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The economics of revoking NAFTA*

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Abstract

In a world economy interconnected by global value chains, where domestic productivity depends on the availability of imported inputs, the vast majority of workers stand to lose from protectionism. To exemplify this, we provide a quantitative assessment of the aggregate and distributional effects of one hypothetical protectionist measure – the case of revoking the North American Free Trade Agreement (NAFTA). Using a multi-sector quantitative model of global production, we show that a full revocation extending to both tariffs and non-tariff trade barriers would result in a real annual GDP loss of US$ 37 billion in Canada, US$ 22 billion in Mexico, and US$ 40 billion in the United States. In contrast, annual combined losses would amount to less than US$ 5 billion if only tariff rates would be increased. However, in both scenarios, average real wages would fall in almost all regions in North America.

Keywords: NAFTA, quantitative trade models, distributional effects, protectionism
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1 Introduction

With the onset of the global financial crisis, the longstanding downward trend in tariffs and other barriers to trade has largely come to a halt. Recent political events - such as the Brexit vote in the United Kingdom, the shift in US trade policy and international responses to it - indicate a danger of rising protectionism and repatriation of production and consumption.

In a highly interconnected world economy with global value chains (GVCs), the productivity of domestic industries depends on the availability of imported inputs. And because imported inputs complement the productivity of domestic labor, the fraction of workers who stand to lose from protectionism is large. To exemplify this, we study the effects of one hypothetical protectionist measure – the case of revoking NAFTA – in the global network of input-output trade. To examine the general equilibrium effects this policy would have, we combine the multi-sector, multi-country, multi-factor general equilibrium Ricardian trade model (e.g. Eaton and Kortum, 2002; Caliendo and Parro, 2015; Levchenko and Zhang, 2016) with a specific-factors model that generates distributional effects of trade across sectors (Jones, 1971; Mussa, 1974; Levchenko and Zhang, 2013; Galle et al., 2017). We calibrate the model to the global matrix of intermediate and final goods trade from the 2016 edition of the World Input-Output Database (WIOD) and the WIOD's Socioeconomic Accounts (Timmer et al., 2015). We then simulate two hypothetical scenarios in which NAFTA is rolled back in full or in part.

Our first counterfactual models the most adverse scenario, with the goal to set an upper bound on potential losses. It entails a hypothetical rise in tariffs from the current NAFTA-negotiated ones to the Most-Favoured Nation (MFN) level, as well as an increase in non-tariff barriers (NTBs) in both goods and service sectors estimated by Felbermayr et al. (2017). This counterfactual is arguably drastic, but its effects can be quantified as there already exist estimates of the impact on tariffs (from current rates to those under MFN) and of the impact on NTBs (from Felbermayr et al. (2017)). In all likelihood, if there would be a change to the NAFTA agreement, it would be much less drastic than in this counterfactual. As an alternative scenario, we thus model a second counterfactual in which tariff rates are increased to MFN levels, while NTBs remain at their current levels.

We assess the economic effect first at the national level, and then at the regional level. To do the latter, we combine the sector-country-specific real wage changes resulting from our general equilibrium model with information on employment shares in those regions. The results at the aggregate level can be summarized as follows. In the first counterfactual - a complete revocation of NAFTA (ie both tariffs and NTBs rise) - the total welfare change (equivalent to a decrease in real GDP per year) would be -0.22% for the United States, -1.8% for Mexico, and -2.2% for Canada. In absolute terms, the annual losses from dismantling NAFTA would be about US$ 40 billion in the US, US$ 37 billion in Canada, and US$ 22 billion in Mexico. The effects for the second counterfactual, in which tariffs increase but NTBs remain at current levels, are much smaller and amount to -0.001% for the United States, -0.26% for Mexico, and -0.08% for Canada (US$ 0.23, 3.1 and 1.3 billion, respectively when measured in absolute terms).[1]

We next turn to the regional effects, showing that in both counterfactuals, hardly any region in North America would benefit from a rollback of NAFTA. We first note that in both counterfactuals, the dispersion of the effects across sectors would be very large. For example, for the first counterfactual, sectoral real wage changes range from -2.70% to 2.26% for the United States, from -16.76% to 9.46% for Mexico, and from -13.90% to 1.74% for Canada. Because sectoral employment is unevenly distributed across geographic locations, there would be considerable distributional consequences across regions. Losses due to a full revocation of NAFTA would affect almost all regions in North America, with real wages falling in all Canadian provinces and Mexican states, and all but one of the 435 US Congressional districts ('districts' in what follows below). In the United States, the average wage changes would range from -0.41% in Ohio's 4th district to 0.08% in Texas' 11th district, with a cross-district standard deviation of 0.04%. Average wage changes would range from -3.34% to -1.34% across Canadian provinces and from -4.08% to -0.85% across Mexican states. For the second counterfactual, the impact is much smaller, but equally widespread: in this counterfactual, all regions in North America would experience real wage reductions.

We then construct three heuristic measures of trade exposure to NAFTA. For expositional clarity and brevity, we focus on the first counterfactual (full revocation) and on the United States. The first is a measure of *import exposure* to NAFTA partner countries, defined as the employment share-weighted average of sectoral imports from NAFTA partners in total US absorption. Intuitively, import exposure to NAFTA partners is high in a district if it has high employment shares in sectors with greater import competition from those countries. All else equal, we should expect wages to rise the most in locations that in the current regime compete most closely with Canada and Mexico. The second is an *export orientation* measure, which is the employment share-weighted average of sectoral

[1] The results of the second counterfactual are comparable in magnitude to the findings of Caliendo and Parro (e.g. 2015), who model the effect of NAFTA on tariff rates (ie they model the reverse scenario as we do in this paper) and also estimate sector-specific trade elasticities. Specifically, they find that NAFTA increased Mexico's real GDP by 1.31%, that of the United States by 0.08%, while it caused Canada's real GDP to decrease by 0.06%.

exports to NAFTA partners in total US output. Intuitively, we should expect locations with higher employment shares in NAFTA-export-oriented industries to lose disproportionately from NAFTA revocation. Finally, the third measure is NAFTA *imported input intensity*, defined as the employment-weighted share of spending on NAFTA inputs in total input spending. As imported inputs complement the productivity of domestic labor, we should expect US districts that rely on NAFTA inputs to experience relatively larger wage decreases if NAFTA is rolled back.

Next, we correlate these three heuristic measures of trade exposure to NAFTA with the general equilibrium effects predicted by the model. This analysis shows that losses would be widespread as regions that suffer the most from NAFTA import competition are also overwhelmingly those that export to NAFTA and use NAFTA intermediates. Taken individually, the bilateral relationships between all three heuristics and model-implied wage changes are negative and statistically significant. This is counterintuitive for import exposure, as it implies that districts suffering the most from direct import competition actually see larger real wage reductions when protection increases following a dismantling of NAFTA. The apparent mystery is resolved by the fact that the correlation between the three heuristics is extremely high: export orientation has a 0.92 correlation with import exposure, and a 0.86 correlation with imported input intensity. Imported input intensity has a 0.95 correlation with import exposure.

Thus, the picture that emerges from this exercise is, first and foremost, one of differences across locations in the overall level of integration in the North American value chain: regions subject to NAFTA import competition overwhelmingly also export to NAFTA and rely on intermediates from NAFTA. It is thus not surprising that locations that are generally more open to NAFTA trade would experience larger net welfare losses: as a revocation of NAFTA would represent a relatively greater reduction in trade openness for those locations, import competition would be reduced there but, by the same token, the cost of imported inputs would increase and higher tariffs abroad would make it more difficult to export.

Our exercise thus underscores the need for a model-based quantitative assessment that takes into account interdependencies in global production arrangements and general equilibrium effects. Heuristic measures of import competition that have been used in other contexts (e.g. Autor et al., 2013, and the large literature that followed) would be misleading as to which locations would stand to lose the most from NAFTA revocation. Indeed, while the bivariate relationships between all three of the heuristic measures and real wage changes all have the same sign, the conditional relationships all have the expected signs: when controlling for export orientation and imported input intensity, exports to NAFTA partners in total US output. Intuitively, we should expect locations with higher employment shares in NAFTA-export-oriented industries to lose disproportionately from NAFTA revocation. Finally, the third measure is NAFTA *imported input intensity*, defined as the employment-weighted share of spending on NAFTA inputs in total input spending. As imported inputs complement the productivity of domestic labor, we should expect US districts that rely on NAFTA inputs to experience relatively larger wage decreases if NAFTA is rolled back.

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Our work follows the tradition of quantitative assessments of trade policy, going back to the first-generation CGE literature (see, among many others, Deardorff and Stern, 1990; Harrison et al., 1997; Hertel, ed, 1997). More recent contributions extend the Eaton and Kortum (2002) framework to study the welfare effects of NAFTA (e.g. Caliendo and Parro, 2015), the effect of the UK leaving the European Union (Dhingra et al., 2017), or greater potential US protectionism (Felbermayr et al., 2017). Our two main contributions are (i) to bring to the fore the distributional aspects of a specific trade policy and (ii) to illustrate why the impact is so pervasive.

We note that our analysis does not model frictions in goods or labor markets, leading to fully flexible goods prices and wages, and consequently full employment. Modelling unemployment dynamics would require us to take a stance on the nature of frictions in good or labor markets, as well as associated parameter values. In the presence of labor market frictions, one would expect unemployment to fall in the sectors and regions that see wage decreases in the model at hand, for if wages cannot adjust downwards fully flexibly, employment must do so.[2]

The rest of the paper is organized as follows. Section 2 lays out the quantitative framework used in the analysis, and Section 3 describes the data. Section 4 presents the real wage and income changes following the revocation of NAFTA. Section 5 discusses the role of import competition, export orientation and imported input intensity. Section 6 presents some extensions and robustness checks, also offering an extension of the model to the case of labor mobility. Section 7 concludes. Details of data, calibration, and model solution are collected in the Appendix.

