L_S^{ij}$ for $ij =UN,\ UE,\ CN,\ CE,\ MN,\ ME$ and $I^{MN} = \Psi^{MN}\left(\Pi_Y^M + \Pi_{X_1}^M + \Pi_{X_2}^M + \Pi_V^M + r\overline{K}^M + G^M\right) + w^{MN}L_S^{MN} + w^I L^{UI} + w^{UG}L^{UG}$.

Given the Armington assumption, the demand functions for domestically produced and imported goods DO^{ijk} :

$$DO^{ijk} = \left[\frac{P_O^{ik}}{\beta_{DO}^{ijk}P_O^{ij}}\right]^{\frac{1}{\rho_{DO}^{ij}-1}} DO^{ij},$$

where the price indexes P_O^{ij} for the composite good O are

$$P_O^{ij} = \left[\sum_k \left[\left(\beta_{DO}^{ijk}\right)^{-\frac{1}{\rho_{DO}^{ij}}} P_O^{ik}\right]^{\frac{\rho_{DO}^{ij}}{\rho_{DO}^{ij}-1}}\right]^{\frac{\rho_{DO}^{ij}-1}{\rho_{DO}^{ij}}}.$$

Producers

Below, we define the producers problem for the United Sates, Mexico, and Canada.

US Manufacturing Sector

Sectoral profits are

$$\Pi_Y^U = P_Y SY^U - r^U K_Y^U - w^{UE} L_Y^{UE},$$

where the production function is

$$SY^U = A^U\left[\left(K_Y^U\right)^{\alpha_Y^U}\left(L_Y^{UE}\right)^{\gamma_Y^U}\right]^{\zeta_Y^U},$$

A^U is total factor productivity, α_Y^U and γ_Y^U are share parameters, and ζ_Y^U is the return-to-scale parameter. Corresponding input demand functions are

$$L_Y^{UE} = \left(\frac{\gamma_Y^U \zeta_Y^U}{w^{UE}}\right)^{\frac{1-\alpha_Y^U \zeta_Y^U}{1-\zeta_Y^U}} \left(\frac{\alpha_Y^U \zeta_Y^U}{r^U}\right)^{\frac{\alpha_Y^U \zeta_Y^U}{1-\zeta_Y^U}} \left[P_Y A^U\right]^{\frac{1}{1-\zeta_Y^U}},$$

$$K_Y^U = \left(\frac{\gamma_Y^U \zeta_Y^U}{w^{UE}}\right)^{\frac{\gamma_Y^U \zeta_Y^U}{1-\zeta_Y^U}} \left(\frac{\alpha_Y^U \zeta_Y^U}{r^U}\right)^{\frac{1-\gamma_Y^U \zeta_Y^U}{1-\zeta_Y^U}} \left[P_Y A^U\right]^{\frac{1}{1-\zeta_Y^U}}.$$

US Service & Construction sector

Profits are

$$\Pi_V^U = P_V^U SV^U - r^U K_V^U - w^{UE} L_V^{UE} - w^{UN} L_V^{UN} - w^{UI} L_V^{UI} - dcL_V^{UI},$$

where the production function is

$$SV^U = A_V^U \left[\left(K_V^U\right)^{\alpha_V^U} \left(L_V^{UE}\right)^{\gamma_V^U} \left(L_V^{UN}\right)^{\beta_V^U} \left(L_V^{UI}\right)^{\upsilon_V^U}\right]^{\zeta_V^U}.$$

Using the wage linkage, $w^{UG} = w^{UI} + dc$, the profit function can be expressed as

$$\Pi_V^U = P_V^U SV^U - r^U K_V^U - w^{UE} L_V^{UE} - w^{UN} L_V^{UN} - w^{UG} L_V^{UI}.$$

Input demand functions are

$$K_V^U = \frac{\zeta_V^U \alpha_V^U P_V^U A_V^U}{r^U} \left[\left[\frac{\zeta_V^U \alpha_V^U P_V^U A_V^U}{r^U}\right]^{\alpha_V^U} \left[\frac{\zeta_V^U \gamma_V^U P_V^U A_V^U}{w^{UE}}\right]^{\gamma_V^U} \left[\frac{\zeta_V^U \beta_V^U P_V^U A_V^U}{w^{UN}}\right]^{\beta_V^U} \left[\frac{\zeta_V^U \upsilon_V^U P_V^U A_V^U}{w^{UG}}\right]^{\upsilon_V^U}\right]^{\frac{\zeta_V^U}{1-\zeta_V^U}},$$

$$L_V^{UE} = \frac{\zeta_V^U \gamma_V^U P_V^U A_V^U}{w^{UE}} \left[\left[\frac{\zeta_V^U \alpha_V^U P_V^U A_V^U}{r^U}\right]^{\alpha_V^U} \left[\frac{\zeta_V^U \gamma_V^U P_V^U A_V^U}{w^{UE}}\right]^{\gamma_V^U} \left[\frac{\zeta_V^U \beta_V^U P_V^U A_V^U}{w^{UN}}\right]^{\beta_V^U} \left[\frac{\zeta_V^U \upsilon_V^U P_V^U A_V^U}{w^{UG}}\right]^{\upsilon_V^U}\right]^{\frac{\zeta_V^U}{1-\zeta_V^U}},$$

