The Macroeconomic Impact of NAFTA Termination

PRELIMINARY—DO NOT CIRCULATE

Joseph B. Steinberg*

February 1, 2018

Abstract

U.S. president Trump's administration has threatened to leave the North American Free Trade Agreement, and policymakers need answers about the effects that will materialize if this threat is carried out. How much would each country and industry gain or lose? Would trade imbalances within the region diminish? What would be the short-run costs of adjusting to new production and expenditure patterns? I use a dynamic general equilibrium model with a detailed input-output production structure and endogenous, time-varying trade elasticities to provide quantitative answers to these questions. If NAFTA is terminated, trade between NAFTA members will fall dramatically, particularly in sectors like agriculture where tariffs trade elasticities are high, and production in the transportation sector would decline. The macroeconomic and welfare consequences of NAFTA termination, however, are minor, and trade imbalances in the region would not decline.

*University of Toronto. Email: joseph.steinberg@utoronto.ca

"We are in the NAFTA (worst trade deal ever made) renegotiation process with Mexico & Canda.Both being very difficult,may have to terminate?"

— U.S. President Donald Trump, Twitter, August 27, 2017

1 Introduction

As a candidate for the U.S. presidency, Donald Trump called the North American Free Trade Agreement "the world trade deal in history." He has blamed NAFTA for persistent U.S. trade deficits and declining manufacturing employment, and following his election threatened to pull out of the agreement if it could not be renegotiated to his adminstration's satisfaction. In this paper, I use a dynamic general equilibrium model to quantify how terminating NAFTA would affect trade flows, welfare, sectoral reallocation, and trade imbalances in the short-run and the long-run.

Signed in 1992 and implemented in 1994, the North American Free Trade Agreement (NAFTA) created the largest free trade area the world had ever seen. Since NAFTA's inception, trade between the United States, Canada, and Mexico has grown dramatically. Today, the three NAFTA economies are heavily intertwined. Canada and Mexico trade significantly more with the United States than they do with any other country, and the United States only trades more with China than it does with its northern and southern neighbors. Extensive regional supply chains blossomed as trade has grown. The transportation equipment sector is the most pronounced example. Intermediate input trade with the United States accounts for 30 percent Canada's gross output in this sector and more than 50 percent of Mexico's.

Recently, however, trade relationships in the region have come under threat. U.S. president Donald Trump has pointed to U.S. trade deficits with its NAFTA partners as evidence of the deal's "unfairness" and his administration has forced talks to renegotiate the agreement, threatening to leave the agreement entirely if a satisfactory deal is not made. The U.S. Commerce Department has accused the Canadian government of subsidizing key exporters. In September, 2017 it imposed countervailing duties of a whopping 292 percent on imports of Bombardier aircraft,[1] and it has promised to impose 24 percent duties on Canadian softwood lumber exporters. Progress in renegotiation talks has been reported to be slow, and there is widespread concern that the Trump adminstration will make good on its threats to terminate the agreement. In this paper, I provide quantitative analysis about the macroeconomic consequences that would follow NAFTA's dissolution, providing answers to key questions such as: how much would each country's welfare rise or fall? Which industries would gain and which would lose? Would trade imbalances within the region shrink? Would the transition to a post-NAFTA equilibrium be costly?

To answer these questions, I develop a dynamic general equilibrium model with a detailed input-output production structure and costs of adjusting sectoral factor allocations and import patterns over time. The

[1] In January, 2018, the U.S. International Trade Comission rejected these duties, finding in favor of Bombardier in the dispute.

model has four countries: the United States, Canada, Mexico, and the rest of the world. Households in each country work, consume, and borrow or lend by trading bonds. Each country has five production sectors: agriculture, resource extraction, transportation equipment, other manufacturing, and services. Firms in each sector make dynamic decisions about investment, employment, and imported intermediates because adjusting each of these inputs over time is costly. I calibrate the model's parameters so that it replicates an input-output matrix from the World Input Output Database (Timmer et al., 2015) that contains data on NAFTA countries' current production and trade relationships.

I use the calibrated model to quantify the impact of NAFTA termination by comparing two equilibria: the *benchmark* in which NAFTA remains in force forever; and the *termination* equilibrium in which NAFTA ends permanently in 2018. When NAFTA is terminated, NAFTA members levy the same most-favored-nation import tariffs on each other's products that they levy on products from other World Trade Organization members. MFN tariffs are particularly high in the transportation sector, and Mexico also levies high tariffs on agricultural products. In the long run, aggregate trade flows between NAFTA members are 7–14 percent lower in the termination equilibrium than in the benchmark. Trade falls most in agriculture and resources, which have high trade elasticities, and least in the transportation sector, which has a very low trade elasticity. Production and consumption in the transportation sector, however, fall substantially, illustrating the importance of intermediate input trade for this sector. The long-run welfare effects of NAFTA termination are small: consumption falls by 0.04 percent in the United States, 0.06 percent in Canada, and 0.01 percent in Mexico. The economy takes many years to transition to its post-NAFTA steady state, but this adjustment process is not costly; including transition dynamics, the welfare losses from NAFTA termination are similar to the long-run declines in consumption. NAFTA termination has little impact on aggregate or bilateral trade balances in both the short and long run.

This paper contributes to several strands of literature. First, it contributes to the growing literature on the consequences of protectionist trade policies. A number of recent studies have analyzed the potential implications of the United Kingdom's impending departure from the European Union Dhingra et al. (2016b,c,a); McGrattan and Waddle (2017); Ebell et al. (2016); Baker et al. (2016); Steinberg (2017). Barattieri et al. (2017); Ruhl (2014) study the macroeconomic consequences of temporary trade barriers like antidumping and countervailing duties. Conconi et al. (2017) show how rules of origin requirements in free trade agreements like NAFTA increase trade costs with the rest of the world. My paper is the first to quantify macroeconomic consequences of NAFTA termination.

More generally, my paper contributes to the recent literature that quantitifies the effects of trade policy reforms using models with many countries, many sectors, and international input-output linkages (Caliendo and Parro, 2015; Costinot and Rodríguez-Clare, 2014; Giri et al., 2017). These studies highlight the importance of intersectoral and international heterogeneity in determining the aggregate effects of changes in trade policy. Caliendo and Parro (2015) in particular quantify the welfare gains from forming NAFTA. My paper

builds on this literature by embedding a rich, input-output production and demand structure into a dynamic model, which allows me to quantify the costs of short-term adjustments to NAFTA termination as well as the long-term consequences.

Finally, a number of other recent studies have analyzed the macroeconomic effects of trade policy reforms and other shocks in dynamic, open-economy models with investment (Bajona and Kehoe, 2010; Brooks and Pujolas, 2016; Ravikumar et al., 2017; Eaton et al., 2011), labor market adjustment frictions (Dix-Carneiro, 2014), and trade adjustment costs (Baldwin, 1992; Krugman, 1986; Engel and Wang, 2011; Alessandria and Choi, 2007; Ruhl, 2008; Alessandria and Choi, 2016; Alessandria et al., 2015). My model features all three, and is the first to integrate them into a model with a realistic input-output production structure.

2 What's at stake: key facts about tariffs, trade, and production

To set the stage for my analysis of the consequences of NAFTA termination, I first turn to the data to summarize what's at stake: how much tariffs on trade between NAFTA members could rise and how important this trade is for these countries.

2.1 Tariffs

How much could tariffs rise if NAFTA is terminated? The United States, Canada, and Mexico are all members of the World Trade Organization, and WTO's most-favored-nation (MFN) rule stipulates that in the absence of a regional free trade agreement, WTO members should levy the same tariff on all other WTO members' products. The WTO reports each member country's MFN tariff schedule at the 6-digit HS industry level. I combine these schedules with COMTRADE data on bilateral trade between NAFTA members at the same 6-digit level to compute import-weighted bilateral tariff rates for five broad sectors: agriculture, resource extraction, transportation equipment, and other manufacturing. Table 1 lists the HS code ranges included in each sector and table 2 shows the results of the analysis.

The transportation equipment sector, whose international supply chain has featured prominently in media coverage of the NAFTA debate, would have relatively high post-NAFTA tariffs compared to other manufactured goods. The elasticity of subsitution between domestic and foreign products—also known as the trade elasticity—in this sector is very low (Caliendo and Parro, 2015), which indicates that a reduction in trade in this sector triggered by NAFTA termination could be particularly painful. The resource sector, which is particularly important for Canada and Mexico, would have low post-NAFTA tariffs. The trade elasticity in this sector is very high, however, which suggests that even a small increase in tariffs could lead to a large drop in trade. Finally, Mexico would levy very high post-NAFTA tariffs on agricultural products, and because the trade elasticity in agriculture is also relatively high this could lead to a large reduction in

agricultural trade.

This analysis may understate the extent to which trade costs could rise as a result of NAFTA termination. The literature on trade costs has found that non-tariff barriers like transportation costs, differences in product regulations, and search costs are often larger than formal import tariffs (Anderson and van Wincoop, 2004; Allen, 2014; Lim, 2016). This is particularly true in the services sector, which I have excluded from my MFN-rate analysis because formal tariffs do not exist. Data limitations make it difficult to conclusively determine the effects of NAFTA termination on bilateral non-tariff barriers in trade between NAFTA members, so I analyze the importance of non-tariff barriers in the context at hand by conducting sensitivity analyses using my quantitative model.

2.2 Trade flows and production

The consequences of NAFTA termination depend not only on potential increases in trade costs, but also on the importance of intra-NAFTA trade for member countries, particularly in sectors like agriculture and transportation equipment in which trade costs could rise substantially.

To depict NAFTA members' key production and demand relationships, I use the World Input Output Database (Timmer et al., 2015), henceforth WIOD. This dataset, which has been widely used in recent international trade studies, contains annual data on production, intermediate inputs, and final demand for 43 countries and 56 industries. Unlike national input-output tables reported by national statistical agencies like the U.S. BEA, the WIOD data break down each reporter country's imports by source country and use (intermediate input or dinal expenditure), and thus provide a complete picture of the world input-output structure. I use the 2014 table—the most recent one available— and aggregate all countries other than the United States, Canada, and Mexico into a single "rest of the world" country, and I aggregate the 56 industries in the WIOD data into the same five sectors described in section 2.1. Table 1 lists the industries in each sector and table 4 lists the key facts about NAFTA members' trade flows and sectoral production.

2.2.1 Aggregate trade openness

NAFTA members differ substantially in their exposure to international trade and to trade within the region. Overall, the United States is less open to trade than Canada and Mexico: international trade (measured as the sum of exports and imports) was only 25 percent of U.S. GDP in 2014, compared to 65 percent and 59 percent in Canada and Mexico, respectively. Further, trade with other NAFTA members is less important for the United States: trade with Canada and Mexico accounts for a quarter of total U.S. trade, while trade with other NAFTA countries—primarily the United States—accounts for more than 60 percent of total trade for Canada and Mexico. These facts suggest that Canada's and Mexico's stakes in the future of NAFTA are

much higher than the United States'.

2.2.2 Sectoral production and trade

NAFTA members also differ substantially in the sectoral composition of their trade and output and in sector-level exposure to NAFTA termination.

The agriculture sector accounts for a small fraction of trade and production in all three countries, and so high post-NAFTA tariffs in this sector are likely to have small aggregate consequences. In Canada and Mexico, however, trade with the United States accounts for 62 and 45 percent of agricultural value added, respectively, and so the stakes for these countries agriculture sectors are high. This is particularly true in Mexico where agriculture tariffs stand to rise dramatically.

NAFTA countries all trade resources intensively—this sector accounts for a larger share of their trade than their value added—but resources trade within NAFTA is particularly important for Canada. Resources trade with the United states, in particular, is more than 100 percent of Canadian value added in this sector and almost 10 percent of Canadian GDP. Post-NAFTA tariffs in this sector are likely to be low, but because resources output is highly substitutable across countries (Caliendo and Parro, 2015), even these low tariffs may have a significant impact on Canada's resource sector and Canada's economy as a whole.

The transportation equipment sector is about the same size as the agriculture sector in all three NAFTA countries but but is more exposed to international trade, particularly trade in intermediate inputs within the NAFTA region. In all three countries, the trade in transportation equipment is larger than value added in this sector due to extensive international input-output linkages. In Canada, the ratio of trade to value added in transportation is more than 6, and imported intermediate inputs from the U.S. transportation sector alone are almost three-quarters of Canadian transportation value added. Combined with high post-NAFTA tariffs on transportation equipment and a very low trade elasticity in this sector(Caliendo and Parro, 2015), these facts imply that NAFTA termination could cause significant disruption in this sector that could have aggregate consequences despite the sector's small size.