2 Quantitative framework

The world is composed of N countries denoted by m, n, and k, and J sectors denoted by i and j. Each sector produces a continuum of goods. There are two types of factors of production: labor and capital (K). Labor is further decomposed into high- (L_H), medium- (L_M), and low-skill (L_L) labor. Capital and labor are perfectly mobile across goods within a sector, but immobile across sectors (Jones, 1971; Mussa, 1974). This assumption means

[2] Similarly, our fully flexible model is static, ie, it does not involve households' savings decisions, implying that our model has no implications for the dynamics of the current account, interest rates, or nominal exchange rates. However, as trade barriers affect relative prices, it does have implications for the real exchange rate. For example, in our first counterfactual, the US dollar appreciates by 2.4% against the Mexican peso, and by 1.3% against the Canadian dollar in real terms.

that the results should be interpreted as the short-run effects of the policy experiments we simulate.[3] Micro evidence shows that following trade shocks, worker mobility across sectors is quite limited (Artuç et al., 2010; Dix-Carneiro, 2014), and thus our model provides a good approximation to the factor adjustment in the short run. Country n, sector j are endowed with $L_{H,jn}$ units of high-skilled labor, $L_{M,jn}$ units of medium-skilled labor, $L_{L,jn}$ units of low-skilled labor, and K_{jn} units of capital.

Preferences and final demand. Utility is identical and homothetic across agents in the economy. Individual ι maximizes utility

$$U_n(\iota) = \prod_{j=1}^{J} Y_{jn}(\iota)^{\xi_{jn}},$$

where the $Y_{jn}(\iota)$ is ι's consumption of the composite good in sector j, subject to the budget constraint:

$$\sum_{j=1}^{J} p_{jn} Y_{jn}(\iota) = I(\iota),$$

where p_{jn} is the price of sector j composite good, and $I(\iota)$ is ι's income. Income in this economy comes from labor and capital earnings, tariff revenue, and a trade deficit in the form of a transfer to n from the rest of the world (which would be negative in countries with a trade surplus):

$$I_n \equiv \sum_{\iota} I_n(\iota) = \sum_{j=1}^{J} w_{H,jn} L_{H,jn} + \sum_{j=1}^{J} w_{M,jn} L_{M,jn} + \sum_{j=1}^{J} w_{L,jn} L_{L,jn} + \sum_{j=1}^{J} r_{jn} K_{jn} + T_n + D_n,$$

where $w_{s,jn}$ and r_{jn} are the wage rate for s-skilled labor and the return to capital in sector j in country n, T_n total tariff revenue in country n, and D_n is the trade deficit. Since utility is Cobb-Douglas, this demand system admits a representative consumer, and thus final consumption spending in each sector is a constant fraction of aggregate income. Denote the economy-wide final consumption on sector j goods in country n by Y_{jn}. We do, however, allow for an extension of the model with labor mobility across sectors.

$$p_{jn} Y_{jn} = \xi_{jn} I_n.$$

[3] Section 6.1 presents the results when factors are mobile across sectors, a scenario intended to capture the long-run outcomes.

The corresponding consumption price index in country, and potentially much more realistic n is:

$$P_n = \prod_{j=1}^{J} \left(\frac{p_{jn}}{\xi_{jn}} \right)^{\xi_{jn}}. \tag{1}$$

In the quantitative implementation below, agents ι would be differentiated by which sectoral factor endowments they own, and thus we will be computing income changes for medium-skilled workers in the apparel sector, for example.

Technology and market structure. Output in each sector j is produced competitively using a CES production function that aggregates a continuum of varieties $q \in [0,1]$ unique to each sector:

$$Q_{jn} = \left[\int_0^1 Q_{jn}(q)^{\frac{\epsilon-1}{\epsilon}} dq \right]^{\frac{\epsilon}{\epsilon-1}},$$

where ϵ denotes the elasticity of substitution across varieties q, Q_{jn} is the total output of sector j in country n, and $Q_{jn}(q)$ is the amount of variety q that is used in production in sector j and country n. The price of sector j's output is given by:

$$p_{jn} = \left[\int_0^1 p_{jn}(q)^{1-\epsilon} dq \right]^{\frac{1}{\epsilon-1}}.$$

The production function of a particular sectoral variety q is:

$$y_{jn}(q) = z_{jn}(q) \left(l_{H,jn}(q)^{\alpha_{H,jn}} l_{M,jn}(q)^{\alpha_{M,jn}} l_{L,jn}(q)^{\alpha_{L,jn}} k_{jn}(q)^{1-\alpha_{H,jn}-\alpha_{M,jn}-\alpha_{L,jn}} \right)^{\beta_{jn}} \left(\prod_{i=1}^{J} m_{ijn}(q)^{\gamma_{ijn}} \right)^{1-\beta_{jn}},$$

where $z_{jn}(q)$ denotes variety-specific productivity, $k_{jn}(q)$ and $l_{s,jn}(q)$ denote inputs of capital and s-skilled labor, and m_{ijn} denotes the intermediate input from sector i used in production sector-j goods in country n. The value-added-based labor intensity is given by $\alpha_{s,jn}$ for skill type s, while the share of value added in total output is given by β_{jn}. Both of these vary by sector and country. The weights on inputs from other sectors, γ_{ijn}, vary by output industry j as well as input industry i and by country n.

Productivity $z_{jn}(q)$ for each $q \in [0,1]$ in each sector j is equally available to all agents in country n, and product and factor markets are perfectly competitive. Following Eaton and Kortum (2002, henceforth EK), the productivity draw $z_{jn}(q)$ is random and comes from the Fréchet distribution with the cumulative distribution function

$$F_{jn}(z) = e^{-A_{jn}z^{-\theta}}.$$

Define the cost of an "input bundle" faced by sector j producers in country n:

$$b_{jn} = \left[\left(w_{H,jn}\right)^{\alpha_{H,jn}} \left(w_{M,jn}\right)^{\alpha_{M,jn}} \left(w_{L,jn}\right)^{\alpha_{L,jn}} \left(r_{jn}\right)^{1-\alpha_{H,jn}-\alpha_{M,jn}-\alpha_{L,jn}} \right]^{\beta_{jn}} \left[\prod_{i=1}^{J} \left(p_{in}\right)^{\gamma_{ijn}} \right]^{1-\beta_{jn}}. \tag{2}$$

The production of a unit of good q in sector j in country n requires $z_{jn}^{-1}(q)$ input bundles, and thus the cost of producing one unit of good q is $b_{jn}/z_{jn}(q)$. International trade is subject to iceberg costs: in order for one unit of good q produced in sector j to arrive at country n from country m, $d_{j,mn} > 1$ units of the good must be shipped (in describing bilateral flows, we follow the convention that the first subscript denotes source, the second destination). We normalize $d_{j,nn} = 1$ for each country n in each sector j. Note that the trade costs would vary by destination pair and by sector, and in general would not be symmetric: $d_{j,nm}$ need not equal $d_{j,mn}$.

In addition to non-policy trade frictions $d_{j,mn}$, there are two policy barriers to trade: an ad valorem tariff $\tau_{j,mn}$ that is paid at the border, and an ad valorem non-tariff barrier $\eta_{j,mn} > 1$, that distorts trade but does not result in any government revenue. The total trade cost is thus given by $\kappa_{j,mn} = d_{j,mn}\eta_{j,mn}(1 + \tau_{j,mn})$.

Goods markets are competitive, and thus prices equal marginal costs. The price at which country m can supply tradable good q in sector j to country n is equal to:

$$p_{j,mn}(q) = \frac{b_{jm}}{z_{jm}(q)}\kappa_{j,mn}.$$

Buyers of each good q in sector j in country n will select to buy from the cheapest source country. Thus, the price actually paid for this good in country n will be:

$$p_{jn}(q) = \min_{m=1,\ldots,N} \left\{ p_{j,mn}(q) \right\}.$$

Following the standard EK approach, define the "multilateral resistance" term

$$\Phi_{jn} = \sum_{m=1}^{N} A_{jm} \left(b_{jm}\kappa_{j,mn}\right)^{-\theta}.$$

This value summarizes, for country n, the access to production technologies in sector j. Its value will be higher if in sector j, country n's trading partners have high productivity

(A_{jm}) or low cost (b_{jm}). It will also be higher if the trade costs that country n faces in this sector are low. Standard steps lead to the familiar result that the probability of importing good q from country m, $\pi_{j,mn}$ is equal to the share of total spending on goods coming from country m, $X_{j,mn}/X_{jn}$, and is given by:

$$\frac{X_{j,mn}}{X_{jn}} = \pi_{j,mn} = \frac{A_{jm}\left(b_{jm}\kappa_{j,mn}\right)^{-\theta}}{\Phi_{jn}}. \tag{3}$$

In addition, the price of good j aggregate in country n is simply

$$p_{jn} = \Gamma\left(\Phi_{jn}\right)^{-\frac{1}{\theta}}, \tag{4}$$

where $\Gamma = \left[\boldsymbol{\Gamma}\left(\frac{\theta+1-\epsilon}{\theta}\right)\right]^{\frac{1}{1-\epsilon}}$, with $\boldsymbol{\Gamma}$ denoting the Gamma function.