$$L_V^{UN} = \frac{\zeta_V^U \beta_V^U P_V^U A_V^U}{w^{UN}} \left[\left[\frac{\zeta_V^U \alpha_V^U P_V^U A_V^U}{r^U}\right]^{\alpha_V^U} \left[\frac{\zeta_V^U \gamma_V^U P_V^U A_V^U}{w^{UE}}\right]^{\gamma_V^U} \left[\frac{\zeta_V^U \beta_V^U P_V^U A_V^U}{w^{UN}}\right]^{\beta_V^U} \left[\frac{\zeta_V^U \upsilon_V^U P_V^U A_V^U}{w^{UG}}\right]^{\upsilon_V^U}\right]^{\frac{\zeta_V^U}{1-\zeta_V^U}},$$

$$L_V^{UT} = \frac{\zeta_V^U \upsilon_V^U P_V^U A_V^U}{w^{UG}} \left[\left[\frac{\zeta_V^U \alpha_V^U P_V^U A_V^U}{r^U}\right]^{\alpha_V^U} \left[\frac{\zeta_V^U \gamma_V^U P_V^U A_V^U}{w^{UE}}\right]^{\gamma_V^U} \left[\frac{\zeta_V^U \beta_V^U P_V^U A_V^U}{w^{UN}}\right]^{\beta_V^U} \left[\frac{\zeta_V^U \upsilon_V^U P_V^U A_V^U}{w^{UG}}\right]^{\upsilon_V^U}\right]^{\frac{\zeta_V^U}{1-\zeta_V^U}}.$$

US Capital-Intensive Agriculture

Profits are

$$\Pi_{X_1}^U = P_{X_1}^U SX_1^U - r^U K_{X_1}^U - w^{UN} L_{X_1}^{UN},$$

where the share form of the CES production technology (see Rutherford, 2002) is

$$SX_1^U = A_{X_1}^U \left[\alpha_{X_1}^U \left(\frac{K_{X_1}^U}{\bar{K}_{X_1}^U}\right)^{\lambda_{X_1}^U} + \beta_{X_1}^U \left(\frac{L_{X_1}^{UN}}{\bar{L}_{X_1}^{UN}}\right)^{\lambda_{X_1}^U}\right]^{\frac{\mu_{X_1}^U}{\lambda_{X_1}^U}},$$

where $\bar{K}^U_{X_1}$ and $\bar{L}^{UN}_{X_1}$ are baseline input levels, and $A^U_{X_1}$ is productivity. Input demand functions are

$$K^U_{X_1} = \bar{K}^U_{X_1}\left(\frac{\alpha^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}A^U_{X_1}}{\bar{K}^U_{X_1}r^U\lambda^U_{X_1}}\right)^{\frac{1}{1-\lambda^U_{X_1}}}$$

$$\times\left[\alpha^U_{X_1}\left(\frac{\alpha^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}A^U_{X_1}}{\bar{K}^U_{X_1}r^U\lambda^U_{X_1}}\right)^{\frac{\lambda^U_{X_1}}{1-\lambda^U_{X_1}}} + \beta^U_{X_1}\left(\frac{\beta^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}A^U_{X_1}}{\bar{L}^{UN}_{X_1}w^{UN}\lambda^U_{X_1}}\right)^{\frac{\lambda^U_{X_1}}{1-\lambda^U_{X_1}}}\right]^{\frac{\mu^U_{X_1}-\lambda^U_{X_1}}{\lambda^U_{X_1}\left(1-\mu^U_{X_1}\right)}},$$

$$L^{UN}_{X_1} = \bar{L}^{UN}_{X_1}\left(\frac{\beta^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}A^U_{X_1}}{\bar{L}^{UN}_{X_1}w^{UN}\lambda^U_{X_1}}\right)^{\frac{1}{1-\lambda^U_{X_1}}}$$

$$\times\left[\alpha^U_{X_1}\left(\frac{\alpha^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}B^U_1}{\bar{K}^U_{X_1}r^U\lambda^U_{X_1}}\right)^{\frac{\lambda^U_{X_1}}{1-\lambda^U_{X_1}}} + \beta^U_{X_1}\left(\frac{\beta^U_{X_1}\lambda^U_{X_1}\mu^U_{X_1}P^U_{X_1}A^U_{X_1}}{\bar{L}^{UN}_{X_1}w^{UN}\lambda^U_{X_1}}\right)^{\frac{\lambda^U_{X_1}}{1-\lambda^U_{X_1}}}\right]^{\frac{\mu^U_{X_1}-\lambda^U_{X_1}}{\lambda^U_{X_1}\left(1-\mu^U_{X_1}\right)}}.$$

US Labor-Intensive Agriculture

Profits are

$$\Pi^U_{X_2} = P^U_{X_2}SX^U_2 - r^U K^U_{X_2} - w^{UN}L^{UN}_{X_2} - w^{UG}L^{UG}_{X_2} - w^{UI}L^{UI}_{X_2} - dcL^{UI}_{X_2},$$

where the share form of the CES production function is

$$SX^U_2 = A^U_{X_2}\left[\alpha^U_{X_2}\left(\frac{K^U_{X_2}}{\bar{K}^U_{X_2}}\right)^{\lambda^U_{X_2}} + \beta^U_{X_2}\left(\frac{L^{UN}_{X_2}}{\bar{L}^{UN}_{X_2}}\right)^{\lambda^U_{X_2}} + \upsilon^U_{X_2}\left(\frac{L^{UT}_{X_2}}{\bar{L}^{UT}_{X_2}}\right)^{\lambda^U_{X_2}}\right]^{\frac{\mu^U_{X_2}}{\lambda^U_{X_2}}}.$$

