Trade Integration, Industry Reallocation, and Welfare in Colombia*

George Alessandria, †Oscar Avila‡

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Preliminary

Abstract

We study empirically and theoretically the effects of the unilateral reduction in import tariffs undertaken by Colombia from 1989-1992, with a particular emphasis on the transition and including any anticipation effects. We develop a two-country, multi-sector heterogeneous firm model with a dynamic exporting decision, input output linkages, and capital accumulation. The model is calibrated to match Colombian firm dynamics, sectoral trade openness, tariffs, imbalances, and input-output linkages in the late 1980s. We introduce an anticipated reform into the model and relate the predicted path of sectoral activity and aggregate activity to the data. Our dynamic exporting model predicts much larger gains from these reforms than models that abstract from firm dynamics in trade, sectoral heterogeneity, and trade in financial assets.
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†george.alessandria@rochester.edu, University of Rochester and NBER
‡Central Bank of Colombia, oscar.avila03@gmail.com

1 Introduction

Since the Great Recession support for trade policy reform, and further trade integration, has waned with numerous prospective trade agreements shelved and existing agreements having been scaled back. The movement to deglobalize has gained some traction owing to the growing uncertainty about the benefits of integration. The rising skepticism on trade reform lends credence to calls for the status quo, which is particularly important for developing countries with relatively large existing policy and non-policy barriers to international trade. In this paper we revisit the benefits of trade reform by considering a case of a well-known reform with excellent data availability through the lens of a new dynamic model.

We study the sectoral and aggregate effects of the change in import tariffs in Colombia from 1989 to 1992, with a particular attention to the transition period. This reform substantially reduced the mean and variance of tariffs and led to a substantial expansion in international trade. It reshaped the pattern of production and expenditures, particularly in the short-run as there was a large temporary investment boom financed through substantial trade deficits. Economic growth also accelerated temporarily.

We analyze the effects of this trade reform through the lens of a two-country, multi-sector dynamic heterogeneous firm model with input output linkages, capital accumulation and trade in financial assets that can be closely related to the data. We use the model to quantify the welfare gains from the reform as well as the effects on key industry and aggregate variables at various horizons. We find that the reform increased welfare, with the scale of the estimated benefits being much larger and more immediate in our dynamic model than in either static models or existing dynamic trade models.

We develop a dynamic model of trade adjustment to more accurately capture the effects of the reforms both in terms of their heterogeneous and dynamic effects. While the trade reforms were large with a very short phaseout, they gave rise to relative slow transition dynamics in the trade share of GDP. In our earlier paper (Alessandria and Avila (2020)) which focuses on the manufacturing sector in Colombia, we show that the gradual trade expansion is related to gradual expansion of the extensive and intensive margins of exporting and can be captured well by a heterogeneous firm model with a dynamic exporting decision. Here we revisit these dynamic effects of trade reform but with a richer multi-sector model that introduces much more sectoral detail that captures the rich heterogeneity in trade policy and industry characteristics. The heterogeneity in reforms along with the heterogeneity in sectors substantially expand the gains compared one sector models.

Our model considers two countries (Home and Foreign) that differ in size and sector-export technologies, and S sectors that are connected through input-output linkages. Households consume final goods, provide labor, accumulate capital, and invest in firms. Final goods and materials are produced using a bundle of intermediate goods from each sector. In each sector, intermediate goods are a combination of domestic and foreign goods produced by heterogeneous firms. Finally, heterogeneous producers use capital, labor and materials to produce domestic and foreign intermediates. Within each sector, these firms differ in their productivity levels, iceberg and export costs.

Our benchmark calibration considers two countries and four sectors: agriculture, services and two manufacturing sectors. The countries differ in size (labor endowment) and export barriers, captured by the iceberg costs and tariffs. Agriculture and the manufacturing sectors are assumed to be tradable sectors, while services are non-tradable. We calibrate the model to match aggregate and sector moments in 1990 using information from the National Statistics Department of Colombia (DANE). This information includes data from the input-output tables, national accounts, and the manufacturing census. The latter, provides a valuable data source for firm and export dynamics and has been used by other authors in the literature[1].

At the sector level, we find that welfare gains are generated mostly by liberalizing the manufacturing sector (almost 90% of the gains). It is important to highlight that this sector starts with a trade deficit; therefore, at producing manufacturing goods, the economy has no comparative advantage with respect to the rest of the world. The mechanism is simple, liberalizing a sector with no comparative advantages reduces the import costs by more, boosts domestic production, and allows other sectors to raise export. We compare our benchmark results with alternative scenarios and find that welfare gains are bigger when:

[1]For instance, Roberts and Tybout (1997), Eslava et al. (2010) and Alessandria and Choi (2019).