Equilibrium and market clearing. A **competitive equilibrium** in this economy is a set of goods prices $\left\{p_{jn}\right\}_{n=1,\ldots,N}^{j=1,\ldots,J}$, factor prices $\left\{w_{s,jn}\right\}_{n=1,\ldots,N}^{j=1,\ldots,J}$ for $s = H, M, L$ and $\left\{r_{jn}\right\}_{n=1,\ldots,N}^{j=1,\ldots,J}$, and resource allocations $\left\{Y_{jn}\right\}_{n=1,\ldots,N}^{j=1,\ldots,J}$, $\left\{Q_{jn}\right\}_{n=1,\ldots,N}^{j=1,\ldots,J}$, $\left\{\pi_{j,mn}\right\}_{n,m=1,\ldots,N}^{j=1,\ldots,J}$, such that (i) consumers maximize utility; (ii) firms maximize profits; and (iii) all markets clear.

The market-clearing condition for sector j aggregate in country n is given by

$$p_{jn}Q_{jn} = p_{jn}Y_{jn} + \sum_{i=1}^{J}(1-\beta_{in})\gamma_{jin}\left(\sum_{k=1}^{N}\frac{\pi_{i,nk}p_{ik}Q_{ik}}{1+\tau_{i,nk}}\right). \tag{5}$$

Total expenditure in sector j, country n, $p_{jn}Q_{jn}$, is the sum of domestic final expenditure $p_{jn}Y_{jn}$ and expenditure on sector j goods as intermediate input in all domestic sectors i: $\sum_{i=1}^{J}(1-\beta_{in})\gamma_{jin}\left(\sum_{k=1}^{N}\frac{\pi_{i,nk}p_{ik}Q_{ik}}{1+\tau_{i,nk}}\right)$. In turn, final consumption is given by:

$$p_{jn}Y_{jn} = \xi_{jn}\left(\sum_{s=\{H,M,L\}}\left(\sum_{i=1}^{J}w_{s,in}L_{s,in}\right) + \sum_{i=1}^{J}r_{in}K_{in} + \sum_{m\neq n}\sum_{i=1}^{J}\frac{\tau_{i,mn}\pi_{i,mn}p_{in}Q_{in}}{1+\tau_{i,mn}} + D_n\right). \tag{6}$$

Finally, since all factors of production are immobile across sectors, sectoral skill-specific $w_{s,jn}$ and sectoral r_{jn} adjust to clear the factor markets:

$$\sum_{m=1}^{N}\frac{\pi_{j,nm}p_{jm}Q_{jm}}{1+\tau_{j,nm}} = \frac{w_{s,jn}L_{s,jn}}{\alpha_{s,jn}\beta_{jn}} = \frac{r_{jn}K_{jn}}{(1-\sum_s \alpha_{s,jn})\beta_{jn}}. \tag{7}$$

Formulation in changes. Following Dekle et al. (2008), we express the model in terms of gross changes relative to the baseline equilibrium and the baseline equilibrium observables. For any baseline value of a variable x, denote by a prime its counterfactual value following some change in parameters, and by a "hat" the gross change in a variable between a baseline level and a counterfactual: $\widehat{x} \equiv x'/x$. The shock we will consider is an hypothetical increase in tariffs $\tau_{j,mn}$ and non-tariff barriers $\eta_{j,mn}$ between the United States, Canada, and Mexico following the revocation of NATFA. In changes, (6) becomes:

$$\widehat{p}_{jn}\widehat{Y}_{jn} = \sum_{s}\left(\sum_{i=1}^{J}\widehat{w}_{s,in}SL_{s,in}\right)+\sum_{i=1}^{J}\widehat{r}_{in}SK_{in}+\sum_{m\neq n}\sum_{i=1}^{J}\frac{\tau'_{i,mn}\widehat{\pi}_{i,mn}\widehat{p}_{in}\widehat{Q}_{in}}{1+\tau'_{i,mn}}\frac{\pi_{i,mn}p_{in}Q_{in}}{I_n}+\widehat{D}_nSD_n \tag{8}$$

where $SL_{s,in}$, SK_{in}, and SD_n are the initial shares of s-skill labor income in sector i, capital income in sector i, and the trade deficit, respectively. The market-clearing condition (5) becomes:

$$\widehat{p}_{jn}\widehat{Q}_{jn}p_{jn}Q_{jn} = \widehat{p}_{jn}\widehat{Y}_{jn}p_{jn}Y_{jn}+\sum_{i=1}^{J}(1-\beta_{in})\gamma_{jin}\left(\sum_{k=1}^{N}\frac{\widehat{\pi}_{i,nk}\widehat{p}_{ik}\widehat{Q}_{ik}\pi_{i,nk}p_{ik}Q_{ik}}{1+\tau'_{i,nk}}\right). \tag{9}$$

The factor market-clearing conditions become:

$$\widehat{w}_{s,jn}=\widehat{r}_{jn} = \frac{\sum_{m=1}^{N}\frac{\widehat{\pi}_{j,nm}\widehat{p}_{jm}\widehat{Q}_{jm}\pi_{j,nm}p_{jm}Q_{jm}}{1+\tau'_{j,nm}}}{\sum_{m=1}^{N}\frac{\pi_{j,nm}p_{jm}Q_{jm}}{1+\tau_{j,nm}}}. \tag{10}$$

The trade shares in changes are

$$\widehat{\pi}_{j,mn}=\frac{\left(\widehat{b}_{jm}\widehat{\kappa}_{j,mn}\right)^{-\theta}}{\sum_{k=1}^{N}\pi_{j,kn}\left(\widehat{b}_{jk}\widehat{\kappa}_{j,kn}\right)^{-\theta}}, \tag{11}$$

where

$$\widehat{b}_{jm}=\left[\left(\widehat{w}_{H,jm}\right)^{\alpha_{H,jm}}\left(\widehat{w}_{M,jm}\right)^{\alpha_{M,jm}}\left(\widehat{w}_{L,jm}\right)^{\alpha_{L,jm}}\left(\widehat{r}_{jm}\right)^{1-\sum_s\alpha_{s,jm}}\right]^{\beta_{jm}}\left[\prod_{i=1}^{J}\left(\widehat{p}_{im}\right)^{\gamma_{ijm}}\right]^{1-\beta_{jm}} \tag{12}$$

and

$$\widehat{\kappa}_{j,mn}=d_{j,mn}\widehat{\eta}_{j,mn}\frac{(1+\tau'_{j,mn})}{(1+\tau_{j,mn})}. \tag{13}$$

Finally, standard steps lead to the counterfactual price indices:

$$\widehat{p}_{jn}=\left(\sum_{m=1}^{N}\pi_{j,mn}\left(\widehat{b}_{jm}\widehat{\kappa}_{j,mn}\right)^{-\theta}\right)^{-\frac{1}{\theta}} \tag{14}$$

and

$$\widehat{P}_n = \prod_{j=1}^{J} \widehat{p}_{jn}^{\xi_{jn}}. \tag{15}$$

Equations (8)-(15) are solved for all the price, wage, and quantity changes between the baseline equilibrium and the counterfactual. The model is solved using the algorithm described in Appendix A.

3 Data

This section describes the sources of our trade, input-output and trade policy.

The 2016 release of the World Input-Output Database (WIOD) is our main data source. It contains data on trade flows, intermediate input usage, and final consumption at the sectoral level. The socio-economic accounts compiled by the WIOD also contain data on labor and capital share in value added. Labor is broken down into three skill levels. A low-skilled worker is defined by the WIOD as one with at most some secondary education. A medium-skilled worker has completed secondary education. A high-skilled worker has some tertiary education or more. We use the latest year available, which is 2014.[4] The WIOD and its construction are described in detail in Timmer et al. (2015). We combine some sectors with too many zeros, and add Turkey, Russia, Luxembourg, and Malta to the composite "Rest of the World" region. The resulting dataset consists of 40 countries and 38 sectors. Tables A1 and A2 in the Appendix provide a list of countries and sectors.

To get a sense of the importance of input and final goods trade among the NAFTA countries, Table 1 reports aggregate intermediate and final spending shares according to WIOD. The left panel reports the share of spending on intermediates from the country in the row of the table in the total intermediate spending in the country in the column. Thus, the United States sources 89.7% of all intermediates it uses from itself, 1.8% from Canada, and 1% from Mexico. The importance of the United States for Canada and Mexico is predictably larger. The United States supplies 12.1% of all intermediates used in Canada, and 15.1% of intermediates used in Mexico. The right panel presents the corresponding shares in final consumption spending. The importance of NAFTA countries in each other's final goods spending is lower, with Canada and Mexico supplying 0.6% and 0.8% of US final consumption spending, and the United States supplying 6.2% and 3.5%

[4] The latest WIOD release does not include worker breakdowns by skill. For that information, we use the previous (2011) WIOD release, with skill-specific sectoral labor data pertaining to 2009.

of final consumption of Canada and Mexico, respectively.

Table 1: NAFTA market shares

	Intermediate spending			Final consumption spending		
	Canada	Mexico	United States	Canada	Mexico	United States
Canada	.783	.007	.018	.876	.002	.006
Mexico	.006	.716	.010	.006	.914	.008
United States	.121	.151	.897	.062	.035	.943

Notes: This table reports the share of input spending (left panel) and final spending (right panel) in the column country coming from the row country. The columns do not add up to 1 because of imports from non-NAFTA countries.

Location-specific employment data come from the US Census Bureau (year 2015), Statistics Canada (year 2015) and the Instituto Nacional de Estadistica y Geografia (year 2014).[5] These are provided at the sectoral level following the NAICS classification. We convert these to ISIC 4 using the correspondence table from the Census Bureau. We do not have breakdowns of location-specific employment by skill level. Employment shares by skill for the US at the county level come from the US Census Bureau (2016). For the US, we convert county-level data to districts by using the Census Bureau's mapping.