Using the wage linkage, $w^{UG} = w^{UI} + dc$, the profit function can be defined as

$$\Pi^U_{X_2} = P^U_{X_2}A^U_{X_2}\left[\alpha^U_{X_2}\left(\frac{K^U_{X_2}}{\bar{K}^U_{X_2}}\right)^{\lambda^U_{X_2}} + \beta^U_{X_2}\left(\frac{L^{UN}_{X_2}}{\bar{L}^{UN}_{X_2}}\right)^{\lambda^U_{X_2}} + \upsilon^U_{X_2}\left(\frac{L^{UT}_{X_2}}{\bar{L}^{UT}_{X_2}}\right)^{\lambda^U_{X_2}}\right]^{\frac{\mu^U_{X_2}}{\lambda^U_{X_2}}} - r^U K^U_{X_2} - w^{UN}L^{UN}_{X_2} - w^{UG}L^{UT}_{X_2}.$$

Input demand functions are

$$K^U_{X_2} = \bar{K}^U_{X_2}\left(\frac{\alpha^U_{X_2}\lambda^U_{X_2}\mu^U_{X_2}P^U_{X_2}A^U_{X_2}}{r^U\bar{K}^U_{X_2}\lambda^U_{X_2}}\right)^{\frac{1}{1-\lambda^U_{X_2}}}$$

$$\times\left[\alpha^U_{X_2}\left(\frac{\alpha^U_{X_2}}{r^U\bar{K}^U_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \beta^U_{X_2}\left(\frac{\beta^U_{X_2}}{w^{UN}\bar{L}^{UN}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \upsilon^U_{X_2}\left(\frac{\upsilon^U_{X_2}}{w^G\bar{L}^{UT}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}}\right]^{\frac{\mu^U_{X_2}-\lambda^U_{X_2}}{\lambda^U_{X_2}\left(1-\mu^U_{X_2}\right)}}$$

$$\times\left(\mu^U_{X_2}P^U_{X_2}A^U_{X_2}\right)^{\frac{\left(\mu^U_{X_2}-\lambda^U_{X_2}\right)}{\left(1-\mu^U_{X_2}\right)^2}},$$

$$L^{UN}_{X_2} = \bar{L}^{UN}_{X_2}\left(\frac{\beta^U_{X_2}\lambda^U_{X_2}\mu^U_{X_2}P^U_{X_2}A^U_{X_2}}{w^{UN}\bar{L}^{UN}_{X_2}\lambda^U_{X_2}}\right)^{\frac{1}{1-\lambda^U_{X_2}}}$$

$$\times\left[\alpha^U_{X_2}\left(\frac{\alpha^U_{X_2}}{r^U\bar{K}^U_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \beta^U_{X_2}\left(\frac{\beta^U_{X_2}}{w^{UN}\bar{L}^{UN}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \upsilon^U_{X_2}\left(\frac{\upsilon^U_{X_2}}{w^G\bar{L}^{UT}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}}\right]^{\frac{\mu^U_{X_2}-\lambda^U_{X_2}}{\lambda^U_{X_2}\left(1-\mu^U_{X_2}\right)}}$$

$$\times\left(\mu^U_{X_2}P^U_{X_2}A^U_{X_2}\right)^{\frac{\left(\mu^U_{X_2}-\lambda^U_{X_2}\right)}{\left(1-\mu^U_{X_2}\right)^2}},$$

$$L^{UT}_{X_2} = \bar{L}^{UT}_{X_2}\left(\frac{\upsilon^U_{X_2}\lambda^U_{X_2}\mu^U_{X_2}P^U_{X_2}A^U_{X_2}}{w^{UG}\bar{L}^{UT}_{X_2}\lambda^U_{X_2}}\right)^{\frac{1}{1-\lambda^U_{X_2}}}$$

$$\times\left[\alpha^U_{X_2}\left(\frac{\alpha^U_{X_2}}{r^U\bar{K}^U_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \beta^U_{X_2}\left(\frac{\beta^U_{X_2}}{w^{UN}\bar{L}^{UN}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}} + \upsilon^U_{X_2}\left(\frac{\upsilon^U_{X_2}}{w^G\bar{L}^{UT}_{X_2}}\right)^{\frac{\lambda^U_{X_2}}{1-\lambda^U_{X_2}}}\right]^{\frac{\mu^U_{X_2}-\lambda^U_{X_2}}{\lambda^U_{X_2}\left(1-\mu^U_{X_2}\right)}}$$

$$\times\left(\mu^U_{X_2}P^U_{X_2}A^U_{X_2}\right)^{\frac{\left(\mu^U_{X_2}-\lambda^U_{X_2}\right)}{\left(1-\mu^U_{X_2}\right)^2}}.$$

Mexican and Canadian Manufacturing Sector

Mexican and Canadian sectors do not employ undocumented workers. Profits are

$$\Pi^i_Y = P^i_Y SY^i - r^i K^i_Y - w^{iE} L^{iE}_Y,$$

where the manufacturing sectors are governed by Cobb-Douglas technology

$$SY^i = A^i_Y\left[\left(K^i_Y\right)^{\alpha^i_Y}\left(L^{iE}_Y\right)^{\gamma^i_Y}\right]^{\zeta^i_Y}.$$

Input demand functions are

$$L_Y^{iE} = \left(\frac{\gamma_Y^i \zeta_Y^i}{w^{iE}}\right)^{\frac{1-\alpha_Y^i \zeta_Y^i}{1-\zeta_Y^i}} \left(\frac{\alpha_Y^i \zeta_Y^i}{r^i}\right)^{\frac{\alpha_Y^i \zeta_Y^i}{1-\zeta_Y^i}} \left[P_Y A^i\right]^{\frac{1}{1-\zeta_Y^i}},$$

$$K_Y^i = \left(\frac{\gamma_Y^i \zeta_Y^i}{w^{iE}}\right)^{\frac{\gamma_Y^i \zeta_Y^i}{1-\zeta_Y^i}} \left(\frac{\alpha_Y^i \zeta_Y^i}{r^i}\right)^{\frac{1-\gamma_Y^i \zeta_Y^i}{1-\zeta_Y^i}} \left[P_Y A^i\right]^{\frac{1}{1-\zeta_Y^i}}.$$