1) Input-output linkages are included; 2) We add more (heterogeneous) sectors; 3) We focus on short-term dynamics; 4) We liberalize sectors with initial trade deficits (no comparative advantage); and 5) We allow households to borrow in foreign markets. The first two results are consistent with the static multi-sector literature, while the third one with the dynamic trade papers. In particular, removing the input-output structure in a three sector model reduces welfare by gains by 16%; while, moving from three sectors to four sectors increases the gains by 30%. Regarding the number of sectors, we find that adding more heterogeneity, in terms of comparative advantage is an important source for increasing welfare gains.

Our paper relates to a large empirical and quantitative literature studying the effects of changes in trade policy on trade and the aggregate economy. With Caliendo and Parro (2015), a largely static literature of multi-sector trade models has developed for policy analysis. Recent work has introduced capital accumulation and trade imbalances into this environment (Ravikumar et al. (2019)). There is an empirical literature that studies the dynamic effects of changes in trade policy on trade flows and finds that trade adjustment from a change in trade barrier takes time (Baier and Bergstrand (2007), Baier et al. (2014)) and is closely related to the slow expansion of the extensive margin of exports. Starting with Alessandria et al. (2014), a more nascent literature has developed general equilibrium models of slow trade adjustment from firm-level investments in market access that abstracts from the rich sectoral heterogeneity in trade and trade policy.

The rest of the paper is organized as follows. Section 2 describes the key changes in Colombia related to trade policy and economic activity (sectoral and aggregate). Section 3 presents a general model of Colombia and the rest of the world. In section 4, we discuss the calibration of the model. Section 5 describes our main results for the quantitative analysis of a unilateral trade liberalization. In section 6 presents the welfare implications of modifying some assumptions of the model, such as the number of sectors, international borrowing, the input-output structure, consumption, and investment technologies, and sector-heterogeneity. Finally, in section 7 we conclude.

2 Background

We begin by summarizing some key aspects of the Colombian economy related to the changes in trade, trade policy, and the aggregate economy. At the aggregate level, trade grew in a sustained way following a large, relatively sudden unilateral trade liberalization from 1989-94 that lowered average tariffs by almost 20 percentage points and substantially reduced dispersion in tariffs. In our previous paper, we showed that that this aggregate slow trade growth arose through slow growth in the number of exporters and sustained growth in the export intensity of exporters. We then discuss the sectoral changes in tariffs. And finally, we review several salient aspects of the aggregate economy during the transition.

2.1 Aggregate Trade Dynamics

We consider the changes in Colombian trade integration from 1975 to the present. Figure 1 plots three measures of Colombia's trade integration over time. The first is the ratio of exports to manufacturing shipments using Census data. The second is the ratio of real exports to real GDP. The third is the ratio of nominal industry exports to nominal GDP. All three measures show a substantial expansion of trade from the early 80s to the present of about 75 log points. The nominal measure, which allows for changes in the relative price of exports to output from real exchange rate or terms of trade fluctuations, shows much greater variability in the export share than the other two measures. Figure 1 makes clear that this is a period of increased integration.

This integration reflects substantial changes in trade policy. Figure 2 plots the real trade share, measured as real exports and imports divided by real GDP, and tariff revenue relative to imports. There is a substantial change in trade policy from 1989 to 1992 with the trade-weighted import tariff falling from about 20 percent to 7.5 percent. This measure of tariffs understates the extent of the reforms as high tariff, low trade industries had even larger declines in tariffs. Moreover, these reforms were also accompanied with a large reduction in non-tariff barriers (see Attanasio, Goldberg, and Pavcnik, 2004, and Alessandria and Avila (2020)). Unlike earlier tariff and licensing reforms in the 70s and 80s, these tariff reductions were maintained with only slight further reductions in the 2000s and 2010. [2]

2.2 Sectoral Reforms

Owing to very different levels of protection, the trade reform from 1989-1994 was quite heterogeneous across sectors. Figure 3 plots the median and dispersion in import tariffs over time. Going into the reform the median tariff is about 35 percent and the standard deviation of tariffs is about 15 percent. The reform brings the median tariff down to about 10 percent and lowers the standard deviation of tariffs to less than five percent. Subsequent reforms lower the median tariff further from 1994 onwards without changing the standard deviation. Since 2000 tariffs the median tariff has hovered around 5 percent. These heterogeneous reforms have expanded trade and exporting in an uneven manner across sectors (see Figure 4. While it is impractical to match the changes in tariffs, trade, and output at this level of sectoral detail, we do consider how heterogeneity in sectoral reforms and sectoral characteristics affect openness and production at a higher level of aggregation in the following model analysis.