At the national level, the sectors in which the bulk of US employment is currently found have at best weak direct connections to NAFTA countries. The left panel of Figure 1 plots US employment at the sector level against the share of intermediate spending sourced from the NAFTA countries. There is a broad negative relationship: the sectors with the greatest NAFTA input spending shares tend not to have much US employment. The right panel plots employment against the share of output exported to NAFTA countries. Here, there are essentially two groups of sectors: the group with a relatively high export intensity to NAFTA and low overall US employment, and sectors that export virtually nothing to NAFTA but have higher employment.

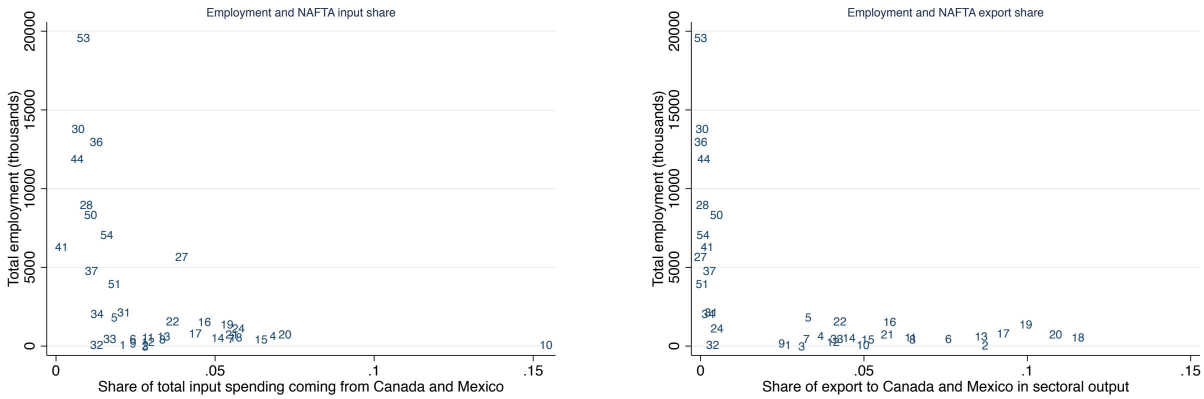
We use the 2014 tariff data for Canada, Mexico and the US from the World Bank's WITS database.[6] We set $\tau_{j,mn}$ to the current effectively applied tariff rate, and $\tau'_{j,mn}$ to the Most Favoured Nation (MFN) rate when m and n are NAFTA countries, and $\tau_{j,mn} = 0$ if either m or n are not one of the NAFTA countries.[7] Estimates of non-tariff trade barrier (NTB) changes in case of rollback of NAFTA come from Felbermayr et al. (2017). Those

[5] Chiquiar et al. (2017) analyze the Mexican data to study the effects NAFTA on local labor market outcomes.

[6] We extract tariff data directly at the ISIC 3 sectoral level, and use a correspondence to ISIC 3.1, then ISIC 4, to match it with the WIOD data classification.

[7] Since we are not changing other countries' tariffs, and are not keeping track of non-NAFTA tariff revenue, this simplification is inconsequential.

Figure 1: US Sectoral Employment, NAFTA Input Share and NAFTA Export Share



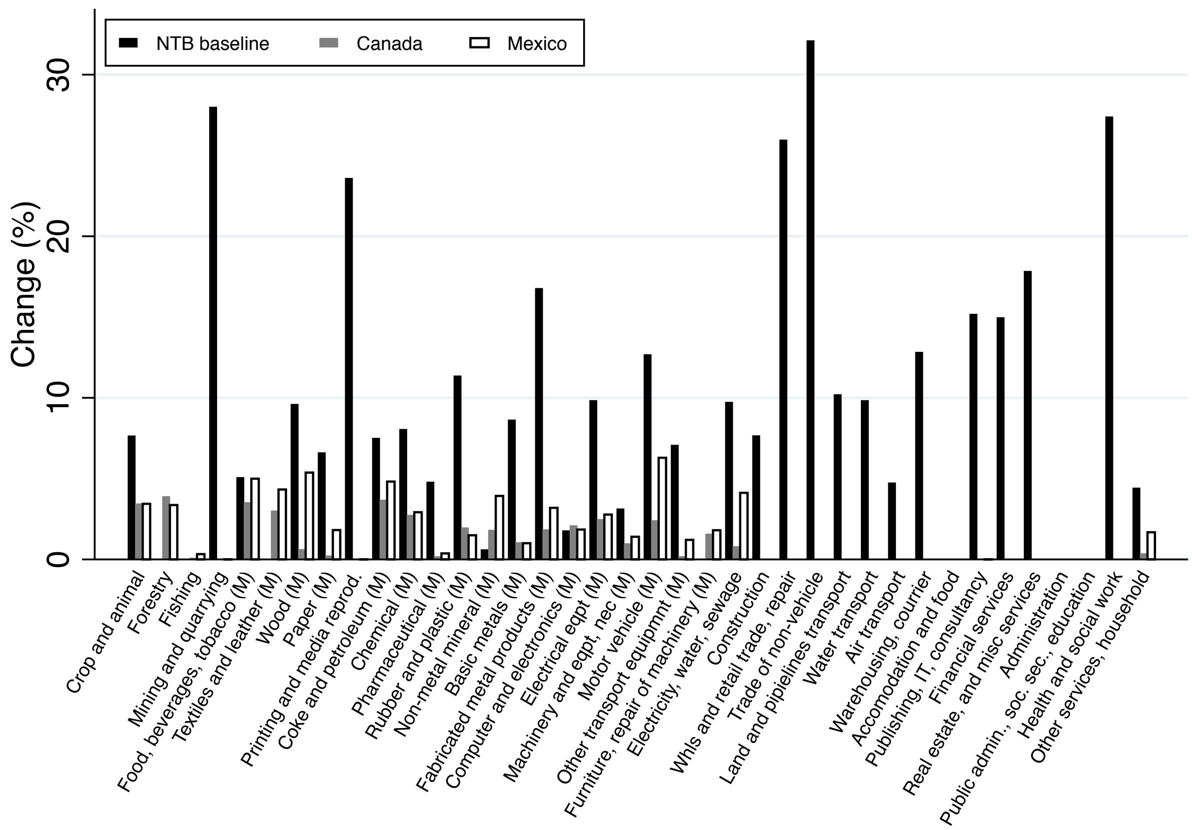
Notes: The left panel depicts the US sectoral employment against the share of total input spending in a sector that is sourced from Canada and Mexico. The right panel depicts the US sectoral employment against the share of total output exported to Canada and Mexico. The sector key is in Appendix Table A2.

authors fit a gravity model and infer non-tariff barriers from the deviation of actual trade volumes from trade volumes predicted based on observable gravity variables in each sector and country pair. According to this procedure, in a small number of sectors NTBs would actually fall as a result of revoking NAFTA. Since this appears implausible, we set the NTB change to zero in instances where the regression model predicts they will fall if NAFTA is revoked.

Figure 2 presents the changes in tariffs and NTBs that we assume would occur if NAFTA were revoked, expressed in percentage points (Appendix Table A3 reports the precise numbers). Since we assume that Canada and Mexico would receive MFN treatment if NAFTA disappeared, the tariff changes that would actually occur are by and large in single digit percentage points. The inferred NTB changes are both larger on average, and more broad-based, affecting also a number of service sectors in which tariffs are zero. It is plausible that a revocation of NAFTA would be accompanied by a general deterioration of the relationship between the countries, and that the NTBs would rise in a wide range of sectors.

At the same time, the NTB changes reported in Figure 2 are inferred from observed variation in trade flows, rather than measured directly. Direct measurement of NTBs is not feasible. To our knowledge, the only comprehensive NTB database is compiled by UNCTAD, and contains count measures of the number of NTBs in place by sector and country pair. We collected these data and compared the number of NTBs among the NAFTA countries with the number of NTBs that the NAFTA countries impose on non-

Figure 2: Assumed changes in US tariffs and NTB on Canada and Mexico if NAFTA is revoked



Notes: This figure reports the change in sectoral tariffs on Mexico and Canada, and the change in the NTBs imposed by the US on Mexico and Canada, if NAFTA is revoked, expressed in percentage points. "(M)" denotes a manufacturing sector.

NAFTA trading partners. It is indeed the case that the within-NAFTA number of NTBs is systematically lower than the number imposed by NAFTA countries on non-NAFTA economies. We computed the bilateral sectoral change in the number of NTBs within NAFTA if each NAFTA country went from the observed number of NTBs to the average that it imposes on the rest of the world. In this exercise, we assumed that, after the lower NTBs due to NAFTA are phased out, each NAFTA country will treat its NAFTA partners with the same level of NTBs that it imposes on the rest of the world, in each sector. The correlation between the implied change in the number of NTBs and the ad valorem NTB change from Felbermayr et al. (2017) in Figure 2 is 0.23 for the US-Mexico NTBs and 0.36 for the US-Canada NTBs. Given the significant caveats with simply using the number of NTBs as a measure of their severity, the positive correlation reassures us that there is some informational content in the NTB values inferred from trade flows and used in the baseline.

Nonetheless, given the large amount of uncertainly surrounding the NTB numbers, we report the results under two additional assumptions throughout. First, we assume that the NTBs don't change following the dismantling of NAFTA, and only tariffs do. This is the most conservative treatment of NTBs, resulting in far smaller overall trade cost increases from dismantling NAFTA. The second alternative we implement is to jettison the sectoral variation in NTB changes, and simply apply a uniform increase in NTBs that is equal to the average change across sectors implied by the Felbermayr et al. (2017) numbers. This implies a 9.62% uniform increase in NTBs when NAFTA is revoked.