Mexican and Canadian Service & Construction Section

Profits are

$$\Pi_V^i = P_V^i SV^i - r^i K_V^i - w^{iN} L_V^{iN} - w^{iE} L_V^{iE},$$

where the Cobb-Douglas production function is

$$SV^i = A_V^i \left[\left(K_V^i\right)^{\alpha_V^i} \left(L_V^{iE}\right)^{\gamma_V^i} \left(L_V^{iN}\right)^{\beta_V^i}\right]^{\zeta_V^i}.$$

Input demand functions are

$$K_V^i = \frac{\alpha_V^i \zeta_V^i P_V^i A_V^i}{r^i} \left[P_V^i A_V^i \left[\frac{\alpha_V^i \zeta_V^i}{r^i}\right]^{\alpha_V^i} \left[\frac{\gamma_V^i \zeta_V^i}{w^{iH}}\right]^{\eta_H} \left[\frac{\beta_V^i \zeta_V^i}{w^{iL}}\right]^{\beta_V^i}\right]^{\frac{\zeta_V^i}{1-\zeta_V^i}},$$

$$L_V^{iE} = \frac{\gamma_V^i \zeta_V^i P_V^i A_V^i}{w^{iE}} \left[P_V^i A_V^i \left[\frac{\alpha_V^i \zeta_V^i}{r^i}\right]^{\alpha_V^i} \left[\frac{\gamma_V^i \zeta_V^i}{w^{iE}}\right]^{\gamma_V^i} \left[\frac{\beta_V^i \zeta_V^i}{w^{iN}}\right]^{\beta_V^i}\right]^{\frac{\zeta_V^i}{1-\zeta_V^i}},$$

$$L_V^{iN} = \frac{\beta_V^i \zeta_V^i P_V^i A_V^i}{w^{iN}} \left[P_V^i A_V^i \left[\frac{\alpha_V^i \zeta_V^i}{r^i}\right]^{\alpha_V^i} \left[\frac{\gamma_V^i \zeta_V^i}{w^{iE}}\right]^{\gamma_V^i} \left[\frac{\beta_V^i \zeta_V^i}{w^{iN}}\right]^{\beta_V^i}\right]^{\frac{\zeta_V^i}{1-\zeta_V^i}}.$$

Mexican and Canadian Capital-Intensive Agriculture

Profits are

$$\Pi_{X_1}^i = P_{X_1}^i SX_1^i - r^i K_{X_1}^i - w^{iN} L_{X_1}^{iN},$$

where the share form of the CES production functions are

$$SX_1^i = A_{X_1}^i \left[\alpha_{X_1}^i \left(\frac{K_{X_1}^i}{\bar{K}_{X_1}^i}\right)^{\lambda_{X_1}^i} + \beta_{X_1}^i \left(\frac{L_{X_1}^{iN}}{\bar{L}_{X_1}^{iN}}\right)^{\lambda_{X_1}^i}\right]^{\frac{\mu_{X_1}^i}{\lambda_{X_1}^i}}.$$

Input demand functions are

$$K^i_{X_1} = \bar{K}^i_{X_1}\left(\frac{\alpha^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}A^i_{X_1}}{\bar{K}^i_{X_1}r^i\lambda^i_{X_1}}\right)^{\frac{1}{1-\lambda^i_{X_1}}}$$
$$\times\left[\alpha^i_{X_1}\left(\frac{\alpha^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}A^i_{X_1}}{\bar{K}^i_{X_1}r^i\lambda^i_{X_1}}\right)^{\frac{\lambda^i_{X_1}}{1-\lambda^i_{X_1}}} + \beta^i_{X_1}\left(\frac{\beta^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}A^i_{X_1}}{\bar{L}^{iN}_{X_1}w^{iN}\lambda^i_{X_1}}\right)^{\frac{\lambda^i_{X_1}}{1-\lambda^i_{X_1}}}\right]^{\frac{\mu^i_{X_1}-\lambda^i_{X_1}}{\lambda^i_{X_1}\left(1-\mu^i_{X_1}\right)}},$$

$$L^{iN}_{X_1} = \bar{L}^{iN}_{X_1}\left(\frac{\beta^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}A^i_{X_1}}{\bar{L}^{iN}_{X_1}w^{iN}\lambda^i_{X_1}}\right)^{\frac{1}{1-\lambda^i_{X_1}}}$$
$$\times\left[\alpha^i_{X_1}\left(\frac{\alpha^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}B^i_{1}}{\bar{K}^i_{X_1}r^i\lambda^i_{X_1}}\right)^{\frac{\lambda^i_{X_1}}{1-\lambda^i_{X_1}}} + \beta^i_{X_1}\left(\frac{\beta^i_{X_1}\lambda^i_{X_1}\mu^i_{X_1}P^i_{X_1}A^i_{X_1}}{\bar{L}^{iN}_{X_1}w^{iN}\lambda^i_{X_1}}\right)^{\frac{\lambda^i_{X_1}}{1-\lambda^i_{X_1}}}\right]^{\frac{\mu^i_{X_1}-\lambda^i_{X_1}}{\lambda^i_{X_1}\left(1-\mu^i_{X_1}\right)}}.$$