Trade, and intermediate input trade in particular, is also important for the rest of the manufacturing sector. As in the transportation equipment sector, trade in other manufacturing exceeds value added for all three countries. The other manufacturing sector accounts for a larger share of each countries GDP than transportation but the consequences of NAFTA termination for this sector are lower: tariffs in other manufacturing will rise less than in transportation equipment and the trade elasticity is higher.

The services sector, the largest sector in all three countries, is unlikely to be significantly affected by NAFTA. Although services are tradable—trade in the services sector accounts for a large fraction of total trade in the United States and Canada—trade represents only a small fraction of services value added. Intra-NAFTA trade is also less important for services; trade with the rest of the world accounts for a larger fraction

of total trade in the services sector than in other sectors in all NAFTA countries. Finally, terminating NAFTA should have little effect on services trade costs since tariffs on services trade are rare.

2.2.3 Trade imbalances

One of the key issues at play in the debate over NAFTA is trade imbalances. U.S. president Trump has stated repeatedly that U.S. trade deficits with Canada and Mexico suggest that NAFTA is "unfair" to the United States, and that shrinking, or even reversing, these deficits is his administration's primary goal in renegotiating or terminating NAFTA.

In 2014, the United States did run a trade deficit with both Canada and Mexico, but these deficits were small relative to the aggregate U.S. trade deficit. The U.S. trade deficit with the rest of the world was almost four times larger than the deficit with Mexico and almost six times larger than the deficit with Canada. Consequently, whatever the effects of NAFTA termination on bilateral U.S. deficits with Canada and Mexico, the effect on the aggregate U.S. trade deficit (not to mention aggregate U.S. production, employment, and welfare) is likely to be small. These imbalances are more important when viewed from the Canadian and Mexican perspectives, however. Trade surpluses with the United States in 2014 were 3.5 percent and 7.3 percent of Canadian and Mexican GDP, respectively. Thus, rebalancing trade within the NAFTA region could have significant macroeconomic consequences for these two countries.

It is not clear ex ante how NAFTA termination will affect these imbalances. Canada's trade surplus with the United States consists mostly of natural resources, which will likely be taxed lightly when NAFTA is terminated but are highly substitutable across countries. Transportation equipment is the largest component of Mexico's trade surplus with the United States, and while post-NAFTA trade in this sector will be taxed more heavily, the trade elasticity in this sector is low.

3 Model

The model I use to analyze the consequences of NAFTA termination is a dynamic, general equilibrium environment with four countries: the United States, Canada, Mexico, and the rest of the world. The length of a period in the model is one year and there is no uncertainty; model agents have perfect foresight. Each country has a representative household and five production sectors: agriculture, resource extraction, transportation equipment, other manufacturing, and services. Countries are indexed by $i, j \in I$ and sectors are indexed by $r, s \in S$. Households work, consume, and save. Competitive firms in each sector produce output using capital, labor, and intermediate inputs. International trade in each sector is facilitated by Armington aggregators (henceforth distributors) that pay import tariffs and iceberg transportation costs to import foreign products.

Trade costs are modeled in two ways: (i) import tariffs that are rebated lump-sum to households, and (ii) iceberg transportation costs that represent all non-tariff barriers to trade. There are two forces in the model that make short-term adjustments to changes in trade policy different than long-term adjustments. First, distributors must pay convex costs to adjust the quantities they import from foreign suppliers, and as a result the elasticity of substitution between products from different countries varies endogenously over time. Second, producers in each sector must pay costs to adjusting their capital stocks and employment levels, and this makes sectoral reallocations following trade policy changes costly.

3.1 Gross output production

Gross output in country i's sector s, $y_{i,t}^s$, is produced using capital, $k_{i,t}^s$, and labor, $\ell_{i,t}^s$, rented from households and intermediate inputs, $m_{i,t}^{s,r}$, purchased from distributors in each sector $r \in S$ according to a Leontief technology:[2]

$$y_{i,t}^s = \min\left\{\frac{(k_{i,t}^s)^{\alpha_i^s}(\ell_{i,t}^s)^{1-\alpha_i^s}}{\lambda_i^{s,v}}, \min_{r\in S}\left[\frac{m_{i,t}^{s,r}}{\lambda_i^{s,r}}\right]\right\}. \tag{1}$$

The direct requirement coefficients $\lambda_i^{s,v}$ and $\lambda_i^{s,r}$, govern the shares of value added and intermediates from each sector, respectively, in gross output.

Gross output producers are perfectly competitive, and choose labor, investment, $x_{i,t}^s$, and intermediate inputs to maximize the present value of their dividends,

$$\sum_{t=0}^{\infty} \Lambda_{i,t} d_{i,t}^s, \tag{2}$$

subject to a law of motion for capital,

$$k_{i,t+1}^s = (1-\delta)k_{i,t}^s + \delta^{1-\phi}(x_{i,t}^s)^{\phi}(k_{i,t}^s)^{1-\phi}, \tag{3}$$

where dividends are given by

$$d_{i,t}^s = p_{i,t}^s y_{i,t}^s - w_{i,t}\ell_{i,t}^s - p_{i,t}^x x_{i,t}^s - \sum_{r\in S} p_{i,t}^{m,r} m_{i,t}^{s,r}. \tag{4}$$

$p_{i,t}^s$ is the price of gross output in country i's s sector, $w_{i,t}$ is the wage, $p_{i,t}^x$ is the price of investment, and $p_{i,t}^{m,r}$ are the prices of intermediate inputs purchased from distributors in each sector $r \in S$. $\Lambda_{i,t}$ is the price used to discount the firm's dividends. The parameter ϕ governs capital adjustment costs. The smaller ϕ, the more difficult it is for firms to effect large changes in their capital stocks (Eaton et al., 2011; Lucas and Prescott,

[2] Atalay (2014) finds that the elasticities of substitution between value added and intermediates and between intermediates from different sectors, respectively, are approximately zero. Kehoe et al. (2017) show that this production function is consistent with data on U.S. intermediate expenditures between 1992 and 2012.

1971). Note that capital adjustments costs affect sectoral capital stocks, not just the aggregate stock of capital; reallocating capital from one sector to another is costly.

3.2 International trade

In each country i and each sector s, there is one distributor for intermediate goods and another for final expenditures. In what follows, I describe the production technology and optimization problem of an intermediate distributor; the techology and problem of a final distributor is analogous. Country i's sector-s intermediate composite, $q_{i,t}^{m,s}$, is produced according to a standard Armington technology,

$$q_{i,t}^{m,s} = \left\{ \sum_{j \in I} \mu_{i,j}^{m,s} \left(z_{i,j,t}^{m,s} \right)^{\frac{\zeta_i^{m,s}-1}{\zeta_i^{m,s}}} \right\}^{\frac{\zeta_i^{m,s}}{\zeta_i^{m,s}-1}}, \tag{5}$$

where $z_{i,j,t}^{m,s}$ denotes the quantity of sector-s intermediates purchased from country j. The parameters $\mu_{i,j}^{m,s}$ governs the share of products that are sourced from each country j. $\zeta_i^{m,s}$ is the long-run elasticity of substitution between products from different countries—the long-run trade elasticity—which are allowed to vary by country, sector, and use. $q_{i,t}^{f,s}$ is the final composite, $z_{i,j,t}^{f,s}$ are the final distributor's inputs, and $\mu_{i,j}^{m,s}$ and $\zeta_i^{f,s}$ are the analogous parameters of the final distributor's technology.

There are two kinds of trade costs: import tariffs and iceberg transportation costs. $\tau_{i,j,t}^{s}$ is the import tariff levied by country i's government on products from country j's sector s. These tariffs are paid by distributors and rebated lump-sum to domestic households. $\xi_{i,j,t}^{s}$ is the iceberg transportation cost, which is also borne by distributors.

Short-run trade elasticities are endogenous due to the presence of adjustment costs. In order to adjust the quantities they purchase from foreign suppliers, distributors must pay convex costs as in Krugman (1986) and Engel and Wang (2011). The cost of adjusting the quantity purchased from country $j \neq i$, paid in units of labor, is $\varphi(z_{i,j,t}^{m,s} - z_{i,j,t-1}^{m,s})^2$. The parameter φ governs the size of the adjustment costs. These costs are paid on the absolute change in the import quantity rather than the percentage change so that adjusting larger import quantities is more costly.

Like gross output producers, distributors face a dynamic optimization problem in which they choose $z_{i,j,t}^{m,s}$ to maximize the present value of dividends. An intermediate distributor's dividends are given by

$$d_{i,t}^{m,s} = p_{i,t}^{m,s} q_{i,t}^{m,s} - \sum_{j \in I} p_{j,t}^{s} (1 + \tau_{i,j,t}^{s})(1 + \xi_{i,j,t}^{s}) z_{i,j,t}^{m,s} - \sum_{j \in I \setminus \{i\}} w_{i,t} \varphi \left(z_{i,j,t}^{m,s} - z_{i,j,t-1}^{m,s} \right)^2; \tag{6}$$

A final expenditure distributor's dividends are defined similarly. To see why this setup delivers time-varying, endogenous elasticities, consider the following expression obtained by taking the ratio of the distributor's

first-order condition for domestic inputs and its first-order condition for inputs from a foreign country $j \neq i$:

$$\frac{z_{i,j,t}^{m,s}}{z_{i,i,t}^{m,s}} = \left\{ \left(\frac{\mu_{i,j}^{m,s}}{\mu_{i,i}^{m,s}} \right) \left(\frac{p_{i,t}^{s}}{p_{j,t}^{s}(1+\tau_{i,j,t}^{s})(1+\xi_{i,j,t}^{s}) + 2\varphi \left[w_{i,t}(z_{i,j,t}^{m,s} - z_{i,j,t-1}^{m,s}) - Q_t w_{i,t+1}(z_{i,j,t+1}^{m,s} - z_{i,j,t}^{m,s}) \right]} \right) \right\}^{\zeta_i^{m,s}} \tag{7}$$

When there are no import adjustment costs, a one-percent increase in the relative price of the imported product always induces a $\zeta_i^{m,s}$-percent decrease in the ratio of imported inputs to domestic inputs—the elasticity of substitution between inputs from different countries always equals the long-run elasticity $\zeta_i^{m,s}$. In the presence of adjustment costs, the change in the ratio of imported inputs to domestic inputs depends on both the long-run elasticity and the trajectory of imports themselves. The larger the adjustment cost parameter φ, the more important these dynamics are in determining the short-run elasticity of substitution. Further, adjustments costs affect short-run elasticities more when import quantities are larger.

3.3 Investment

Each country has a nontradable investment good, $q_{i,x,t}$, that is an aggregate of inputs, $z_{i,x,t}^{s}$ purchased from final distributors:

$$q_{i,t}^{x} = \prod_{s \in S} (z_{i,t}^{x,s})^{\mu_i^{x,s}}. \tag{8}$$

The Cobb-Douglas formulation follows Bems (2008); Kehoe et al. (2017) who show that sectoral expenditure shares in investment are approximately constant over time. The ideal price index of investment is $p_{i,t}^{x}$.

3.4 Households

The representative household in each country i chooses consumption, $c_{i,t}^{s}$, of each product $s \in S$, labor supply, $\ell_{i,t}$, bond holdings, $b_{i,t+1}$, to maximize its lifetime utility,

$$\sum_{t=0}^{\infty} \beta^t \frac{1}{\psi} \left[c_{i,t}^{\gamma} (\bar{\ell}_i - \ell_{i,t})^{1-\gamma} \right]^{\psi}, \tag{9}$$

subject to the budget constraints

$$\sum_{s \in S} p_{i,t}^{f,s} c_{i,t}^{s} + Q_t b_{i,t+1} = w_{i,t} \ell_{i,t} + b_{i,t} + \sum_{s \in S} (d_{i,t}^{s} + d_{i,t}^{f,s} + d_{i,t}^{m,s}) + T_{i,t}, \tag{10}$$

and initial conditions for bonds. $c_{i,t}$, the aggregate consumption bundle, is given by

$$c_{i,t} = \left[\sum_{s \in S} \varepsilon_i^{s} (c_{i,t}^{s})^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}}, \tag{11}$$

and $T_{i,t}$ denotes the lump-sum transfer of revenues raised by tariffs and other taxes from the government. The parameters γ and ψ govern the share of time devoted to leisure and the intertemporal elasticity of substitution, respectively, and ρ is the elasticity of substitution between different sectors in consumption. $\bar{\ell}_i$ are time endowments. The discount factor used to value producers' and distributors' dividends is given by

$$\Lambda_{i,t} = \beta \frac{p_{i,t}^{f,s}}{p_{i,t+1}^{f,s}} \frac{u_{i,t+1}^{\prime s}}{u_{i,t}^{\prime s}}, \tag{12}$$

for any $s \in S$, where $u_{i,t}^{\prime s}$ denotes the household's marginal utility with respect to consumption in sector s in period t.