4 Quantitative results

4.1 Calibration

All parameters except the trade elasticity θ can be calibrated directly from the WIOD data. All numbers in the WIOD data are in *basic prices* and therefore ex-tariff. One cell in the WIOD database is $M_{ij,mn}$, the exports from country m, sector i to country n, sector j, where j could be $j = C$ the final consumption. Denoting $M_{j,mn} = \sum_{i=1}^{J} M_{ji,mn} + M_{jC,mn}$ the total WIOD value of good j exported from m to n, we have that in terms of our model $M_{j,mn} = \frac{\pi_{j,mn} p_{jn} Q_{jn}}{1+\tau_{j,mn}}$.

The quantities needed to solve the model are:

$$p_{jn}Q_{jn} = \sum_{m=1}^{N} (1+\tau_{j,mn}) M_{j,mn} \tag{16}$$

$$\pi_{j,mn} = \frac{(1+\tau_{j,mn}) M_{j,mn}}{p_{jn}Q_{jn}} \tag{17}$$

$$D_n = \sum_{j=1}^{J} D_{jn} \text{ where } D_{jn} = \sum_{m=1}^{J} M_{j,nm} - \sum_{m=1}^{J} M_{j,mn} \tag{18}$$

$$T_n = \sum_{m=1}^{N} \sum_{j=1}^{J} \tau_{j,mn} M_{j,mn} \tag{19}$$

$$p_{jn}Y_{jn} = \sum_{m=1}^{N} (1+\tau_{j,mn}) M_{jC,mn.} \tag{20}$$

The production and utility parameters can be calibrated using the optimality conditions described above:

$$
\begin{aligned}
\xi_{jn} &= \frac{\sum_{m=1}^{N}(1+\tau_{j,mn})M_{jC,mn}}{\sum_{i=1}^{J}\sum_{m=1}^{N}(1+\tau_{i,mn})M_{iC,mn}} && (21)\\
\beta_{jn} &= 1-\frac{\sum_{m=1}^{N}\sum_{i=1}^{J}(1+\tau_{i,mn})M_{ij,mn}}{\sum_{m=1}^{N}M_{j,nm}} \text{ for } j\neq C && (22)\\
\gamma_{ij,n} &= \frac{\sum_{m=1}^{N}(1+\tau_{i,mn})M_{ij,mn}}{\sum_{m=1}^{N}\sum_{j'=1}^{J}(1+\tau_{j',mn})M_{ij',mn}} && (23)\\
\alpha_{s,jn} &= \frac{labor\_revenue_{s,jn}}{value\_added_{jn}}, && (24)
\end{aligned}
$$

where skill-specific labor revenue and value added come from the social and economic accounts of the WIOD.

In the baseline we set the trade elasticity $\theta = 5$, a common value in the quantitative trade literature (e.g. Costinot and Rodríguez-Clare, 2014). Section 6.2 assesses the robustness of the results to alternative θ's.

4.2 Sectoral and aggregate effects

With immobile factors, the sectoral wage change for each skill level is identical (see equation 10). Figure 3 reports the change in the real wage for each sector following the full revocation of NAFTA. As discussed above, we present three scenarios for NTB changes: (i) baseline depicted in Figure 2; (ii) no NTB changes (tariff changes only), and (iii) uniform NTB changes.

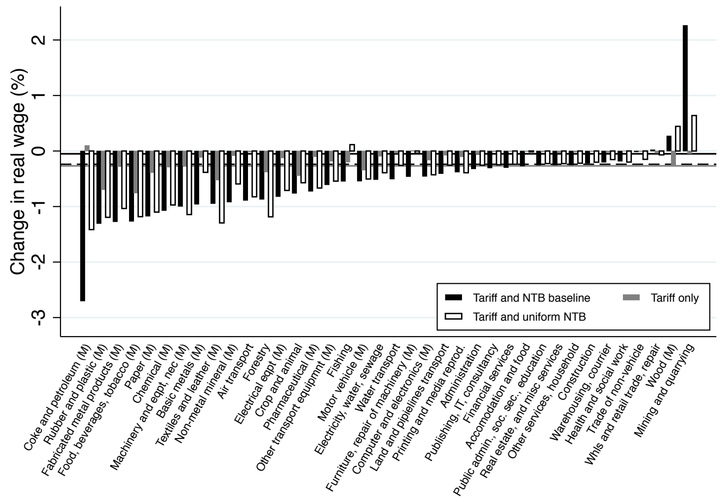
The real wage change is simply the change in the sectoral wage divided by the consumption price index, expressed in net terms: $\widehat{w}_{s,jn}/\widehat{P}_n - 1$. US sectors experience a range of wage changes, from a 2.26% increase in the mining and quarrying sector to a 2.7% decline in the coke and petroleum sector. The large majority of sectors experience wage decreases, with five sectors, all in manufacturing, seeing reductions in excess of 1%. With unchanged NTBs, wage decreases would be much smaller on average, as would be expected since this scenario involved much smaller trade cost increases. In the United States, overall the uniform NTB case is quite highly correlated with the baseline, with the notable difference for the outlier sectors, where the uniform NTB scenario implies changes smaller in absolute terms. In Canada and Mexico, the range of sectoral wage changes is much greater. Both Mexico and Canada have sectors that experience wage reductions in excess of 10%.

In all three countries, the employment-weighted average wage changes would be negative for all three scenarios, as reported by the horizontal lines in Figure 3. The numbers are in the first column of Table 2. The average wage fall in the US is an order of magnitude smaller than in Mexico and Canada in all scenarios. However, when computing aggregate welfare changes, we must take into account changes in the capital income and tariff revenue. Proportional changes in capital income would be the same as for wage income in our framework. Adding tariff revenue, the second column of Table 2 reports the overall welfare changes. The US loses 0.22% from the dismantling of NAFTA in the baseline scenario. Canadian and Mexican losses would be about ten times larger in proportional terms at around -2%. The numbers would be quite similar under a uniform NTB change. When only tariffs change, the US is indifferent, whereas Canadian and Mexican welfare fall by 0.08% and 0.26% respectively.

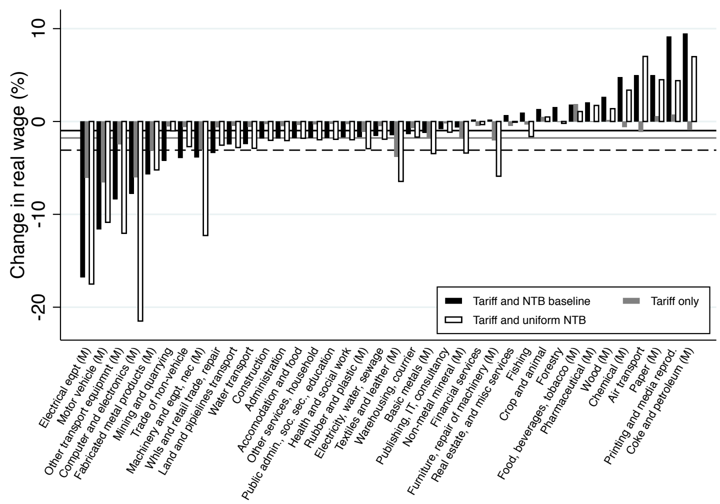
Though proportional changes would be smaller in the US, it bears the largest dollar losses from dismantling NAFTA, at about US$ 40 billion, as reported in the last column. Canada is a close second at US$ 37 billion, and Mexico at US$ 22. Our exercise implies that relative price levels (real exchange rates) also move, with the US dollar appreciating by 2.4% against the Mexican peso, and by 1.3% against the Canadian dollar in real terms.

Figure 3: Sectoral wage changes in NAFTA countries due to full rollback of NAFTA

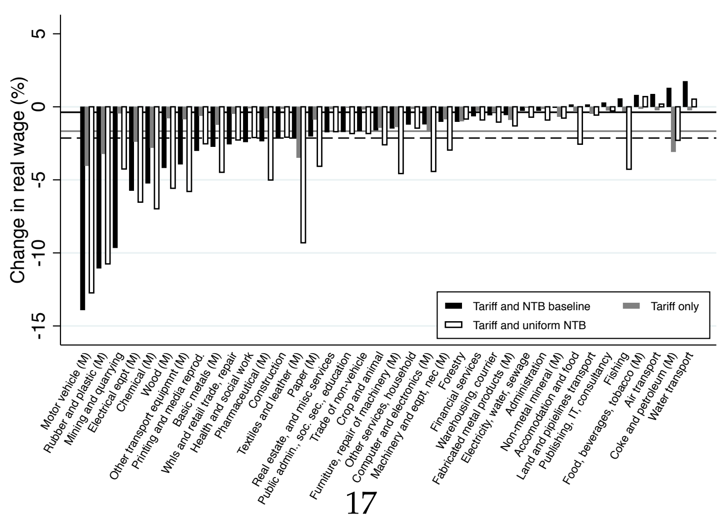
United States



Mexico



Canada



Notes: This Figure depicts sectoral real wage changes due to revocation of NAFTA. "(M)" denotes a manufacturing sector.

Table 2: Employment-weighted average wage and total welfare changes

	Real wage change, %	Total welfare change, %	in bln. US$
	Tariff and NTB counterfactual		
Canada	-1.67	-2.18	-36.58
Mexico	-1.78	-1.80	-21.99
United States	-0.27	-0.22	-39.86
	Tariff only counterfactual		
Canada	-0.37	-0.08	-1.29
Mexico	-0.98	-0.26	-3.11
United States	-0.05	-0.00	-0.23
	Tariff and uniform NTB		
Canada	-2.14	-2.05	-34.47
Mexico	-3.09	-2.03	-24.74
United States	-0.24	-0.22	-39.17

Notes: This table reports the aggregate real wage changes and the total welfare changes, in percentage points and in billion US$, for the NAFTA countries under the three NAFTA revocation scenarios.