Mexican and Canadian Labor-Intensive Agriculture

Profits are

$$\Pi^i_{X_2} = P^i_{X_2}SX^i_2 - r^iK^i_{X_2} - w^{iN}L^{iN}_{X_2},$$

where the share form of the CES production function is

$$SX^i_2 = A^i_{X_2}\left[\alpha^i_{X_2}\left(\frac{K^i_{X_2}}{\bar{K}^i_{X_2}}\right)^{\lambda^i_{X_2}} + \beta^U_{X_2}\left(\frac{L^{iN}_{X_2}}{\bar{L}^{iN}_{X_2}}\right)^{\lambda^i_{X_2}}\right]^{\frac{\mu^i_{X_2}}{\lambda^i_{X_2}}}.$$

Input demand functions are

$$K^i_{X_2} = \bar{K}^i_{X_2}\left(\frac{\alpha^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}A^i_{X_2}}{\bar{K}^i_{X_2}r^i\lambda^i_{X_2}}\right)^{\frac{1}{1-\lambda^i_{X_2}}}$$
$$\times\left[\alpha^i_{X_2}\left(\frac{\alpha^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}A^i_{X_2}}{\bar{K}^i_{X_2}r^i\lambda^i_{X_2}}\right)^{\frac{\lambda^i_{X_2}}{1-\lambda^i_{X_2}}} + \beta^i_{X_2}\left(\frac{\beta^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}A^i_{X_2}}{\bar{L}^{iN}_{X_2}w^{iN}\lambda^i_{X_2}}\right)^{\frac{\lambda^i_{X_2}}{1-\lambda^i_{X_2}}}\right]^{\frac{\mu^i_{X_2}-\lambda^i_{X_2}}{\lambda^i_{X_2}\left(1-\mu^i_{X_2}\right)}},$$

$$L^{iN}_{X_2} = \bar{L}^{iN}_{X_2}\left(\frac{\beta^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}A^i_{X_2}}{\bar{L}^{iN}_{X_2}w^{iN}\lambda^i_{X_2}}\right)^{\frac{1}{1-\lambda^i_{X_2}}}$$
$$\times\left[\alpha^i_{X_2}\left(\frac{\alpha^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}B^i_{2}}{\bar{K}^i_{X_2}r^i\lambda^i_{X_2}}\right)^{\frac{\lambda^i_{X_2}}{1-\lambda^i_{X_2}}} + \beta^i_{X_2}\left(\frac{\beta^i_{X_2}\lambda^i_{X_2}\mu^i_{X_2}P^i_{X_2}A^i_{X_2}}{\bar{L}^{iN}_{X_2}w^{iN}\lambda^i_{X_2}}\right)^{\frac{\lambda^i_{X_2}}{1-\lambda^i_{X_2}}}\right]^{\frac{\mu^i_{X_2}-\lambda^i_{X_2}}{\lambda^i_{X_2}\left(1-\mu^i_{X_2}\right)}}.$$

Market-Clearing Conditions

The market-clearing conditions and corresponding complementarity variables, given in brackets, are

$$[P_Y^{CC}] \qquad SY^C = DY^{CNC} + DY^{CEC} + DY^{UNC} + DY^{UEC} + DY^{MNC} + DY^{MEC} + DY^{RC}$$

$$[P_{X_1}^{CC}] \qquad SX_1^C = DX_1^{CNC} + DX_1^{CEC} + DX_1^{UNC} + DX_1^{UEC} + DX_1^{MNC} + DX_1^{MEC} + DX_1^{RC}$$

$$[P_{X_2}^{CC}] \qquad SX_2^C = DX_2^{CNC} + DX_2^{CEC} + DX_2^{UNC} + DX_2^{UEC} + DX_2^{MNC} + DX_2^{MEC} + DX_2^{RC}$$

$$[P_V^{C}] \qquad SV^C = DV^{CN} + DV^{CE}$$

$$[P_Y^{UU}] \qquad SY^U = DY^{CNU} + DY^{CEU} + DY^{UNU} + DY^{UEU} + DY^{MNU} + DY^{MEU} + DY^{RU}$$

$$[P_{X_1}^{UU}] \qquad SX_1^U = DX_1^{CNU} + DX_1^{CEU} + DX_1^{UNU} + DX_1^{UEU} + DX_1^{MNU} + DX_1^{MEU} + DX_1^{RU}$$

$$[P_{X_2}^{UU}] \qquad SX_2^U = DX_2^{CNU} + DX_2^{CEU} + DX_2^{UNU} + DX_2^{UEU} + DX_2^{MNU} + DX_2^{MEU} + DX_2^{RU}$$

$$[P_V^{U}] \qquad SV^U = DV^{UN} + DV^{UE}$$

$$[P_Y^{MM}] \qquad SY^M = DY^{CNM} + DY^{CEM} + DY^{UNM} + DY^{UEM} + DY^{MNM} + DY^{MEM} + DY^{RM}$$

$$[P_{X_1}^{MM}] \qquad SX_1^M = DX_1^{CNM} + DX_1^{CEM} + DX_1^{UNM} + DX_1^{UEM} + DX_1^{MNM} + DX_1^{MEM} + DX_1^{RM}$$

$$[P_{X_2}^{MM}] \qquad SX_2^M = DX_2^{CNM} + DX_2^{CEM} + DX_2^{UNM} + DX_2^{UEM} + DX_2^{MNM} + DX_2^{MEM} + DX_2^{RM}$$