3.5 Market clearing

There are several markets that must clear in each period t. First, gross output must equal demand from all domestic and foreign distributors:

$$y_{i,t}^{s} = \sum_{j \in I} \left(z_{j,t}^{m,s} + z_{j,t}^{f,s} \right), \ \forall i \in I, \ \forall s \in S. \tag{13}$$

Second, firms' demand for intermediate inputs must equal output of intermediate distributors:

$$q_{i,t}^{m,s} = \sum_{r \in S} m_{i,t}^{r,s}, \ \forall i \in I, \ \forall s \in S. \tag{14}$$

Third, demand for investment inputs and consumption must equal final distributors' output:

$$q_{i,t}^{f,s} = c_{i,t}^{s} + z_{i,t}^{x,s}, \ \forall i \in I, \ \forall s \in S. \tag{15}$$

Fourth, firms' demand for investment must equal total output of the investment good:

$$q_{i,t}^{x} = \sum_{s \in S} x_{i,t}^{s}, \ \forall i \in I. \tag{16}$$

Fifth, labor markets must clear:

$$\ell_{i,t} = \sum_{s \in S} \left\{ \ell_{i,t}^{s} + \sum_{j \in I \setminus \{i\}} \varphi \left[\left(z_{i,j,t}^{m,s} - z_{i,j,t-1}^{m,s} \right)^2 + \left(z_{i,j,t}^{f,s} - z_{i,j,t-1}^{f,s} \right)^2 \right] \right\}, \ \forall i \in I. \tag{17}$$

Sixth, the international bond market must clear:

$$\sum_{i \in I} b_{i,t+1} = 0. \tag{18}$$

3.6 Equilibrium

An equilibrium, given a sequence of trade policy parameters, $\{(\tau^s_{i,j,t}, \xi^s_{i,j,t})_{i,j\in I, s\in S}\}_{t=0}^{\infty}$, is a sequence of quantities and prices that satisfy the optimality conditions of households, firms, and distributors; marginal product pricing conditions for investment, and all market clearing conditions. In the long run, if trade costs are constant, an equilibrium will always converge to a steady state. As in Kehoe et al. (2017), though, there is not a unique steady state—there is a continuum of possible steady states indexed by the vector of long-run bondholdings $(b_{i,\infty})_{i\in I}$, and the steady state to which the economy converges depends on initial conditions as well as the other model parameters.

I construct two equilibria in my model. In the first, the *benchmark*, trade costs are constant at their NAFTA levels forever. In the second, the *termination* equilibrium, trade costs between NAFTA countries rise to the values shown in table 2 in period $t = 4$, which corresponds to 2018. I assume that this policy change is unanticipated: in periods $t = 0, 1, 2$, and 3 of the termination equilibrium, model agents believe that trade costs will not change from their benchmark values. With these two equilibria in hand, we can measure the impact of NAFTA termination on each country's macroeconomic and trade dynamics by comparing the trajectories of model variables in the termination equilibrium to their benchmark counterparts.

4 Calibration

My calibration proceeds in three stages. First, I assign common parameters like discount factors and elasticities of substitution to standard values from the literature. Second, I set most of the remaining parameters so that the benchmark equilibrium—the one in which NAFTA is never terminated—matches recent input-output data that describe production and demand in NAFTA countries and the rest of the world. Third, I set φ, the import adjustment cost parameter, so that short-run trade elasticities in the termination equilibrium are consistent with findings from the trade dynamics literature.

4.1 Assigned parameters

I set the discount factor, β, so that the steady-state real interest rate is 2 percent per year. ψ, which governs the intertemporal elasticity of substitution, is set to -1. The depreciation rate, δ, is set to 6 percent. The capital shares, α^s_i, are all set to the standard value of one-third. I follow Kehoe et al. (2017) and Atalay (2014) and set ρ, the elasticity of substitution between sectors in consumption, to 0.65. I set γ, the share of consumption in households' utility, so that households supply one-third of their labor endowments in a steady state. I set ϕ, the capital adjustment cost parameter, to 0.8, the value reported by Steinberg (2016) and Sposi (2017). To set initial bondholdings, $b_{i,0}$, for the three NAFTA countries, I use data on their 2014 net foreign assets reported

in the Lane and Milesi-Feretti (2007) dataset; the rest of the world's initial bondholdings are implied by market clearing. Table 5 lists these assigned parameter values.

To set the long-run Armington elasticities— the elasticities of substitution between products from different countries—I refer to the trade literature. For the four goods sectors—agriculture, resources, transportation equipment, and other manufacturing, I use Caliendo and Parro (2015)'s estimates of trade elasticities for 2-digit ISIC industries; the ISIC classification maps directly to the set of industries in the WIOD database. For each country i and sector s, I set the intermediate and final elasticities, $\zeta_i^{m,s}$ and $\zeta_{s,i}^{f}$, to the average of the Caliendo and Parro (2015) estimates for the industries that comprise that sector, weighted by these industries shares' in country i's intermediate and final imports, respectively, of goods in sector s. For the services sector, I follow Costinot and Rodríguez-Clare (2014) and set all elasticities to five. Table 6 lists the assigned long-run elasticities, which range from 0.8 in transportation equipment to more than 40 in resources.

4.2 Expenditure shares and other parameters calibrated to input-output data

I calibrate the expenditure share parameters, $\lambda_i^{s,v}$, $\lambda_i^{s,r}$, $\mu_{i,j}^{m,s}$, $\mu_{i,j}^{f,s}$, $\mu_{s,i}^{x}$, ε_i^s, and the time endowments, $\bar{\ell}_i$, so that in the benchmark equilibrium, first-period expenditures on factors, intermediate inputs, consumption, and investment equal the values in the aggregated WIOD input-output table described in section **??**. This portion of the calibration procedure uses marginal product pricing equations and other equilibrium conditions to infer the expenditure share parameters that are consistent with the input-output data. Kehoe et al. (2017) describe this kind of procedure in more details. As in Steinberg (2017), I set all trade costs—import tariffs, $\tau_{i,j,t}^s$, and iceberg cost, $\xi_{i,j,t}^s$—to zero in the benchmark equilibrium. Thus, the Armington shares, $\mu_{i,j}^{m,s}$ and $\mu_{i,j}^{f,s}$, absorb all trade costs reflected in the 2014 input-output data as well as subjective home bias. This is without loss of generality since tariffs are rebated lump-sum to households. The parameters calibrated in this section contain many elements (for example, $\mu_{i,j}^{m,s}$ has $80 = 4 \times 5 \times 4 = 80$) so I do not include them in the paper. They can be found in the appendix.

4.3 Import adjustment costs

The last parameter that must be calibrated is φ, which governs import adjustment costs. I set this parameter so that in the termination equilibrium, the average of each country's aggregate short-run trade elasticity in response to NAFTA termination is 1.5, the standard value in the international macro literature. I measure short-run trade elasticities following Alessandria et al. (2015). For each country i, I measure the bilateral short-run trade elasticity in sector s with trade partner j as the one-year percent change in country i's imports of sector-s products from country j in the period that NAFTA is terminated divided by the percent change

in import tariffs:

$$e^s_{i,j,t} = \log\left(\frac{p^s_{j,t}(z^{m,s}_{i,j,t} + z^{f,s}_{i,j,t})}{p^s_{j,t-1}(z^{m,s}_{i,j,t-1} + z^{f,s}_{i,j,t-1})}\right) \Big/ \log\left((1+\tau^s_{i,j,t})(1+\xi^s_{i,j,t})\right). \tag{19}$$

To measure each country's aggregate trade elasticity, I simply take the average of its sector-partner elasticities weighted by pre-termination imports. This average excludes elasticities in trade with the rest of the world; since trade costs with the rest of the world do not change, the trade elasticity with the rest of the world measured in this way is undefined.

5 Effects of NAFTA withdrawal on member countries

Having laid out the model and calibrated its parameters, I turn now to the quantitative analysis. Table 7 summarizes the long-run effects of NAFTA termination on trade, production, consumption, and employment. Figures 1–6 illustrate the transition dynamics that follow NAFTA termination. Table 8 lists welfare losses, which include the effects of transition dynamics as well as long-run changes.

5.1 Trade flows

Figure 1 shows how aggregate trade flows respond to NAFTA termination. In the long run, NAFTA members' aggregate trade flows fall by 2.1–6.7 percent. The effects are largest for Mexico, which levies the largest post-NAFTA tariffs, and smallest for the United States, which levies smaller tariffs and is the least exposed to NAFTA trade (and trade in general). The short-run effects of NAFTA termination on aggregate trade are more muted. It takes more than ten years for aggregate trade flows to adjust to their post-NAFTA steady states. This is due largely to the presence of import adjustment costs which, as discussed above, cause short-run trade elasticities to differ endogenously from the assigned long-run elasticity values. Figure 1c shows how each NAFTA country's aggregate trade elasticity responds to NAFTA termination. All three countries' short-run trade elasticities in the period in which NAFTA is terminated are less than 2.0 and it takes many years to reach their long-run values, which range from 7.3 to 9.7.

Figure 2 shows how NAFTA termination affects bilateral trade. All bilateral trade flows between NAFTA countries fall substantially. For the United States, trade with Mexico falls more than trade with Canada. For Canada, exports to Mexico fall more than exports to the United States, while imports from the United States fall more than imports from Mexico. Mexican exports to the United States fall most, while Mexican imports from both the United States and Canada fall by about the same amount. All three NAFTA countries see an increase in trade with the rest of the world since trade costs with the rest of the world do not change.

Figure 3 illustrates the impact of NAFTA termination on trade within the NAFTA region at the sectoral level. Trade among NAFTA countries falls most in the agriculture sector, which has high post-NAFTA tariffs and a high trade elasticity; Mexican agricultural imports (and U.S. agricultural exports) decline substantially becdause of Mexico's particularly high tariffs in this sector. Trade falls least in the transportation sector despite relatively high tariffs because this sector has the lowest trade elasticity; as discussed below, the small drop in trade in this sector nevertheless causes large drops in production and consumption. Trade rises slightly in the services sector, where tariffs do not increase. Trade in the resources sector also falls substantially despite small tariff increases due to this sector's high trade elasticity.

5.2 Trade balances

As figure 4 shows, NAFTA termination also has little effect on trade balances. In the aggregate, the U.S. trade balance is almost entirely unaffected, while the Canadian and Mexican trade balances fall slightly relative to the size of their economies. The Canadian and Mexican trade balances rise in the short run before adjusting back downwards, but these fluctuations are smal relative to those that occur over the business cycle.

From the United States' perspective, bilateral trade balances also respond little to NAFTA termination. The U.S. trade deficit with Canada improves while the trade deficit with Mexico rises further, but these changes are small because U.S. trade flows—particularly current trade deficits—with Canada and Mexico are small relative to the size of the U.S. economy. Canadian bilateral trade rebalances in response to NAFTA termination. Canada's trade surplus with the United States and its trade deficit with the rest of the world both fall. For Mexico, by contrast, bilateral trade becomes more imbalanced. Mexico's trade surplus with the U.S. and trade deficit with the rest of the world both grow.

5.3 Sectoral reallocation

Figure 5 shows that NAFTA termination causes large sectoral reallocations in production and consumption. In the United States, the largest drop in sectoral production is seen in the agriculture sector due to the significant reduction in agriculture exports to Mexico. Production in the resources sector rises slightly, while production in other sectors declines. U.S. consumption falls most in the transportation sector. In Canada, production and consumption both fall significantly more in the transportation sector than in other sectors. This is due to the low trade elasticity and Canada's extensive international input-output linkages in this sector. In Mexico, transportation production falls dramatically, but consumption falls less since Mexico exports most of its output in this sector. Production in Mexico's agriculture sector rises dramatically to offset Mexico's massive decline in imports in this sector, but consumption still declines.