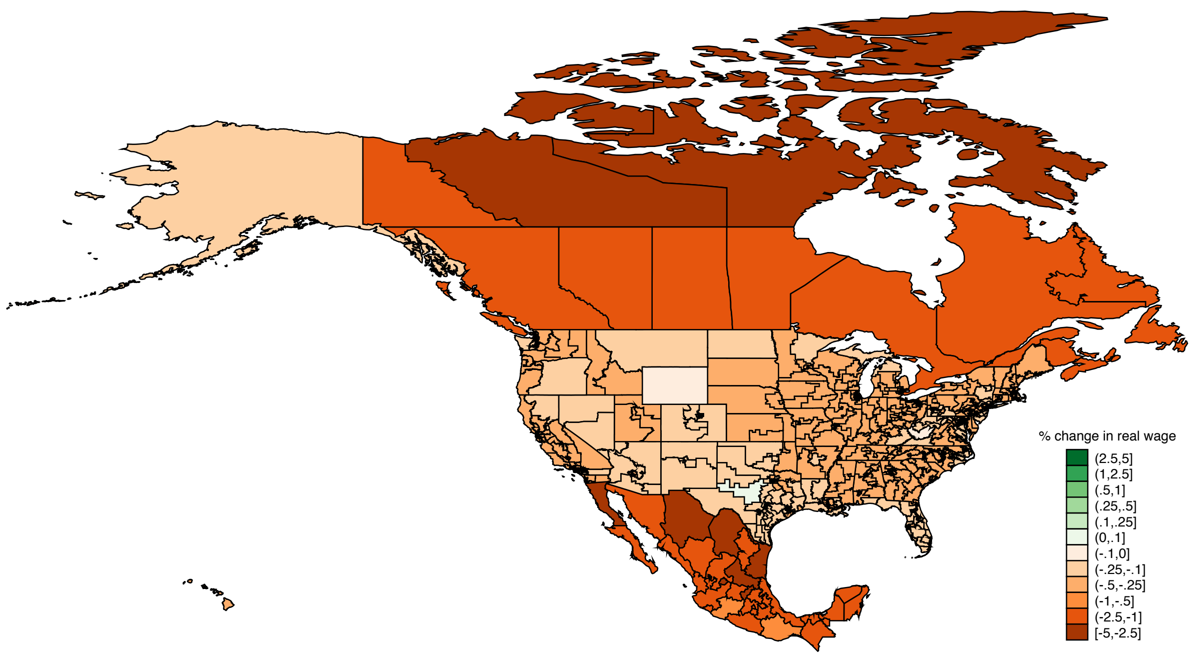
4.3 Geographic distribution a hypothetical rise in tariffs from the current NAFTA-negotiated ones to the MFN level, but NTBs remaining at current levels.

We next move on to the geographical distribution of relative gains and losses. To this end, we aggregate county-level sectoral employment to obtain sectoral employment shares in each district. Then, we construct the weighted average real wage change in a district by applying the sectoral wage changes to district-level sectoral employment shares. In Canada and Mexico, we use province- and state-level sectoral employment shares, respectively. Let c subscript locations, and let ω_{jc} be the share of sector j employment in total district c employment. The mean real wage change in location c is then

$$\sum_j \omega_{jc} \left(\frac{\widehat{w}_{jn}}{\widehat{P}_n} - 1 \right).$$

Figure 4 depicts the average real wage changes following the revocation of NAFTA, by geographical region. Darker shades denote larger wage reductions. The first distinctive feature of the figure is that the location-specific real wage changes are overwhelmingly negative throughout North America. Second, the systematically darker colors are outside of the United States: as reported above, wage reductions would be greater in Canada and Mexico. The figure highlights the pervasiveness of average wage reductions geographically in Canada and Mexico: though individual sectors sometimes experience wage increases, no region in Canada or Mexico sees real wage gains. In the US, the largest losses are in the eastern portion of the country, with two distinct darker bands in the upper Midwest and the South. The lightest hues (smallest wage decreases) are in mining areas of Texas, West Virginia, and Wyoming.

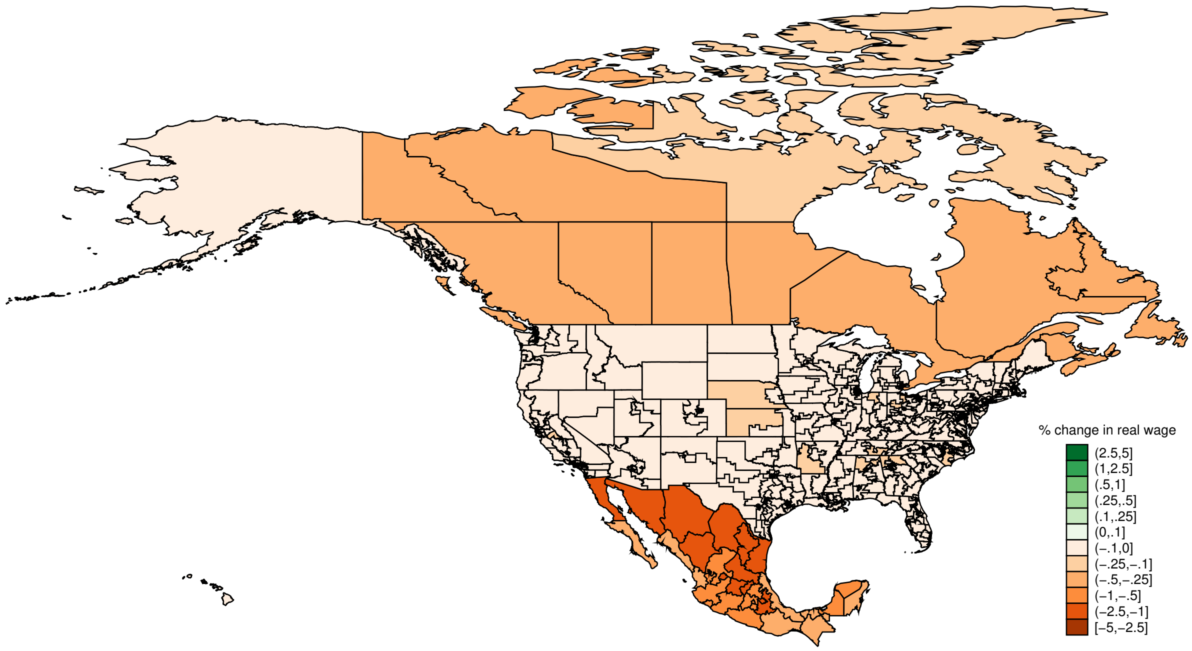
Figure 4: Real wage changes in NAFTA countries in tariff and NTB counterfactual



Notes: This figure depicts the average wage changes by geographic region in North America for the first counterfactual modelling a hypothetical rise in tariffs from the current NAFTA-negotiated ones to the MFN level, as well as an increase in NTBs in both goods and service sectors estimated by Felbermayr et al. (2017).

Figure 5 presents the same map for the second counterfactual in which tariffs are increased to MFN levels, but NTBs remain at current levels.

Figure 5: Real wage changes in NAFTA countries in tariff counterfactual



Notes: This figure depicts the average wage changes by geographic region in North America for the first counterfactual modelling a hypothetical rise in tariffs from the current NAFTA-negotiated ones to the MFN level, while NTBs remain at current levels.

5 The role of import competition, imported input use, and export opportunities

We next dig into the reasons underlying the surprising finding that almost all regions in North America would lose from the policy. The gist of our results is that while higher trade barriers would shield some domestic industries from import competition, the resulting wage gains would be more than offset by the detrimental effects of reduced export opportunities and the increased costs of imported inputs for manufacturing firms. For expositional clarity and brevity, we focus on the regional effects across US districts.

To better understand the patterns documented above, we next construct heuristic measures of trade exposure to NAFTA and correlate them with the real wage changes. We use three simple observable measures, intended to capture some of the main driving forces behind the geographic distribution of losses. The specific-factors model delivers the intuition that factors employed in import-competing sectors should benefit from a uniform increase in trade barriers, and sectors with an export orientation should lose. In a model with input-output linkages, factors in a sector employing imported inputs might lose, although that prediction depends on the substitution elasticities in production and demand.

Thus, at the sector level, we define import penetration as the share of imports from NAFTA in total absorption:

$$IMP_j^{NAFTA} = \frac{IMPORTS_j^{NAFTA}}{p_{jn}Q_{jn}},$$

where, as before, $p_{jn}Q_{jn}$ is the total US spending (absorption) in an industry. Define export intensity as the share of output exported to NAFTA countries:

$$EXP_j^{NAFTA} = \frac{EXPORTS_j^{NAFTA}}{\sum_k \pi_{j,nk} p_{jk} Q_{jk}},$$

where $\sum_k \pi_{j,nk} p_{jk} Q_{jk}$ is the total US output/sales in sector j. Define NAFTA input dependency as:

$$INPDEP_j^{NAFTA} = \frac{INTERMIMPORTS_j^{NAFTA}}{INTERMUSE_j},$$

where $INTERMIMPORTS_j^{NAFTA}$ is the value of intermediate imports from the NAFTA countries, and $INTERMUSE_j$ is total spending on intermediate inputs for sector j.