$$[P_V^{M}] \qquad SV^M = DV^{MN} + DV^{ME}$$

$$[P_Y^{RR}] \qquad SY^R = DY^{CNR} + DY^{CER} + DY^{UNR} + DY^{UER} + DY^{MNR} + DY^{MER}$$

$$[P_{X_1}^{RR}] \qquad SX_1^R = DX_1^{CNR} + DX_1^{CER} + DX_1^{UNR} + DX_1^{UER} + DX_1^{MNR} + DX_1^{MER}$$

$$[P_{X_2}^{RR}] \qquad SX_2^R = DX_2^{CNR} + DX_2^{CER} + DX_2^{UNR} + DX_2^{UER} + DX_2^{MNR} + DX_2^{MER}$$

$$[r] \qquad \overline{K^C} + \overline{K^U} + \overline{K^M} = K_Y^C + K_{X_1}^C + K_{X_2}^C + K_V^C + K_Y^U + K_{X_1}^U + K_{X_2}^U + K_V^U + K_Y^M + K_{X_1}^M + K_{X_2}^M + K_V^M$$

$$[w^{CN}] \qquad \overline{L}^{CN} = L_S^{CN} + DL^{CN}$$

$$[w^{CE}] \qquad \overline{L}^{CE} = L_S^{CE} + DL^{CE}$$

$$[w^{UN}] \qquad \overline{L}^{UN} = L_S^{UN} + DL^{UN}$$

$$[w^{UE}] \qquad \overline{L}^{UE} = L_S^{UE} + DL^{UE}$$

$$[w^{ME}] \qquad \overline{L}^{ME} = L_S^{ME} + DL^{ME}$$

$$[w^{MN}] \qquad \overline{L}^{MN} = L^I + L^{UI} + L^{UG} + L_S^{MN} + DL^{MN}$$

After substituting demand and supply function into these equations, we obtain a system of 22 equations in 22 endogenous prices.

Data

Tables S1, S2, and S3 give all data sources and corresponding variables.

Table S1. Data and Parameter Sources

Variable Type and Name	Notation	Source
Endogenous variable under baseline		
Production	SO^i	GTAP 9
Consumption	DO^{ij}	GTAP 9
Bilateral trade	DO^{ik}	GTAP 9
Output price	P_O^i	Set to 1
Wage	w^{ij}	NAWS, USDL, Marosi (2016), Calibration
Rental	r^i	Set to 1
Production input	K_O^i, L_O^{ij}	GTAP 9
Undocumented labor	L^{UI}	Calibrated using labor input data from GTAP 9 data and undocumented labor percentage employed in US labor intensive agriculture from Ruark (2011), and unauthorized-worker percentages hired by different US industries from Cohn and Passel (2009)
Immigration	L^I	Calibration
Endogenous and policy variable		
Tariff	t_O^{ki}	GTAP 9
Portion of migrants caught at the border	b	Calculated from Gonzalez (2015)
Fraction of deportation	d	Calculated from Gonzalez (2015)
Labor endowment	$\bar{L}^{ij}$	World Bank (2011)
Capital endowment	$\bar{K}^i$	GTAP 9
Guest workers	L_O^{UG}	U.S. Department of State (2015)
Immigration cost	g	Calibration
Fine	c	Calibration
National income share	Ψ^{ij}	Calibration
Labor share	$\frac{L^{iN}}{L^{iE}}$	OECD
Function parameter		
Utility and composite goods CES	ρ^{ij}, ρ_O^{ij}	Assumption
Production CES	λ_O^i	Assumption
Production return to scale	$\mu_{X_2}^U$	Calibration
ROW demand/supply elasticity	$\theta_O^{D/S}$	Assumption
ROW demand/supply scale	$\delta_O^{D/S}$	Calibration

Table S2. Bilateral Trade and Tariff under USMCA/NAFTA

	Destination			
Origin	**United States**	**Mexico**	**Canada**	**ROW**
		Manufacturing Ad Valorem Tariff		
US	0.0	0.1	0.0	3.2
ME	0.0	0.0	0.0	2
CA	0.0	0.0	0.0	1.9
ROW	1.7	4	2	2.5
		Capital Intensive Agricultural Ad Valorem Tariff		
US	0.0	0.5	14.7	19
ME	0.2	0.0	6.2	11.7
CA	1.3	1.7	0.0	11.8
ROW	2.3	10.3	12.5	7.7
		Labor Intensive Agricultural Ad Valorem Tariff		
US	0.0	5.1	0.0	10.3
ME	0.0	0.0	0.0	2.3
CA	0.0	0.0	0.0	19.5
ROW	0.3	5.3	0.6	5.9
		Manufacturing Bilateral Trade (US$ millions)		
US	6,387,333.00	156,732.80	207,869.90	975,601.70
ME	238,851.00	388,862.20	13,821.00	71,671.80
CA	268,574.70	5,740.50	561,349.30	105,551.30
ROW	1,673,165.00	116,395.80	140,447.60	11,742,065.00
		Capital-Intensive Agricultural Bilateral Trade (US$ millions)		
US	1,104,832.9	20,298.70	20,379.60	148,563.20
ME	11,622.70	159,205.00	313.80	5,327.20
CA	23,302.20	2,117.70	145,108.70	24,700.70
ROW	83,907.60	6,351.10	12,357.60	1,131,815.00
		Labor-Intensive Agricultural Bilateral Trade (US$ millions)		
US	57,784.80	1,210.10	4,622.20	10,048.50
ME	10,613.90	7,481.90	978.20	785.90
CA	1,932.40	54.10	2,087.60	2,961.70
ROW	10,676.90	267.30	1,296.30	117,295.70

Source: Aguiar, Narayanan, and McDougall (2016).