5.4 Macroeconomic dynamics and welfare

Figure 6 illustrates the macroeconomic effects of NAFTA termination. Production, consumption, and investment fall in the long run in all three NAFTA countries, but none of these effects are large— the long-run drop in consumption in each country is less than a tenth of a percent. The macroeconomic consequences for the United States are particularly small because the U.S. is least exposed to NAFTA trade. In Canada and Mexico, GDP falls by about quarter of a percent in the long run. Consumption falls less because investment falls three times more than output.

Figures 5 and 6 depict a long adjustment process to the new post-NAFTA steady state, suggesting that the welfare losses associated with NAFTA termination could differ from the long-run changes in consumption. I measure welfare losses in the usual consumption-equivalent way, which asks households in each country the fraction of their annual consumption baskets that they would give up to remain in the benchmark equilibrium. Table 8 shows that welfare losses for all three countries are small—even smaller than the long-run drops in consumption. In Mexico, welfare actually rises as a result of the initial increase in consumption.

6 Sensitivity analyses and alternative scenarios

In this section I analyze the sensitivity of my results to key aspects of my calibration and explore several alternative scenarios for how trade costs could change when NAFTA is terminated. Table 8 shows how the effects of NAFTA termination on welfare and trade change in the sensitivity analyses and alternative scenarios, and table 9 shows how the effects on the transportation sector change.

6.1 Sensitivity analyses

I conduct three sensitivity analyses. In the first, I analyze the roles of adjustment costs to capital and imports. In the second, I analyze the role of sectoral heterogeneity in trade elasticities. In the third, I analyze the role of intermediate input linkages.

6.1.1 Adjustment costs

In order to capture stylized facts in the literature about the dynamics of trade adjustment and investment, I have incorporated two kinds of adjustment costs in my baseline model: distributors must pay to adjust their usage of imported products, and firms must pay to adjust their sector-specific capital stocks. Figures 1 and 6 show that, as a result of these adjustment costs, the U.S., Canadian, and Mexican economies take many

years to transition to the new post-NAFTA steady state. Here, I ask: how costly is this adjustment process? To answer this question, I analyze two alternative versions of the model: one without import adjustment costs, and another without capital adjustment costs.

Figures 7–9 show compare each country's macroeconomic dynamics in the baseline model to their counterparts in the two alternatives. Capital adjustment costs have only a minor impact on transition dynamics. Import adjustment costs have a larger impact, however. In the alternative model without import adjustment costs, regional imports (shown in panel (d) of each figure) fall immediately to their long-run levels. GDP, consumption, and investment take many years to transition to their new steady states, but their transition paths are quite different, particularly for the United States and Canada. In the baseline model, U.S. and Canadian macroeconomic variables fall sharply in the short run when NAFTA is terminated. By contrast, in the model without import adjustment costs, U.S. and Canadian aggregates fall steadily and gradually towards their new steady states. In Mexico, the initial increases in consumption and investment are stronger in the alternative model than in the baseline. Table 8 shows that the welfare costs of import and capital adjustments during the transition process are small, however; the effects of NAFTA termination on welare are similar in the two alternatives to the baseline model's effects.

6.1.2 Trade elasticities

Elasticities of substitution between domestic and foreign products—trade elasticities—are key parameters in any trade reform analysis becauset they determine how trade flows and welfare respond to changes in trade costs (Arkolakis et al., 2012). In multi-sector models, cross-sectoral differences in trade elasticities are particularly important (Caliendo and Parro, 2015; Costinot and Rodríguez-Clare, 2014). In my baseline analysis, I assigned sectoral trade elasticities based on Caliendo and Parro (2015)'s estimates. Agriculture and resources have high trade elasticities, while the transportation equipment sector has a low one. Here, I ask: how do cross-sectoral difference in trade elasticities shape the quantitative effects of NAFTA termibnation? To answer this question, I analyse an alternative version of my model in which all sectors have a long-run trade elasticity of 5, the average estimate reported by Caliendo and Parro (2015).

As table 8 shows, aggregate regional trade declines by about the same amount in the symmetric-elasticity model as in the baseline model, but the welfare effects are different. U.S. welfare losses are smaller, while Canadiand Mexican welfare losses are larger. For Mexico, welfare losses are significantly higher in the symmetric-elasticity alternative because the decline in agricultural imports caused by its high tariffs in this sector is more painful. In the transportation sector, which has a low elasticity in the baseline model, imports fall more in the alternative. This is less painful than in the baseline model, however, because it is easier to substitute domestic products for foreign ones.

6.1.3 Intermediate linkages

Giri et al. (2017), Caliendo and Parro (2015), and other recent quantitative trade studies have shown that intermediate input linkages are also important in shaping economic responses to trade policy reforms. Like these studies, my baseline model features a rich input-output structure in which firms in each sector use domestic and imported intermediates to produce their goods and services. As I have shown, all three NAFTA countries' transportation sectors rely particularly heavily on imported intermediate inputs. Here, I ask: what is the role of input-output linkages in determining the macroeconomic and sectoral consequences—particularly for the transportation sector—of NAFTA termination? To answer this question, I analyze a version of my model in which there are no intermediate inputs. In this alternative, I zero out all intermediate-input cells in my input-output matrix before calibrating the model .[3] Thus, gross output equals value added in all sectors and international trade consists only of final expenditures.

Table 8 shows that for the United States and Canada, regional imports fall by about the same amount in the no-intermediates alternative as in the baseline model and welfare losses are lower. For Mexico, imports fall less in the alternative but welfare losses are larger. Table 9 shows that the effects of NAFTA termination are on the transportation equipment sector are less pronounced in the no-intermediates alternative than in the baseline model. In all three NAFTA countries, value added in this sector falls less in the alternative than in the baseline; the difference is largest for Canada, which imports the most intermediate inputs in this sector. Consumption in this sector falls less in the no-intermediates alternative in the United States and Canada, and slightly more in Mexico.

6.2 Alternative scenarios

In my baseline analysis, I assume that NAFTA is terminated entirely, and when this happens its members will levy the same most-favored-nation tariffs on each others imports that they levy on imports from other World Trade Organization members. Trade policies towards other countries are unaffected, and no "deal" is reached between even a subset of NAFTA members. Here, I explore the effects of several alternative scenarios that could arise in place of, or in addition to, NAFTA termination.

6.2.1 Higher U.S. tariffs

The first alternative scenario, NAFTA is terminated and the United States becomes unilaterally more protectionist by doubling all of its most-favored-nation tariffs. U.S. tariffs on Canadian and Mexican rise twice as much as in the baseline model, and U.S. tariffs on imports from the rest of the world rise as well. Canadian

[3] I use the RAS procedure **?** to "balance" the alternative input-output matrix to ensure that all markets clear, ensuring that this matrix can represent an intratemporal equilibrium in my model.

and Mexican tariffs are the same in this scenario as in the baseline. **??** lists all changes in tariffs in this scenario.

As expected, in this scenario U.S. imports from Canada and Mexico fall more than in the baseline and its imports from the rest of the world fall as well. Nevertheless, U.S. welfare actually rises; it is Canada and Mexico that bear the burden of increased U.S. protectionism in this scenario. Their imports from other NAFTA countries also fall more than in the baseline model and their welfare losses are larger. As table 9 shows, the Canadian and Mexican transportation sectors shrink significantly more in terms of both production and consumption in this scenario, suggesting that input-output linkages may play a role in why the increase in welfare losses falls on Canada and Mexico. To verify this, I have conducted a second version of this analysis without intermediate inputs. Here, as tables 8 and 9 show, welfare and transportation output in Canada and Mexico indeed fall less than in the first version of this scenario.

6.2.2 Canada-Mexico free trade agreement

In the second alternative scenario, NAFTA is terminated Canada and Mexico sign a bilateral free trade agreement. Thus, U.S. tariffs on imports from Canada and Mexico rise the same amount as in the baseline scenario, as do Mexican and Canadian tariffs on imports from the U.S., but tariffs on trade between Canada and Mexico do not change.

Table 8 shows that while a Canada-Mexico free trade agreement would do little to change the effects of NAFTA termination on these countries. Canada's welfare falls slightly less than in the baseline, while Mexico's rises slightly less, and their imports from other NAFTA countries fall by about the same amount. These results follow from the fact that Canada and Mexico currently trade little with each other; most of their trade within NAFTA is with the United States.

6.2.3 Renegotiation with stronger domestic content requirements

One of the major sticking points in NAFTA renegotiation talks is domestic content requirements, especially in the transportation equipment sector. Also called rules of origin, these regulations restrict the amount of intermediate inputs that firms can purchase from non-NAFTA countries while remaining eligible for duty-free trade within NAFTA. Conconi et al. (2017) show that these requirements have already significantly reduced intermediate inputs from non-NAFTA countries. U.S. trade representatives, however, have demanded even stricter domestic content requirements as a condition of remaining in NAFTA. Here, I analyze what would happen if NAFTA remains in force but domestic content requirements are increased. I model this by assuming that in the termination equilibrium, trade costs between NAFTA countries do not change, but all NAFTA countries' tariffs on imported intermediate inputs from the rest of the world rise by 10 percent; tariffs on final goods and services imported from the rest of the world do not change.

Table 8 shows that welfare in all NAFTA countries would rise if NAFTA's rules of origin were strengthened. Imports from the rest of the world would fall significantly, though, and value added in the automotive sector would fall—in the United States, value added in this sector would fall even more than in the baseline scenario. Thus, while stricter rules of origin would be beneficial, they would not achieve their stated goal of boosting the transportation equipment sector.

7 Conclusion

In this paper I have used a dynamic general equilibrium model with an input-output production structure to assess how terminating the North American Free Trade Agreement would member countries' trade flows, macroeconomic dynamics, welfare, and sectoral performance. The model is calibrated so that it replicates a recent input-output matrix. When NAFTA is terminated in 2018, NAFTA members charge the same import tariffs on each other's products that they charge on products from other World Trade Organization members. Tariffs rise most in the transportation equipment sector and, in the case of Mexico, agriculture. It is costly for firms to adjust their imports of foreign products and their capital stocks, so the transition to the new post-NAFTA steady state is gradual.

In the long run, NAFTA termination would reduce aggregate trade flows between NAFTA members by 6–14 percent and would cause output and consumption to fall in all three member countries. Howwver, it would have little effect on member countries' aggregate and bilateral trade balances. At the sectoral level, Mexican imports of U.S. agricultural products would fall most because Mexico charges high tariffs in this sector. Trade in natural resources, which is highly substitutable across countries, would also fall significantly. Despite high tariffs, trade in transportation equipment would fall the least because the trade elasticity in this sector is low. Precisely because of this low elasticity, however, the small drop in trade is costly: transportation value added and consumption fall significantly in all three countries; my results indicate that strong international input-output linkages in this sector also play an important role in how it is affected by NAFTA termination.

In the short run, trade would fall gradually after NAFTA is terminated because it is costly for importers to adjust the quantities they purchase from foreign suppliers, and sectoral investment also adjusts gradually. Taking into account these transition dynamics, welfare would fall by 0.03 percent in the United States and 0.06 percent in Canada after NAFTA is terminated, and it would rise by 0.01 percent in Mexico. These welfare effects are similar to the long-run changes in consumption, which implies that the process of adjustment to the new post-NAFTA steady state is not costly.

In addition to the baseline NAFTA termination scenario, I have analyzed a range of alternatives: one in which the United States raises all import tariffs unilaterally, another in which Canada and Mexico form a bilateral free trade agreement, and a third in which NAFTA is renegotiated to include stricter domestic

content requirements. Canada and Mexico would bear the brunt of increased U.S. protectionism, and a bilateral Canada-Mexico free trade agreement would do little to mitigate the effects of terminating NAFTA. Increasing domestic content requirements would reduce imports of intermediate inputs from non-NAFTA countries and raise welfare within the region, but it would not benefit the transportation equipment sector.

References

Alessandria, George and Horag Choi, "Do Sunk Costs of Exporting Matter for Net Export Dynamics?," *The Quarterly Journal of Economics*, 2007, *122* (1), 289–336.

_ and _, "The Dynamics of the U.S. Trade Balance and Real Exchange Rate: The J Curve and Trade Costs?," Working Paper February 2016.