These are aggregated to the district level with employment shares:

$$IMPORT\ EXPOSURE_c = \sum_j \omega_{jc} IMP_j^{NAFTA},$$

$$EXPORT\ ORIENTATION_c = \sum_j \omega_{jc} EXP_j^{NAFTA},$$

and

$$IMPORTED\ INPUT\ INTENSITY_c = \sum_j \omega_{jc} INPDEP_j^{NAFTA}.$$

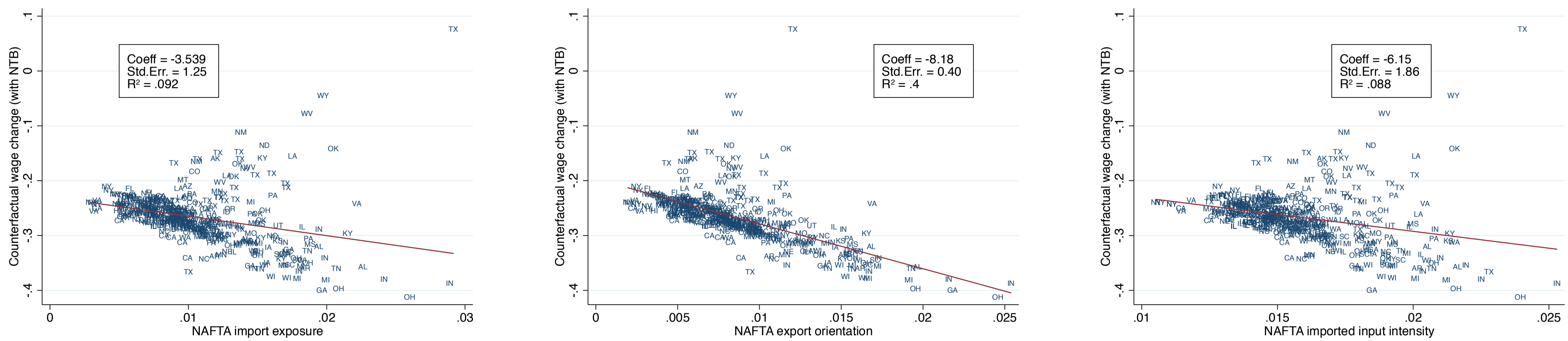
Thus, a district has a high import exposure, for example, if it has high employment shares in sectors with high import penetration from NAFTA countries, and similarly for other measures.

The top row of Figure 6 presents the scatterplot of the real wage change due to the revocation of NAFTA against import exposure (left panel), export orientation (center panel) and imported input intensity (right panel). All three measures have statistically significant negative correlation with the real wage change. This is intuitive in the case of two of the measures: NAFTA export-oriented districts and those that import a lot of

NAFTA inputs should lose more from dismantling NAFTA. However, the relationship is also negative for import exposure, which is not intuitive, as locations that compete with NAFTA imports should benefit in relative terms if NAFTA disappeared. This apparent incoherence is resolved by observing that the three heuristic measures are highly correlated among themselves. Import exposure has a 0.92 correlation with export orientation, and a 0.95 correlation with imported input intensity. Export orientation has a 0.86 correlation with imported input intensity. The picture that emerges is that US districts differ systematically in their overall trade openness with NAFTA. Locations that compete with NAFTA imports are also the ones that export the most to NAFTA, and use most NAFTA inputs. For these areas, a dismantling of NAFTA would represent a larger fall in trade openness compared to locations not engaged with NAFTA, and they would thus suffer a larger fall in real income.

Figure 6: Heuristic measures and real wage changes

Import exposure | Export orientation | Imported input intensity



Notes: The Figure depicts the scatterplots of the real wage change at a district level against each of the heuristic measures defined in Section 5.The lines through the data are the OLS fit. The boxes report the coefficient, robust standard error, and the R^2 of the bivariate regression.

This discussion shows how misleading it can be to rely on simple heuristic measures, especially in isolation: the patterns imply that the districts with higher import exposure would actually lose systematically more from revoking NAFTA. To further illustrate this point, Table 3 shows the results of a regression of the real wage changes on the three heuristic measures. Columns 1-3 report the regressions underlying the bivariate plots in Figure 6. Column 4 uses all three heuristics together. Now, the export orientation and imported input intensity still have same the "intuitive" sign, but the import exposure indicator switches sign and thus also becomes intuitive. Controlling for export orientation and imported input intensity, locations with greater NAFTA import exposure experience relatively positive (less negative) wage changes from revoking NAFTA.

Table 3: Wage changes and heuristic measures

	(1)	(2)	(3)	(4)
Dep. Var.:	NAFTA rollback wage change			
Export orientation	-8.178***			-30.74***
	(0.401)			(0.684)
Import exposure		-3.539**		25.64***
		(1.247)		(0.880)
Imported input intensity			-6.151**	-6.858***
			(1.860)	(1.562)
N. obs.	435	435	435	435
R^2	0.400	0.092	0.088	0.932

Notes: Robust standard errors in parentheses. ***: significant at the 1% level; **: significant at the 5% level. In all columns, the dependent variable is the percentage wage change caused by a revocation of NAFTA in the district. Variable definitions and sources are described in detail in the text.

6 Extensions and robustness

6.1 Mobile factors

All of the above analysis assumes that factors are immobile across sectors, and thus is meant to capture the short-run effects of a hypothetical trade policy. In this section, we instead allow factors to be mobile across sectors, as is more standard in multi-sector trade models. Since cross-sectoral factor movements are subject to large frictions even at multi-year horizons (Artuç et al., 2010; Dix-Carneiro, 2014), this exercise is meant to capture the long-run effects. Note that in this environment, factor market clearing ensures that factor prices are the same in all sectors, and thus there is a single factor price change for each factor of production (capital and the three types of labor). However, there would be still distributional effects across workers according to skill type, and across geographic locations according to the skill composition of the labor force.

Table 4: Skill specific wage and welfare changes

	Real wage change, %				
	High skill	Medium skill	Low skill	Total welfare change, %	in bln. US$
			Tariff and NTB baseline		
Canada	-1.40	-1.29	-0.29	-2.06	-34.70
Mexico	-1.18	-1.89	-0.72	-1.56	-19.03
United States	-0.31	-0.33	-0.38	-0.23	-41.35
			Tariff only		
Canada	-0.27	-0.39	-0.49	-0.07	-1.098
Mexico	-0.33	-0.67	0.02	-0.14	-1.691
United States	-0.05	-0.06	-0.10	-0.01	-2.305
			Tariff and uniform NTB		
Canada	-1.86	-1.99	-1.79	-2.00	-33.61
Mexico	-1.44	-2.56	-1.37	-1.67	-20.37
United States	-0.27	-0.28	-0.31	-0.24	-42.69

Notes: This table reports the aggregate real wage changes for each skill type, and the total welfare changes, in percentage points and in billion US$, for the NAFTA countries under the three NAFTA revocation scenarios.

Table 4 reports the real wage changes by skill type. In the United States, in all scenarios the wage changes increase with skill: more skilled workers are hurt less by dismantling of NAFTA. Intriguingly, the pattern is U-shaped in Mexico, with the medium-skilled workers hurt the most by NAFTA dissolution in all scenarios. In Canada, all skill types would be worse off, but the relative ranking is not stable across scenarios, indicating sensitivity to assumptions on the pattern of trade cost changes across sectors.

The fourth and fifth columns report the total proportional and dollar amount welfare changes. These are very similar to the baseline, indicating that assumptions on cross-sectoral factor mobility are not crucial for the aggregate welfare. A similar result was found by Levchenko and Zhang (2013).

Turning to the geographic distribution of real wage changes, we construct district average real wage changes by using skill shares in each district, similarly to the immobile factor case:

$$\sum_s \omega_{sc} \left(\frac{\widehat{w}_{sn}}{\widehat{P}_n} - 1 \right),$$

where ω_{sc} is the share of skill s in district c. Thus, districts with more skilled workers lose relatively less in the long run from the dismantling of NAFTA, as their wages fall by less. Note that the range of wage changes across skills, at only 0.07 percentage points in the baseline, is far smaller than the range of wage changes across sectors in the specific-factors model, which was about 5 percentage points. Thus, as expected the range of average wage changes across locations is also quite small, about 0.02 percentage points.

6.2 Varying the productivity dispersion parameter

In this robustness check, we repeat the main counterfactuals using alternative values of $\theta = \{2.5; 8\}$. These values represent the typical range of θ used in the trade literature. Table 5 shows the employment weighted average wage change for the different values of θ. Table 5 presents the aggregate real wage changes and welfare changes. We only report the baseline NTB scenario (the others deliver similar results and are available upon request). The alternative values of θ produce quite similar overall welfare changes.

Table 5: Aggregate real wage changes and welfare changes for different θ (Tariff and NTB baseline)

	Real wage change, %	Total welfare change, %	in bln. US$
	$\theta = 2.5$		
Canada	-1.93	-2.25	-37.76
Mexico	-1.97	-1.77	-21.59
United States	-0.32	-0.26	-46.97
	$\theta = 8$		
Canada	-1.40	-2.00	-33.64
Mexico	-1.59	-1.72	-21.00
United States	-0.23	-0.19	-34.73

Notes: This table reports the aggregate real wage changes and the total welfare changes, in percentage points and in billion US$, for the NAFTA countries under the two alternative values of θ.

7 Conclusion

Today's global production arrangements could lead to strong spillovers of protectionist policies. Barriers to input trade can reduce the competitiveness of domestic industries as internationally sourced inputs become more expensive. In a global input-output network, a tariff aimed at one specific trade partner or import sector ultimately affects all sectors of the domestic economy, yet very heterogeneously so. In a highly interconnected world economy with supply chains crossing country borders, the equilibrium effects of protectionism can be very different from what simple measures, such as exposure to import competition might suggest.