Table S3. Values of Variables and Parameters

Variable/Parameter		United States	Mexico	Canada	ROW
Aggregate production (US$ millions)	Manufacturing	7,711,229.40	710,210.80	939,146.20	1,873,226.30
	Capital-intensive agriculture	1,290,432.22	175,908.17	189,374.73	87,249.75
	Labor-intensive agriculture	73,635.55	19,305.30	7,018.14	11,025.93
	Service/construction	18,848.78	1,068.32	1,983.59	–
Price (normalized)	Manufacturing	1	1	1	1
	Capital-intensive agriculture	1	1	1	1
	Labor-intensive agriculture	1	1	1	1
	Service/construction	1	1	1	–
Wage ($/hour)	Low-skilled	10.33	1.50	10.33	–
	Skilled	31.60	11.43	19.76	–
	Undocumented	8.98	–	–	–
	Guest worker	10.33	–	–	–
	Rental rate	1	1	1	–
Immigration policy	Portion of migrants caught at the border	50%	–	–	–
	Fraction of deportation	1.5%	–	–	–
CES utility	Low-skilled	-0.50	-0.50	-0.50	–
	Skilled	-0.50	-0.50	-0.50	–
Low-skilled worker CES goods	Manufacturing	0.6	0.6	0.6	–
	Capital-intensive agriculture	0.6	0.6	0.6	–
	Labor-intensive agriculture	0.6	0.6	0.6	–
Skilled worker CES goods	Manufacturing	0.6	0.6	0.6	–
	Capital-intensive agriculture	0.6	0.6	0.6	–
	Labor-intensive agriculture	0.6	0.6	0.6	–
	Skilled labor share	0.424	0.15	0.51	–
Labor endowment (millions of hours)	Low-skilled	1,572,258.8	889,052.4	143,709.6	–
	Skilled	1,157,357.2	156,891.6	149,575.2	–
Capital input (US$ millions)	Manufacturing	798,628.6	151,673.4	159,363.9	–
	Capital-intensive agriculture	151,779	48,471.9	29,255.2	–
	Labor-intensive agriculture	12,892.4	1,250.6	3,880.6	–
	Service/construction	2,933,848	358,253.4	474,910.5	–

Other Endogenous Variables

Next, we give the computations of endogenous variables that are not observed in the data. Total time to consumers is obtained by multiplying 365 days by 24 hours times the number of workers. Leisure is defined as all non-working hours. We calculate the ratio of expenditures for each group of workers to total expenditures to obtain Ψ^{ij}. Price variables are calculated using the linkage equations

$$w^{UI} = w^{MN}\left(1 + \frac{d}{1-b}\right) + \frac{d}{1-b}g$$

$$w^{UG} = w^{UI} + dc$$

$$P_Y^{CU} = t_Y^{CU} P_Y^{CC}$$

$$P_{X_1}^{CM} = t_{X_1}^{CM} P_{X_1}^{CC}$$

$$P_{X_2}^{CR} = t_{X_2}^{CR} P_{X_2}^{CC}$$

$$P_Y^{UC} = t_Y^{UC} P_Y^{UU}$$

$$P_{X_1}^{UM} = t_{X_1}^{UM} P_{X_1}^{UU}$$

$$P_{X_2}^{UR} = t_{X_2}^{UR} P_{X_2}^{UU}$$

$$P_Y^{MU} = t_Y^{MU} P_Y^{MM}$$

$$P_{X_1}^{MC} = t_{X_1}^{MC} P_{X_1}^{MM}$$

$$P_{X_2}^{MR} = t_{X_2}^{MR} P_{X_2}^{MM}$$

$$P_Y^{RC} = t_Y^{RC} P_Y^{RR}$$

$$P_{X_1}^{RC} = t_{X_1}^{RC} P_{X_1}^{RR}$$

$$P_{X_2}^{RC} = t_{X_2}^{RC} P_{X_2}^{RR}$$

$$P_Y^{RU} = t_Y^{RU} P_Y^{RR}$$

$$P_{X_1}^{RU} = t_{X_1}^{RU} P_{X_1}^{RR}$$

$$P_{X_2}^{RU} = t_{X_2}^{RU} P_{X_2}^{RR}$$

$$P_Y^{RM} = t_Y^{RM} P_Y^{RR}$$

$$P_{X_1}^{RM} = t_{X_1}^{RM} P_{X_1}^{RR}$$

$$P_{X_2}^{RM} = t_{X_2}^{RM} P_{X_2}^{RR}.$$

Calibration

We set all prices to one in the baseline (e.g., Kehoe and Ruhl, 2009). Using data from Gonzalez (2015), the fraction of undocumented workers deported by the US government is $d = 1.5\%$. Also, the proportion of unauthorized immigrants caught at the border of $b = 0.5$. The CES parameters in the production function are assumed to be $\lambda^U_{X_1} = \lambda^U_{X_2} = \lambda^M_{X_1} = \lambda^M_{X_2} = -1.85$, which give an elasticity of substitution of 0.35. The ROW price elasticity of demand and supply are -0.3 and 0.3. The top-level CES parameter for utility is assumed to be $\rho^{ij} = -0.5$. The CES parameter in the Armington composite goods is assumed to be $\rho^{ij}_{DO} = 0.6$.