_ , _ , and Kim J. Ruhl, "Trade Adjustment and the Welfare Gains from Trade," Working paper 2015.

Allen, Treb, "Information Frictions in Trade," *Econometrica*, November 2014, *82*, 2041–2083.

Anderson, James E. and Eric van Wincoop, "Trade Costs," *Journal of Economic Literature*, September 2004, *42* (3), 691–751.

Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez-Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, 2012, *102* (1), 94–130.

Atalay, Enghin, "How Important Are Sectoral Shocks?," Working Paper 2014.

Bajona, Claustre and Timothy Kehoe, "Trade, Growth, and Convergence in a Dynamic Heckscher-Ohlin Model," *Review of Economic Dynamics*, July 2010, *13* (3), 487–513.

Baker, Jessica, Oriol Carreras, Simon Kirby, Jack Meaning, and Rebecca Piggott, "Modelling events: The short-term economic impact of leaving the EU," *Economic Modelling*, 2016, *58* (C), 339–350.

Baldwin, Richard E, "Measurable Dynamic Gains from Trade," *Journal of Political Economy*, February 1992, *100* (1), 162–74.

Barattieri, Alessandro, Matteo Cacciatore, and Fabio Ghironi, "Protectionism and the Business Cycle," Working paper 2017.

Bems, Rudolfs, "Aggregate Investment Expenditures on Tradable and Nontradable Goods," *Review of Economic Dynamics*, 2008, *11* (4), 852–883.

Brooks, Wyatt J. and Pau S. Pujolas, "Capital Accumulation and the Welfare Gains from Trade," Working Paper 2016.

Caliendo, Lorenzo and Fernando Parro, "Estimates of the Trade and Welfare Effects of NAFTA," *Review of Economic Studies*, 2015, *82* (1), 1–44.

Conconi, Paola, Manuel García-Santana, Laura Puccio, and Roberto Venturini, "From Final Goods to Inputs: The Cascade Effect of Preferential Rules of Origin," CEPR Working Paper 11084 2017.

Costinot, Arnaud and Andrés Rodríguez-Clare, "Chapter 4 - Trade Theory with Numbers: Quantifying the Consequences of Globalization," in Elhanan Helpman Gita Gopinath and Kenneth Rogoff, eds., *Handbook of International Economics*, Vol. 4 of Handbook of International Economics, Elsevier, 2014, pp. 197 – 261.

Dhingra, Swati, , Gianmarco Ottaviano, Thomas Sampson, and John van Reenen, "The Impact of Brexit on Foreign Investment in the UK," CEP Brexit Analysis 3, Centre for Economic Performance 2016.

_ , Gianmarco Ottaviano, Thomas Sampson, and John Van Reenen, "The Consequences of Brexit for UK Trade and Living Standards," CEP Brexit Analysis 2, Centre for Economic Performance 2016.

_ , Hanwei Huang, Gianmarco Ottaviano, João Paulo Pessoa, Thomas Sampson, and John Van Reenen, "The Costs and Benefits of Leaving the EU: Trade Effects," CEP Brexit Analysis Technical Paper, Centre for Economic Performance May 2016.

Dix-Carneiro, Rafael, "Trade Liberalization and Labor Market Dynamics," *Econometrica*, 2014, *82* (3), 825–885.

Eaton, Jonathan, Samuel Kortum, Brent Neiman, and John Romalis, "Trade and the Global Recession," NBER Working Paper 16666,, National Bureau of Economic Research, Inc January 2011.

Ebell, Monique, Ian Hurst, and James Warren, "Modelling the long-run economic impact of leaving the European Union," *Economic Modelling*, 2016, *59*, 196 – 209.

Engel, Charles and Jian Wang, "International trade in durable goods: Understanding volatility, cyclicality, and elasticities," *Journal of International Economics*, January 2011, *83* (1), 37–52.

Giri, Rahul, Kei-Mu Yi, and Hakan Yilmazkuday, "Sectoral Heterogeneity and the Gains from Trade," Working paper 2017.

Kehoe, Timothy J., Kim J. Ruhl, and Joseph B. Steinberg, "Global Imbalances and Structural Change in the United States," *Journal of Political Economy*, 2017, *Forthcoming*.

Krugman, Paul, "Pricing to Market when the Exchange Rate Changes," NBER Working Papers 1926, National Bureau of Economic Research, Inc May 1986.

Lane, P. R. and G. M. Milesi-Feretti, "The External Wealth of Nations Mark II: Revised and Extended Estimates of Foreign Assets and Liabilities, 1970–2004," *Journal of International Economics*, 2007, *73*, 223–250.

Lim, Kevin, "Firm-to-Firm Trade in Sticky Production Networks," Working paper 2016.

Lucas, Robert E. and Edward C. Prescott, "Investment Under Uncertainty," *Econometrica*, 1971, *39* (5), 659–681.

McGrattan, Ellen R. and Andrea L. Waddle, "The Impact of Brexit on Foreign Investment and Production," NBER Working Papers 23217 2017.

Ravikumar, B., Ana Maria Santacreu, and Michael Sposi, "Capital Accumulation and Dynamic Gains from Trade," Working paper 2017.

Ruhl, Kim J., "The International Elasticity Puzzle," Working paper 2008.

_ , "The Aggregate Impact of Antidumping Policies," Working paper 2014.

Sposi, Michael, "Demograhics and the Evolution of Global Imbalances," Working paper 2017.

Steinberg, Joseph B., "On the Source of U.S. Trade Deficits: Global Saving Glut or Domestic Saving Drought?," Working Paper, 2016.

_ , "Brexit and the Macroeconomic Impact of Trade Policy Uncertainty," Working paper 2017.

Timmer, Marcel P., Erik Dietzenbacher, Bart Los, Robert Stehrer, and Gaaitzen J. de Vries, "An Illustrated User Guide to the World Input-Output Database: the Case of Global Automotive Production," *Review of International Economics*, 2015, *23* (3), 575–605.

Table 1: WIOD sectoral aggregation scheme

Sector	HS codes	WIOD industries
Agriculture	1–14	Crop and animal production, hunting and related service activities; Forestry and logging; Fishing and aquaculture
Resources	25–27	Mining and quarrying; Manufacture of coke and refined petroleum products
Transportation	86–89	Manufacture of motor vehicles, trailers and semi-trailers; Manufacture of other transport equipment
Manufacturing	15–24; 28–85; 90–97	Manufacture of food products, beverages and tobacco products; Manufacture of textiles, wearing apparel and leather products; Manufacture of wood and of products of wood and cork, except furniture, manufacture of articles of straw and plaiting materials; Manufacture of paper and paper products; Printing and reproduction of recorded media; Manufacture of chemicals and chemical products; Manufacture of basic pharmaceutical products and pharmaceutical preparations; Manufacture of rubber and plastic products; Manufacture of other non-metallic mineral products; Manufacture of basic metals; Manufacture of fabricated metal products, except machinery and equipment; Manufacture of computer, electronic and optical products; Manufacture of electrical equipment; Manufacture of machinery and equipment n.e.c.; Manufacture of furniture, other manufacturing
Services	N/A	Repair and installation of machinery and equipment; Electricity, gas, steam and air conditioning supply; Water collection, treatment and supply; Sewerage, waste collection, treatment and disposal activities, materials recovery, remediation activities and other waste management services; Construction; Wholesale and retail trade and repair of motor vehicles and motorcycles; Wholesale trade, except of motor vehicles and motorcycles; Retail trade, except of motor vehicles and motorcycles; Land transport and transport via pipelines; Water transport; Air transport; Warehousing and support activities for transportation; Postal and courier activities; Accommodation and food service activities; Publishing activities; Motion picture, video and television programme production, sound recording and music publishing activities, programming and broadcasting activities; Telecommunications; Computer programming, consultancy and related activities, information service activities; Financial service activities, except insurance and pension funding; Insurance, reinsurance and pension funding, except compulsory social security; Activities auxiliary to financial services and insurance activities; Real estate activities; Legal and accounting activities, activities of head offices, management consultancy activities; Architectural and engineering activities, technical testing and analysis; Scientific research and development; Advertising and market research; Other professional, scientific and technical activities, veterinary activities; Administrative and support service activities; Public administration and defence, compulsory social security; Education; Human health and social work activities; Other service activities; Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use; Activities of extraterritorial organizations and bodies

Table 2: Change in import tariffs after NAFTA termination

Trade partner	Agriculture	Resource extraction	Trans. equip.	Other manuf.	Total
(a) United States					
Canada	1.74	0.74	2.30	1.79	1.51
Mexico	3.19	0.52	7.75	1.76	3.14
Rest of world	0.00	0.00	0.00	0.00	0.00
(b) Canada					
United States	3.28	0.61	4.55	1.55	2.14
Mexico	0.57	0.38	5.20	1.47	2.56
Rest of world	0.00	0.00	0.00	0.00	0.00
(c) Mexico					
United States	29.18	0.18	7.62	3.65	5.40
Canada	13.29	0.08	12.22	2.97	6.19
Rest of world	0.00	0.00	0.00	0.00	0.00

Table 3: Change in import tariffs after NAFTA termination + higher U.S. tariffs

Trade partner	Agriculture	Resource extraction	Trans. equip.	Other manuf.	Total
(a) United States					
Canada	3.48	1.49	4.59	3.59	3.01
Mexico	6.39	1.05	15.49	3.52	6.28
Rest of world	2.28	1.95	1.89	2.40	2.29
(b) Canada					
United States	3.28	0.61	4.55	1.55	2.14
Mexico	0.57	0.38	5.20	1.47	2.56
Rest of world	0.00	0.00	0.00	0.00	0.00
(c) Mexico					
United States	29.18	0.18	7.62	3.65	5.40
Canada	13.29	0.08	12.22	2.97	6.19
Rest of world	0.00	0.00	0.00	0.00	0.00

Table 4: Sectoral production and trade in 2014 (percent GDP)

Quantity	Agriculture	Resource extraction	Trans. equip.	Other manuf.	Services	Total
(a) United States						
Value added	1.24	3.67	1.57	9.66	83.86	100.00
Exports	0.31	0.98	1.31	3.93	4.48	11.01
to Canada	0.04	0.23	0.35	0.86	0.18	1.66
to Mexico	0.04	0.14	0.13	0.67	0.04	1.01
to rest of world	0.23	0.61	0.83	2.41	4.26	8.33
Imports	0.30	1.94	1.75	7.24	2.52	13.76
from Canada	0.06	0.69	0.29	0.76	0.21	2.00
from Mexico	0.06	0.19	0.35	0.84	0.08	1.52
from rest of world	0.19	1.06	1.11	5.64	2.23	10.23
Net exports	0.01	-0.96	-0.44	-3.31	1.95	-2.74
with Canada	-0.01	-0.45	0.06	0.10	-0.03	-0.34
with Mexico	-0.01	-0.05	-0.22	-0.18	-0.05	-0.51
with rest of world	0.04	-0.45	-0.28	-3.23	2.03	-1.89
(b) Canada						
Value added	1.63	8.99	1.53	9.44	78.41	100.00
Exports	1.44	8.32	3.76	11.58	7.93	33.03
to United States	0.58	7.03	2.96	7.79	2.17	20.53
to Mexico	0.07	0.00	0.04	0.28	0.09	0.48
to rest of world	0.80	1.28	0.76	3.51	5.67	12.02
Imports	0.62	3.42	5.55	17.54	4.74	31.87
from United States	0.43	2.41	3.60	8.79	1.83	17.07
from Mexico	0.02	0.09	0.32	0.66	0.06	1.15
from rest of world	0.17	0.92	1.63	8.09	2.85	13.65
Net exports	0.82	4.89	-1.78	-5.96	3.20	1.16
with United States	0.15	4.62	-0.64	-1.00	0.34	3.46
with Mexico	0.05	-0.09	-0.28	-0.38	0.03	-0.67
with rest of world	0.63	0.36	-0.87	-4.58	2.83	-1.63
(c) Mexico						
Value added	3.29	7.98	3.51	14.33	70.88	100.00
Exports	1.02	4.55	6.08	16.42	1.73	29.80
to United States	0.83	2.71	4.97	11.97	1.17	21.65
to Canada	0.03	0.13	0.44	0.91	0.08	1.59
to rest of world	0.17	1.71	0.66	3.54	0.48	6.56
Imports	0.89	2.29	3.47	19.29	3.17	29.11
from United States	0.64	1.98	1.80	9.45	0.51	14.37
from Canada	0.09	0.00	0.06	0.39	0.12	0.67
from rest of world	0.16	0.30	1.61	9.45	2.53	14.07
Net exports	0.13	2.26	2.60	-2.87	-1.44	0.69
with United States	0.19	0.73	3.18	2.53	0.66	7.28
with Canada	-0.07	0.13	0.38	0.52	-0.04	0.92
with rest of world	0.00	1.41	-0.95	-5.92	-2.05	-7.51