In this paper, we exemplify these channels and undertake a quantitative assessment of both the aggregate and the distributional effects of one hypothetical protectionist policy: revoking NAFTA. We find that NAFTA revocation would lower real incomes in the large majority of sectors in all three NAFTA countries, and that average wages would fall in nearly all regions in North America. While there would be differences in outcomes across locations, hardly anybody would gain in net terms. Correlating real wage changes with simpler and intuitive measures of trade, we highlight why this is the case: while higher trade barriers would shield some domestic industries from import competition, the resulting wage gains would be more than offset by the detrimental effects of reduced export opportunities and the increased costs of imported inputs for manufacturing firms. Our results underscore the importance of modelling the general equilibrium impact of protectionism and looking beyond simple heuristic judgements about who gains and who loses from trade policy changes in the current global production economy.

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Appendix A Solution algorithm

To solve equations (8) to (15) start by guessing $\{\hat{w}_{jn}, \hat{r}_{jn}\}$ and use the following algorithm.

i. Solve for $\hat{p}_{jn}$ using equations (14) and (12):

$$\hat{p}_{jn} = \left(\sum_{m=1}^{N} \pi_{j,mn} (\hat{c}_{jm} \hat{\kappa}_{j,mn})^{-\theta} \right)^{-\frac{1}{\theta}}$$

$$\hat{p}_{jn} = \left[\sum_{m=1}^{N} \pi^{j}_{j,mn} \left((\hat{w}_{jm}^{\alpha_{jm}} \hat{r}_{jm}^{1-\alpha_{jm}})^{\beta_{jm}} (\prod_{i=1}^{J} (\hat{p}_{im})^{\gamma_{ij,m}})^{1-\beta_{im}} \hat{\kappa}_{j,mn} \right)^{-\theta} \right]^{-\frac{1}{\theta}}$$

which can be solved iteratively. Then use $\hat{p}_{jn}$ to solve for $\hat{c}_{jn}$ and $\hat{P}_n$:

$$\hat{c}_{jn} = (\hat{w}_{jn}^{\alpha_{jn}} \hat{r}_{jn}^{1-\alpha_{jn}})^{\beta_{jn}} (\prod_{i=1}^{J} (\hat{p}_{in})^{\gamma_{ij,n}})^{1-\beta_{jn}}$$

$$\hat{P}_n = \prod_{j=1}^{J} (\hat{p}_{jn})^{\xi_{jn}}$$

ii. Solve for $\hat{\pi}_{j,mn}$ using equation (11) and $\hat{c}_{jn}$:

$$\hat{\pi}_{j,mn} = \frac{(\hat{c}_{jm} \hat{\kappa}_{j,mn})^{-\theta}}{\sum_{m'=1}^{N} \pi_{j,m'n} (\hat{c}_{jm'} \hat{\kappa}_{j,m'n})^{-\theta}}$$

iii. Use equations (8) and (9) to solve for $\hat{Y}_{jn}$ and $\hat{Q}_{jn}$:

$$\hat{p}_{jn} \hat{Y}_{jn} = \sum_{i=1}^{J} \widehat{w}_{in} SL_{in} + \sum_{i=1}^{J} \widehat{r}_{in} SK_{in} + \sum_{m \neq n} \sum_{i=1}^{J} \frac{\tau'_{i,mn} \widehat{\pi}_{i,mn} \widehat{p}_{in} \widehat{Q}_{in}}{1 + \tau'_{i,mn}} \frac{\pi_{i,mn} p_{in} Q_{in}}{I_n} + \widehat{D}_n SD_n$$

$$\hat{p}_{jn} \hat{Q}_{jn} (p_{jn} Q_{jn}) = \hat{p}_{jn} \hat{Y}_{jn} (p_{jn} Y_{jn}) + \sum_{i=1}^{J} (1 - \beta_{in}) \gamma_{ji,n} (\sum_{m=1}^{N} \frac{\hat{\pi}_{i,nm} \pi_{i,nm} \hat{p}_{im} \hat{Q}_{im} (p_{im} Q_{im})}{(1 + \tau'_{i,nm})})$$

This can be solved iteratively.

iv. update the next guess for $\hat{w}_{jn}$, $\hat{r}_{jn}$ from the labor market clearing condition

$$\widehat{w}_{jn} = \widehat{r}_{jn} = \frac{\sum_{m=1}^{N} \frac{\widehat{\pi}_{j,nm} \widehat{p}_{jm} \widehat{Q}_{jm} \pi_{j,nm} p_{jm} Q_{jm}}{1+\tau'_{j,nm}}}{\sum_{m=1}^{N} \frac{\pi_{j,nm} p_{jm} Q_{jm}}{1+\tau_{j,nm}}}.$$

the solution is defined up to a numeraire, and in updating the $\hat{w}_{jn}$ and $\hat{r}_{jn}$'s, re-set a numeraire country's $\hat{w}_1 = 1$ (where country 1, sector 1 is the numeraire). Then the actual next guess to be returned to step 1 is:

$$\hat{w}_{jn}^{next} = \frac{\hat{\hat{w}}_{jn}^{next}}{\hat{\hat{w}}_{11}^{next}} \tag{A.1}$$

$$\hat{r}_{jn}^{next} = \frac{\hat{\hat{r}}_{jn}^{next}}{\hat{\hat{w}}_{11}^{next}} \tag{A.2}$$

Table A3: Assumed changes in US tariffs and NTB on Canada and Mexico if NAFTA is revoked

WIOD Sector	$\Delta\tau_{j,CAN\,USA}$	$\Delta\tau_{j,MEX\,USA}$	$\Delta\eta_{j,mUSA}$
1	3.447	3.440	7.651
2	3.898	3.362	0
3	0.088	0.324	0
4	0.003	0.006	27.997
5	3.526	4.992	5.076
6	3.006	4.323	0
7	0.620	5.371	9.606
8	0.225	1.812	6.609
9	0.020	0.001	23.593
10	3.677	4.815	7.506
11	2.741	2.918	8.056
12	0.176	0.370	4.795
13	1.962	1.491	11.365
14	1.816	3.927	0.606
15	1.043	0.999	8.637
16	1.844	3.190	16.779
17	2.094	1.846	1.782
18	2.482	2.772	9.840
19	0.982	1.400	3.134
20	2.406	6.288	12.682
21	0.188	1.206	7.074
22-23	1.573	1.803	0
24-26	0.800	4.118	9.734
27	0	0	7.660
28-29	0	0	25.964
30	0	0	32.112
31	0	0	10.204
32	0	0	9.840
33	0	0	4.741
34-35	0	0	12.830
36	0	0	0
37-40	0.004	0.002	15.182
41-43	0	0	14.974
44-49	0	0	17.838
50	0	0	0
51-52	0	0	0
53	0	0	27.396
54	0.364	1.677	4.424

Notes: This Table reports the change in sectoral tariffs on Mexico and Canada, and the change in the NTBs imposed by the US on Mexico and Canada, if NAFTA is revoked, expressed in percentage points. The sector key is in Table A2.

Table A1: List of countries

Country	Country code
Australia	AUS
Austria	AUT
Belgium	BEL
Bulgaria	BGR
Brazil	BRA
Canada	CAN
Switzerland	CHE
China	CHN
Cyprus	CYP
Czech Republic	CZE
Germany	DEU
Denmark	DNK
Spain	ESP
Estonia	EST
Finland	FIN
France	FRA
United Kingdom	GBR
Greece	GRC
Croatia	HRV
Hungary	HUN
Indonesia	IDN
India	IND
Ireland	IRL
Italy	ITA
Japan	JPN
Korea	KOR
Lithuania	LTU
Latvia	LVA
Mexico	MEX
Netherlands	NLD
Norway	NOR
Poland	POL
Portugal	PRT
Romania	ROU
Slovakia	SVK
Slovenia	SVN
Sweden	SWE
Taiwan	TWN
United States	USA
Rest of the World	ROW

Table A2: List of sectors

Sector description	WIOD sector
Crop and animal production, hunting	1
Forestry and logging	2
Fishing and aquaculture	3
Mining and quarrying	4
Manufacture of food products, beverages and tobacco products	5
Manufacture of textiles, wearing apparel and leather products	6
Manufacture of wood and of products of wood and cork, except furniture	7
Manufacture of paper and paper products	8
Printing and reproduction of recorded media	9
Manufacture of coke and refined petroleum products	10
Manufacture of chemicals and chemical products	11
Manufacture of basic pharmaceutical products and pharmaceutical preparations	12
Manufacture of rubber and plastic products	13
Manufacture of other non-metallic mineral products	14
Manufacture of basic metals	15
Manufacture of fabricated metal products, except machinery and equipment	16
Manufacture of computer, electronic and optical products	17
Manufacture of electrical equipment	18
Manufacture of machinery and equipment n.e.c.	19
Manufacture of motor vehicles, trailers and semi-trailers	20
Manufacture of other transport equipment	21
Other manufacturing, repair and installation of machinery and equipment	22-23
Energy, AC; Water ; Sewerage and waste management services	24-26
Construction	27
Wholesale and retail trade	28-29
Retail trade, except of motor vehicles and motorcycles	30
Land transport and transport via pipelines	31
Water transport	32
Air transport	33
Warehousing and support activities for transportation; Postal activities	34-35
Accommodation and food service activities	36
Publishing, telecommunications, computer, information service	37-40
Financial and insurance service activities and auxiliaries	41-43
Real estate, legal, accounting, consultancy, scientific, veterinary activities	44-49
Administrative and support service activities	50
Public admin. and defense; compulsory social security; Education	51-52
Human health and social work activities	53
Other service activities; Activities of households as employers	54

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