Supply Parameters

The share parameters—α^i_Y, α^i_V, $\alpha^i_{X_1}$, $\alpha^i_{X_2}$, β^i_V, $\beta^i_{X_1}$, $\beta^i_{X_2}$,γ^i_Y, γ^i_V, υ^U_V, $\upsilon^U_{X_2}$, α^M_Y— in the production function are calibrated as the share of each input cost to the total cost of production. The return to scale parameters—ζ^i_Y, $\mu^i_{X_1}$, $\mu^i_{X_2}$, ζ^i_V—are calibrated by dividing total cost of production by the value of production. With total production, inputs, share parameters, and returns-to-scale parameters calibrated the productivity parameters—$A^i_Y, A^i_{X_1}, A^i_{X_2}, A^i_V$—are calculated as residuals.

Demand Parameters

The utility share parameters are calibrated as $\beta^{ij}_{DO} = \frac{P^{ij}_O \left(DO^{ij}\right)^{1-\rho^{ij}}}{w^{ij}\left(DL^{ij}\right)^{1-\rho^{ij}} + \sum_O P^{ij}_O \left(DO^{ij}\right)^{1-\rho^{ij}}}$ and $\beta^{ij}_{DL} = 1 - \sum_O \beta^{ij}_{DO}$ and composite goods share parameters as $\beta^{ijk}_{DO} = \frac{P^{ik}_O \left(DO^{ijk}\right)^{1-\rho^{ijk}}}{\sum_k P^{ik}_O \left(DO^{ijk}\right)^{1-\rho^{ijk}}}$ (Rutherford, 2002).

Other Parameters

Using the data on the wage rates and domestic and border control policies, the g is calibrated using the wage-linkage equation $g = w^{UI}\frac{1-b}{d} - w^M\left(\frac{1-b}{d} + 1\right)$ and c is calibrated by utilizing the wage-linkage equation $c = \frac{1}{d}\left(w^U - w^I\right)$.

Absolute Difference

Table S4. Impacts of Heightened Immigration Policies on Undocumented Workers, Low-Skilled and Skilled Workers, and Capital[a]

		Labor-Intensive Agriculture	Service & Construction	Capital-Intensive Agriculture	Manufacturing
US	Undocumented workers	−94.9	−2317.94	n/a	n/a
	Low-skilled	−43.79	128.67	−1.93	n/a
	Skilled	n/a	70.56	n/a	−1.85
	Capital	−444.62	677.52	−30.26	−228.24
ME	Low-skilled	96.74	193.8	18.26	n/a
	Skilled	n/a	9.44	n/a	3.87
	Capital	85.78	6.53	23.12	−22.32
CA	Low-skilled	2.01	−0.32	−0.34	n/a
	Skilled	n/a	0.37	n/a	−0.69
	Capital	21.86	−44.97	−4.94	−39.46

Notes: Units for the results are mil. hrs for labor inputs and US$ millions for capital input.

Table S5. Impacts of Immigration Policies on Bilateral Trade

		United States	Mexico	Canada	ROW
US	Labor-intensive agriculture	−1,645.59	−60.44	−159.73	−88.17
	Service/construction	−22,209.92	n/a	n/a	n/a
	Capital-intensive agriculture	−66.93	6.09	4.72	5.91
	Manufacturing	−411.65	59.47	29.66	35.81
ME	Labor-intensive agriculture	221.43	−4.89	15.19	−2.06
	Service/construction	n/a	404.84	n/a	n/a
	Capital-intensive agriculture	−0.50	50.69	0.08	0.21
	Manufacturing	−57.55	78.78	−0.47	1.11
CA	Labor-intensive agriculture	31.75	−0.33	21.02	−10.04
	Service/construction	n/a	n/a	−40.89	n/a
	Capital-intensive agriculture	−6.34	0.10	−2.43	0.23
	Manufacturing	−55.88	1.35	−0.54	2.08
ROW	Labor-intensive agriculture	56.45	−4.28	−0.50	0.00
	Capital-intensive agriculture	−6.86	1.50	2.19	0.00
	Manufacturing	−126.43	41.75	17.80	0.00

Notes: Units for the results are US$ millions.

Table S6. Impacts of Immigration Policies on Total Production and Producer Prices

		United States	Mexico	Canada
Total production (US$ millions)	Labor-intensive agriculture	−1,953.93	229.67	42.41
	Service/construction	−22,209.92	404.84	−40.89
	Capital-intensive agriculture	−50.20	50.48	−8.44
	Manufacturing	−286.71	21.87	−53.00
Producer prices (change from 1)	Labor-intensive agriculture	0.03	0.01	0.01
	Service/construction	0.00	0.00	0.00
	Capital-intensive agriculture	0.00	0.00	0.00
	Manufacturing	0.00	0.00	0.00

Table S7. Impacts of Immigration Policies on Leisure, Wage Rates, and Welfare

	United States		Mexico		Canada	
CES Manu Price Index	0.00		0.00		0.00	
CES CapAg Price Index	0.00		0.00		0.00	
CES LabAg Price Index	0.08		0.03		0.08	
	Low-Skilled	**Skilled**	**Low-Skilled**	**Skilled**	**Low-Skilled**	**Skilled**
CES manu cons index	−77.44	−145.80	113.53	−56.99	5.18	9.17
CES CapAg cons index	−11.79	−21.82	40.03	−17.93	0.71	1.14
CES LabAg cons index	−129.39	−278.95	−10.29	−17.38	−10.82	−21.55
S/C cons (US$ millions)	−7,077.80	−15,132.13	633.71	−228.87	−11.02	−29.87
Leisure (millions of hours)	−82.95	−68.71	2,079.41	−13.31	−1.35	0.31
Undocumented wage ($/hr)	2.20	n/a	n/a	n/a	n/a	n/a
Wage ($/hr)	0.00	0.00	0.00	−0.01	0.00	0.00
Welfare	−805.20	−1,073.87	1,092.86	−50.31	−4.81	−5.92

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