Table 5: Assigned parameters other than trade elasticities; import adjustment cost

Parameter	Meaning	Value	Source or target
β	Discount factor	0.98	2% Long-run interest rate
ψ	Intertemporal elasticity	-1	Standard
δ	Depreciation rate	0.06	Standard
α_i^s	Capital shares	0.33	Standard
ρ	Consumption elasticity	0.65	Kehoe et al. (2017); Atalay (2014)
γ	Consumption utility share	0.33	Standard
ϕ	Capital adjustment cost	0.8	Steinberg (2016); Sposi (2017)
φ	Import adjustment cost	1.0	Short-run trade elascicity = 10.0
$b_{i,0}$	Initial bondholdings	(-40.6 0.52 -2.85)	Lane and Milesi-Feretti (2007)

Table 6: Assigned long-run trade elasticities

Use	Agriculture	Resource extraction	Trans. equip.	Other manuf.	Services
(a) United States					
Intermediate	8.11	30.82	0.80	5.46	5.00
Final	8.11	37.23	0.88	4.78	5.00
(b) Canada					
Intermediate	8.11	29.80	0.87	5.48	5.00
Final	8.11	39.74	0.82	4.62	5.00
(c) Mexico					
Intermediate	8.11	35.01	0.97	5.64	5.00
Final	8.11	31.49	0.97	3.71	5.00
(d) Rest of world					
Intermediate	8.11	27.25	0.87	5.75	5.00
Final	8.11	45.72	0.84	4.61	5.00

Table 7: Long-run effects of NAFTA termination (percent changes)

Quantity	Agriculture	Resource extraction	Trans. equip.	Other manuf.	Services	Total
(a) United States						
Value added	-1.68	0.37	-0.46	-0.29	-0.04	-0.08
Employment	-1.61	0.45	-0.39	-0.21	0.03	-0.00
Consumption	-0.28	-0.04	-0.58	-0.13	-0.02	-0.04
Exports	-13.39	-3.10	-1.61	-3.33	0.16	-2.05
to Canada	-21.37	-16.87	-3.05	-6.06	-1.28	-7.25
to Mexico	-85.04	-8.38	-6.54	-12.80	-0.96	-14.07
to rest of world	0.17	0.53	0.06	0.02	0.20	0.18
Imports	-6.77	-7.18	-1.77	-1.94	-0.14	-2.26
from Canada	-12.06	-13.82	-1.76	-8.32	0.84	-8.22
from Mexico	-22.24	-10.10	-5.91	-10.06	0.33	-9.01
from rest of world	0.38	0.81	0.09	0.38	-0.28	0.23
Net exports/GDP (p.p.)	-0.03	0.03	0.01	-0.03	0.01	-0.01
with Canada	-0.00	0.03	-0.01	0.01	-0.00	0.02
with Mexico	-0.03	0.00	0.01	-0.01	-0.00	-0.02
with rest of world	-0.00	0.00	-0.00	-0.02	0.02	0.00
(b) Canada						
Value added	-0.32	-1.21	-1.76	-1.17	0.01	-0.22
Employment	-0.09	-0.98	-1.53	-0.94	0.24	0.00
Consumption	-0.43	-0.05	-1.90	-0.40	0.07	-0.06
Exports	-6.14	-8.51	-2.43	-5.45	1.32	-4.21
to United States	-12.06	-13.82	-1.76	-8.32	0.84	-8.22
to Mexico	-56.09	1.98	-10.29	-9.42	-0.10	-14.08
to rest of world	0.88	6.91	0.17	0.36	1.13	1.68
Imports	-15.39	-14.46	-2.21	-2.82	-1.37	-4.14
from United States	-21.37	-16.87	-3.05	-6.06	-1.28	-7.25
from Mexico	-2.83	-6.99	-3.57	-7.42	-0.85	-5.93
from rest of world	2.02	-0.07	0.55	1.71	-1.46	0.81
Net exports/GDP (p.p.)	0.01	-0.12	0.05	-0.18	0.17	-0.06
with United States	0.04	-0.27	0.06	-0.06	0.04	-0.18
with Mexico	-0.04	0.01	0.01	0.02	0.00	-0.00
with rest of world	0.01	0.14	-0.01	-0.14	0.13	0.13
(c) Mexico						
Value added	9.38	0.46	-3.30	-2.26	-0.15	-0.27
Employment	9.63	0.68	-3.08	-2.04	0.08	0.00
Consumption	-0.90	0.13	-0.82	-0.45	0.17	-0.01
Exports	-17.76	-2.42	-5.98	-8.51	0.51	-6.70
to United States	-22.24	-10.10	-5.91	-10.06	0.33	-9.01
to Canada	-2.83	-6.99	-3.57	-7.42	-0.85	-5.93
to rest of world	-1.65	4.37	0.17	-2.09	0.62	0.58
Imports	-66.57	-8.10	-3.57	-4.77	-1.14	-6.50
from United States	-85.04	-8.38	-6.54	-12.80	-0.96	-14.07
from Canada	-56.09	1.98	-10.29	-9.42	-0.10	-14.08
from rest of world	18.27	-3.26	0.31	4.67	-1.24	3.13
Net exports/GDP (p.p.)	0.44	0.09	-0.18	-0.42	0.04	-0.03
with United States	0.42	-0.04	-0.16	0.12	0.01	0.35
with Canada	0.05	-0.01	-0.01	-0.03	-0.00	-0.00
with rest of world	-0.03	0.14	-0.01	-0.52	0.03	-0.38

Table 8: Welfare and long-run trade effects in alternative models (percent changes)

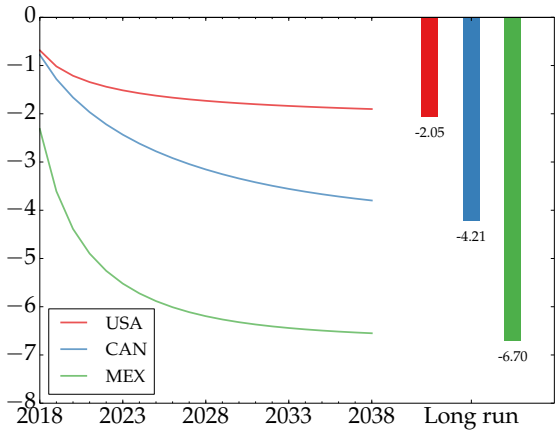
	Welfare			Imports from NAFTA			Imports from ROW		
Model	USA	Canada	Mexico	USA	Canada	Mexico	USA	Canada	Mexico
Baseline	-0.03	-0.06	0.01	-8.80	-7.24	-14.10	0.23	0.81	3.13
Sensitivity analyses									
No import adj. costs	-0.03	-0.07	-0.00	-8.73	-7.26	-14.15	0.23	0.78	3.09
No capital adj. costs	-0.03	-0.06	0.01	-8.79	-7.25	-14.11	0.22	0.81	3.13
Sym. trade elasticities	-0.03	-0.09	-0.22	-8.39	-6.34	-16.29	0.30	1.84	1.51
No intermediate inputs	-0.00	-0.01	-0.04	-9.37	-9.95	-8.51	0.34	3.79	-1.23
Alternative scenarios									
Higher U.S. tariffs	0.04	-0.22	-0.14	-11.24	-10.76	-18.41	-5.72	0.99	2.67
Higher U.S. tariffs + no IO	0.02	-0.05	-0.06	-10.20	-17.18	-16.60	-20.06	9.77	3.80
Canada-Mexico TA	-0.03	-0.06	0.01	-8.82	-6.90	-13.37	0.23	0.78	3.02
Stricter ROO	0.13	0.21	0.32	1.73	2.53	3.75	-16.28	-15.60	-16.02

Table 9: Long-run effects on transportation sector in alternative models (percent changes)

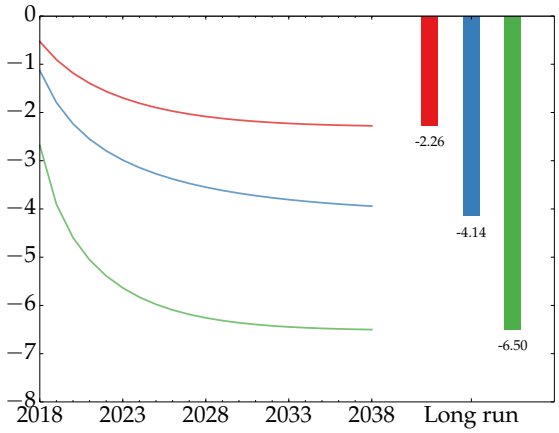
	Value added			Consumption		
Model	USA	Canada	Mexico	USA	Canada	Mexico
Baseline	-0.46	-1.76	-3.30	-0.58	-1.90	-0.82
Sensitivity analyses						
Sym. trade elasticities	0.16	-5.74	-12.24	-0.50	-1.95	-1.16
No intermediate inputs	-0.10	-0.16	-0.56	-0.03	-0.38	-0.95
Alternative scenarios						
Higher U.S. tariffs	-0.73	-2.65	-5.57	-1.10	-2.35	-1.09
Higher U.S. tariffs + no IO	-0.16	-0.35	-1.12	-0.05	-0.45	-1.01
Canada-Mexico FTA	-0.47	-1.63	-3.11	-0.58	-1.72	-0.77
Stricter ROO	-0.51	-0.81	-0.39	-0.06	0.07	-0.02

Figure 1: Effects of NAFTA termination on aggregate trade flows

(a) Aggregate exports (percent change)



(b) Aggregate imports (percent change)



(c) Aggregate trade elasticities

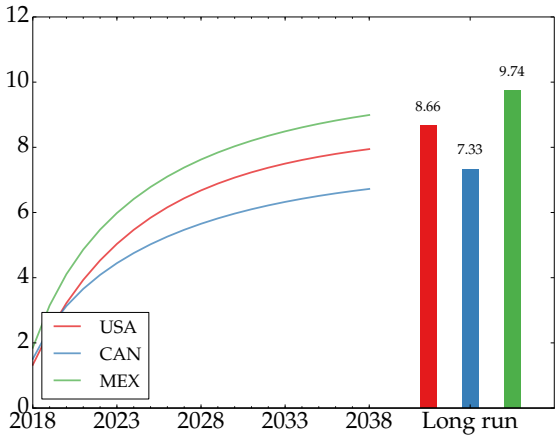


Figure 2: Effects of NAFTA termination on bilateral trade flows

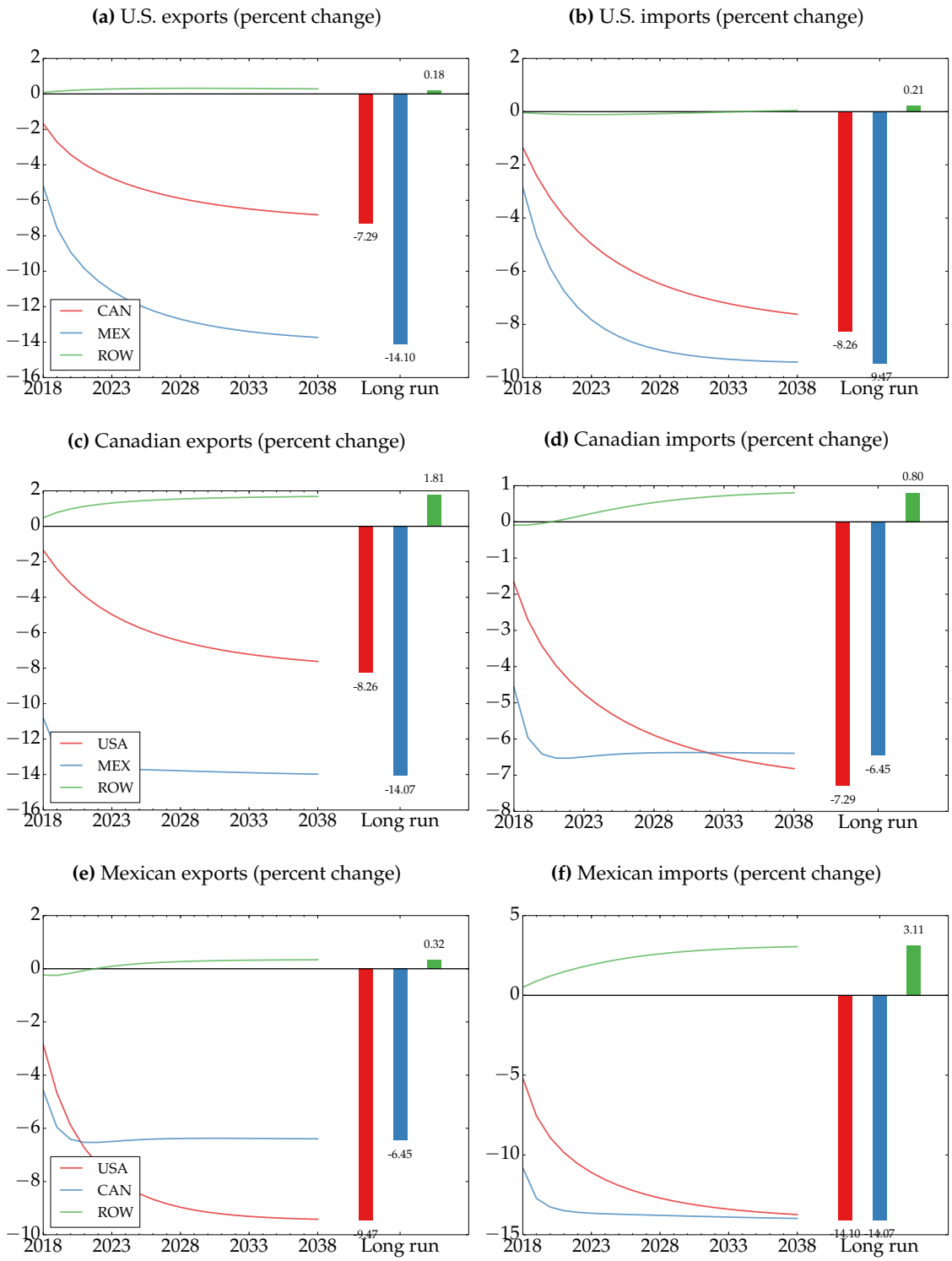


Figure 3: Effects of NAFTA termination on sectoral trade flows to/from NAFTA countries

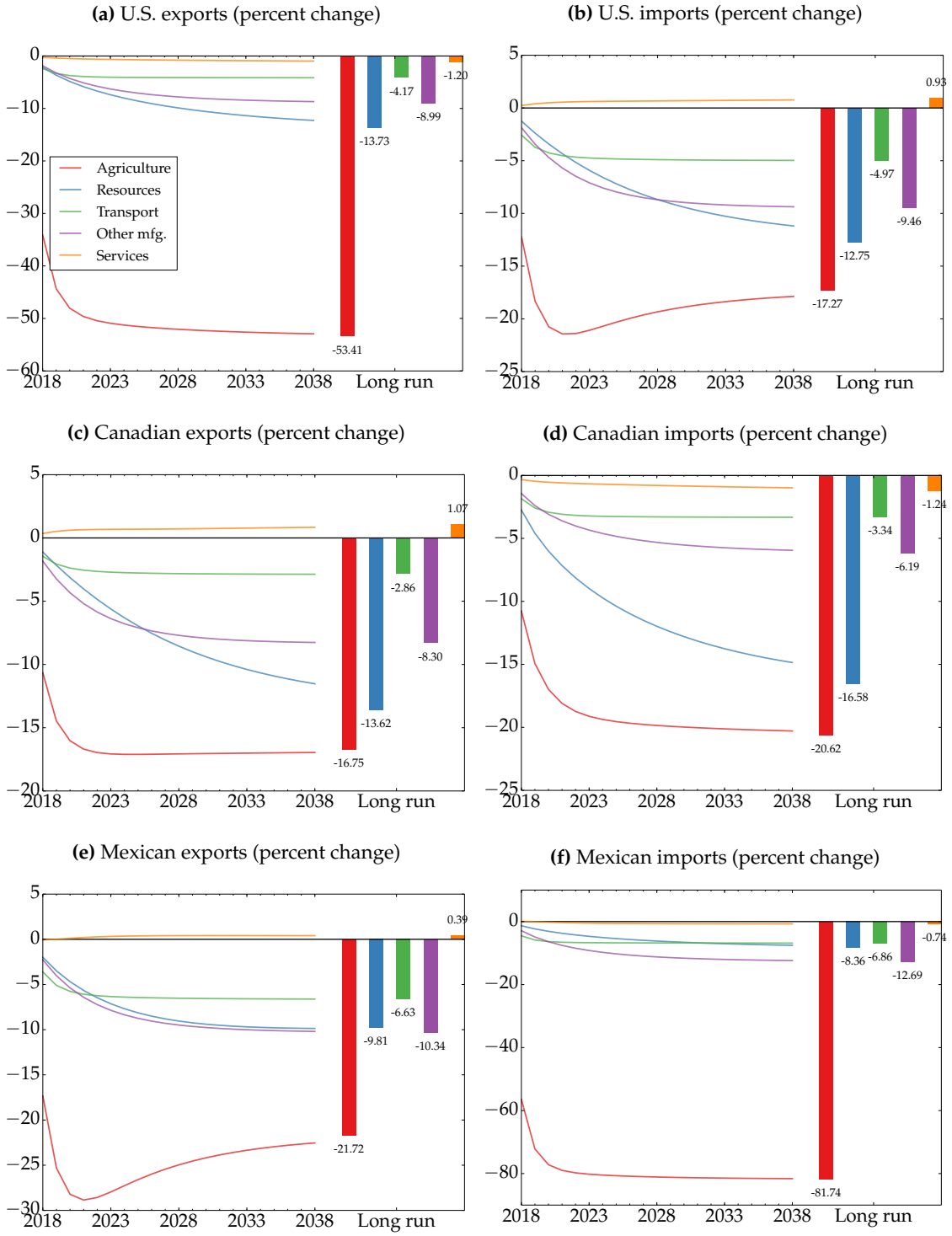
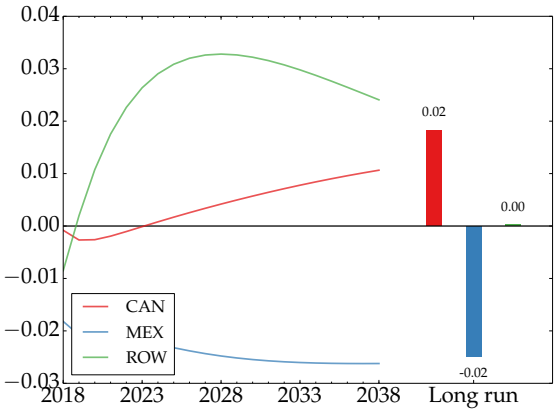
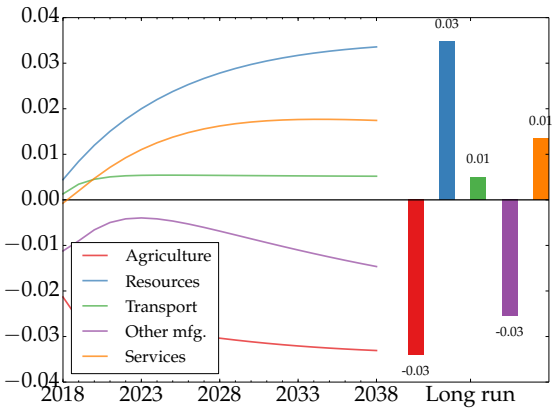


Figure 4: Effects of NAFTA termination on bilateral and sectoral trade balance/GDP ratios

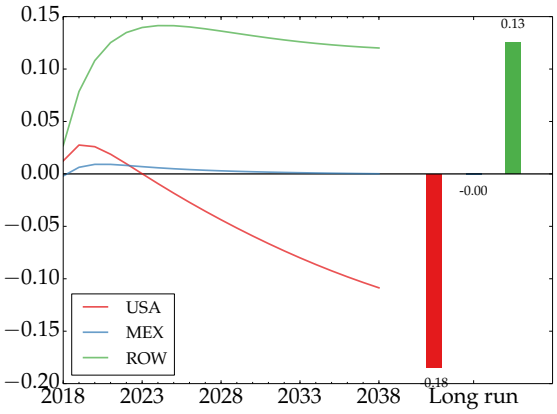
(a) U.S. bilateral trade balances (p.p. change)



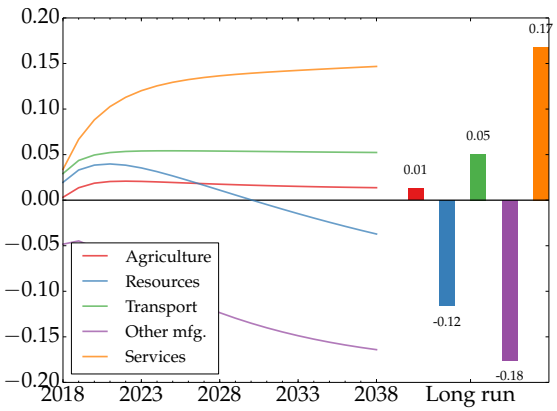
(b) U.S. sectoral trade balances (p.p. change)



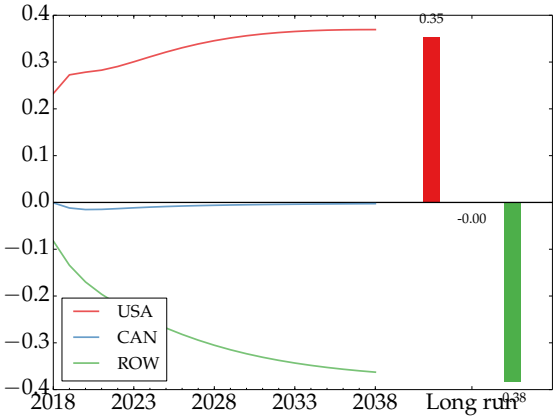
(c) Canadian bilateral trade balances (p.p. change)



(d) Canadian sectoral trade balances (p.p. change)



(e) Mexican bilateral trade balances (p.p. change)



(f) Mexican sectoral trade balances (p.p. change)

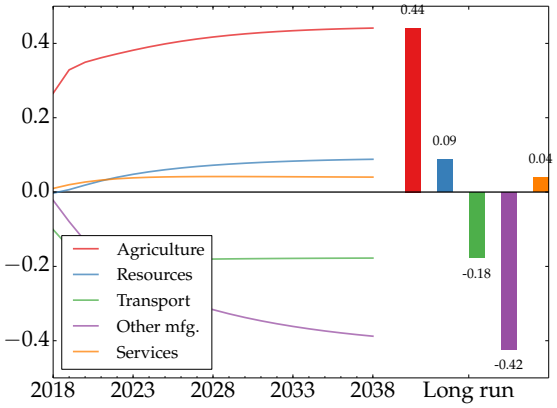


Figure 5: Effects of NAFTA termination on sectoral production and consumption

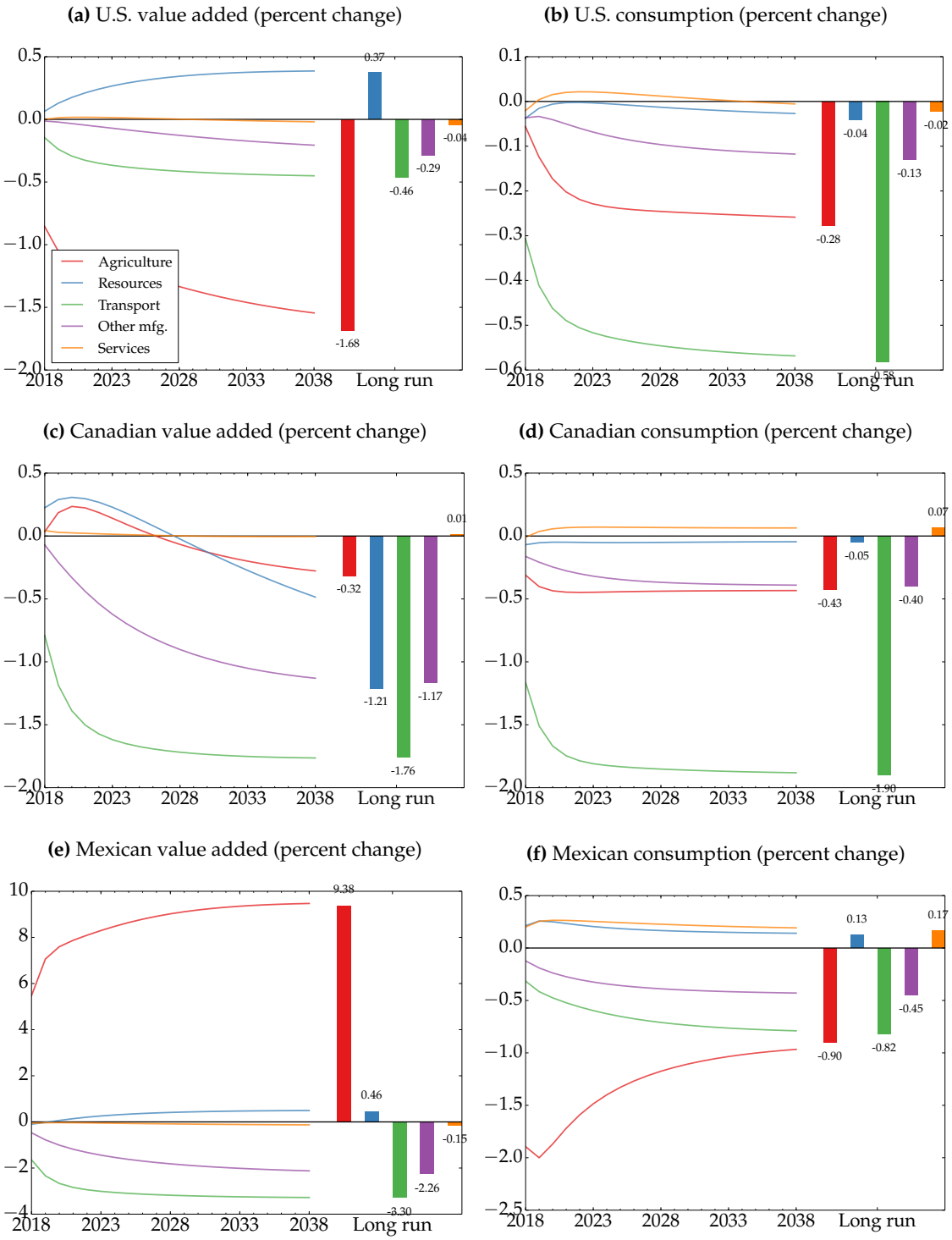
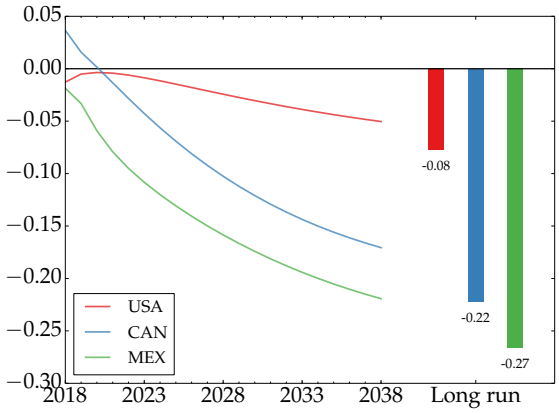
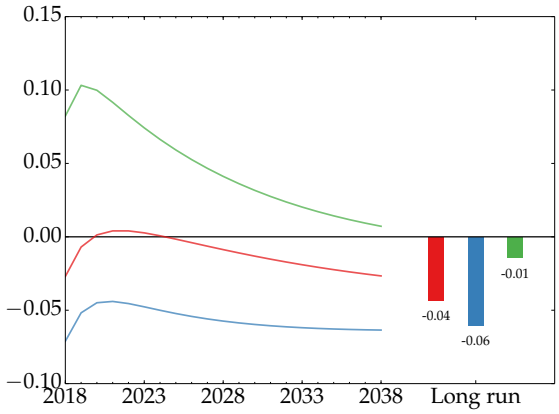


Figure 6: Effects of NAFTA termination on macroeconomic dynamics

(a) GDP (percent change)



(b) Aggregate consumption (percent change)



(c) Aggregate investment

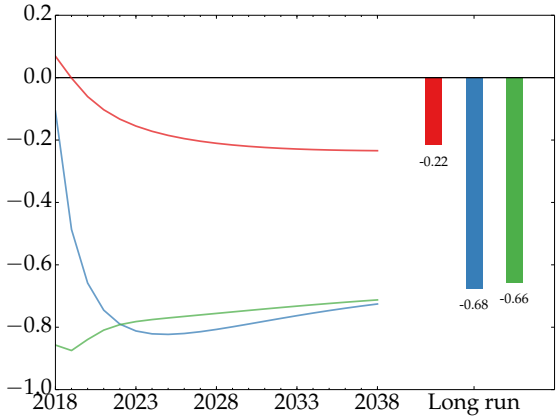


Figure 7: Sensitivity analysis: effects of NAFTA termination on U.S. macroeconomic dynamics

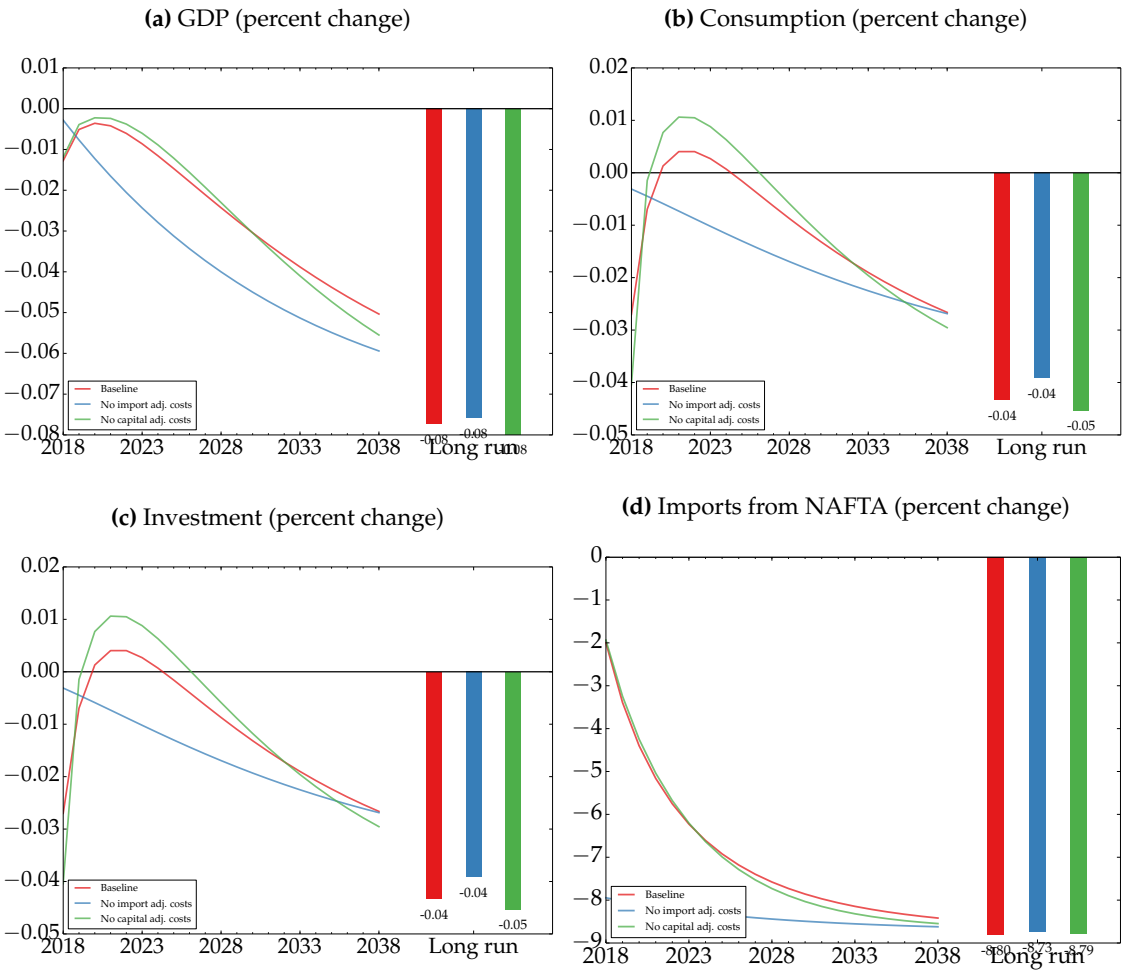


Figure 8: Sensitivity analysis: effects of NAFTA termination on Canadian macroeconomic dynamics

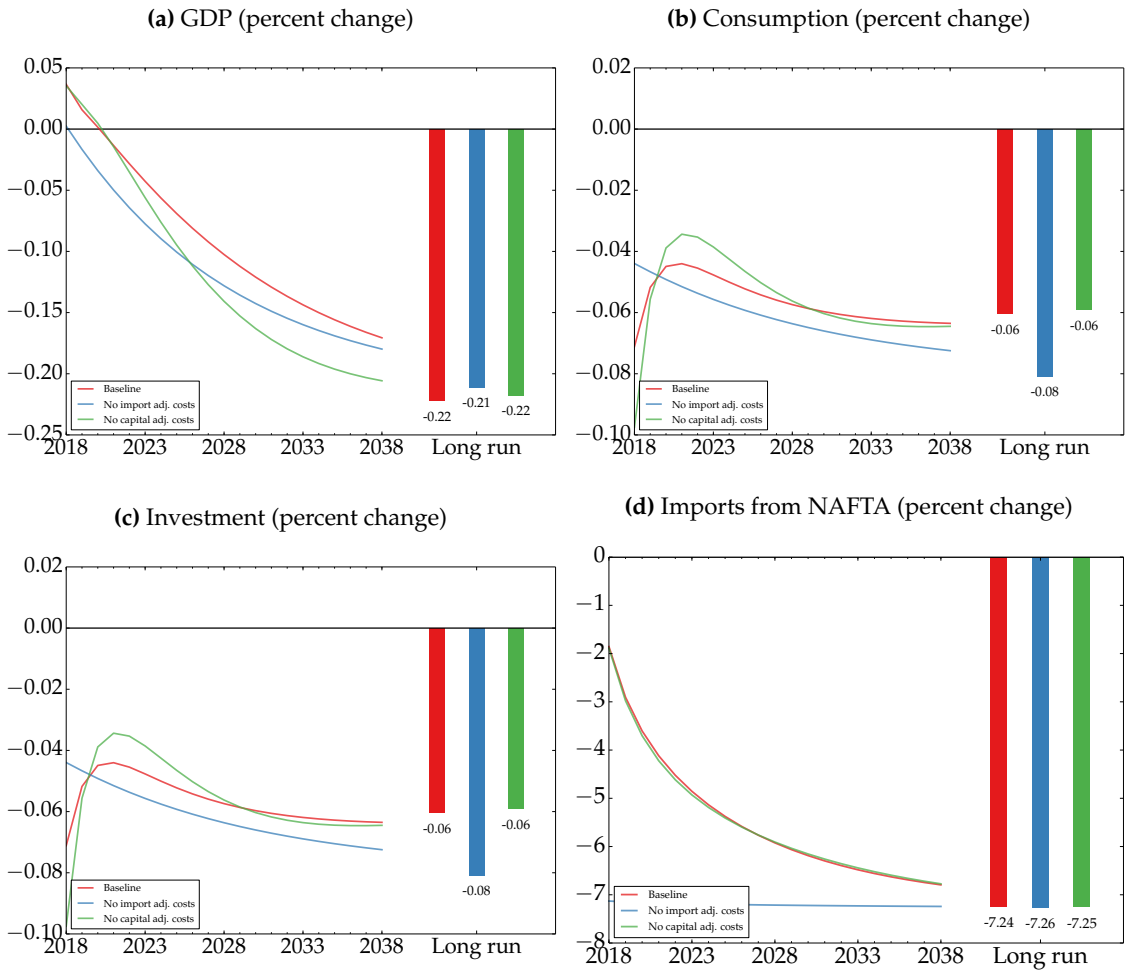


Figure 9: Sensitivity analysis: effects of NAFTA termination on Mexican macroeconomic dynamics