2.3 Aggregate Dynamics

We now describe some salient features of the aggregate economy in the period around the reform. We emphasize four points. First, following the initial increase in trade, trade continued to grow even as tariffs did not change. This suggests that the trade elasticity increases with time from the reform. Second, the Colombian trade balance shifted from surplus to deficit. Third, GDP growth accelerated. And fourth the investment rate increased substantially. The second through fourth observations change considerable with the 1999 economic crisis.

These four aspects of the evolution of the economy are summarized in the four panels

[2] Roberts (1996), Edwards and Steiner (2000), Attanasio, Goldberg, and Pavcnik (2004), Villar and Esguerra (2006), and Fernandes (2007) provide a detailed discussion of Colombia's trade reforms. Three trade regimes are evident: (i) from 77–81 tariffs were lowered and the fraction of products freely imported rose; (ii) 82–84, liberalization was partly reversed with tariffs increased and more products restricted or prohibited (iii) a second liberalization (85–91) with reduction of licenses and restrictions and a substantial reduction in tariffs. The tariffs in the second liberalization were originally planned to phase-out in 1994 but this phase-out was accelerated with the Gavira election in August 1990 to start in 1992.

of figure 5 measured in real and nominal terms. The first panel plots total trade as a share of GDP (on a log scale). Focusing on real flows, we see that about half of the growth in trade's share of GDP occurred in the first few years after the reform and was followed by gradual growth through 2010. The second panel shows that in the early stages of the reform the trade balance rose a few percentage points to about 7 percent of GDP in 1991 then fell sharply and went into deficit of about 3 percent a year from 1993 to 1998. The third panel shows that economic growth fell in 1991 before picking up for the next four years. The final panel shows that investment fell early in the reforms before rising by about 6 percent and then falling back in 1996.

To properly capture the gradualness in trade growth with aggregate data requires accounting for the change in composition of expenditures related to the investment boom following the trade reform as well as estimating a time-varying trade elasticity. To control for trade being intensive in capital goods, we create a measure of final demand that is weighted equally between consumption and investment and measure the share of trade to this measure of demand. To measure the dynamics of trade to the change in tariffs, it is also common to estimate short-run and long-run import elasticities along with a speed of adjustment using an error-correction model specification (Johnson and Oksanen, 1977; Johnson et al., 1992; Gallaway et al., 2003):

$$\Delta v_t = \sigma^{SR} \Delta \tau_t + \gamma \left(v_{t-1} - \sigma^{LR} \tau_{t-1} - c \right) + \epsilon_t. \tag{1}$$

The ECM formulation assumes that there is a long-run relationship between tariffs and trade and that the short-run movements in trade are driven by shocks to trade policy and some partial adjustment to the long-run relationship. The dependent variable is the 1-year log difference our trade measure. The independent variable is the change in the median tariff on imports as well as the lags of the tariffs our trade measure. As we have seen the median tariffs fall sharply from 89 - 92. The short-run elasticity, σ^{SR}, is the coefficient on the 1-year log difference in tariffs. The speed of adjustment, γ is the coefficient on the lagged terms and the long-run elasticity, σ^{LR} is the coefficient on lagged tariffs.

Table 1 summarizes our elasticity estimates using our two measures of trade. In the first column, using trade to GDP, we we estimate a short-run trade elasticity of 1.5 and a long-run trade elasticity of 4.5 along with a speed of adjustment of almost 20%. Using the alternative measure of demand (column 2) does not change our estimates much but improves the precision of our estimates. Indeed, the R^2 rises from 0.31 to 0.45. Figure 6 plots the actual and predicted path of our demand adjusted measure of trade along with tariffs. This parsimonious model with just four parameters captures the transition path from the data quite well.

3 Model

We now develop a two-country multi-sector model with heterogeneous firms making dynamic exporting decisions. The model extends the two-sector heterogeneous firm dynamic exporting model of Alessandria and Choi (2014) along several dimensions. Different from Alessandria and Choi (2014), we allow for asymmetric economies, multiple sectors, input-output linkages, and asymmetric trade policies. In each sector, there are many heterogeneous producers entering, growing, starting, and stopping to export. We follow Alessandria et al. (2021) and allow for a flexible exporting technology that captures the tendency of new exporters to export on a small scale, to have low survival rates, and take time to grow into large exporters. These micro frictions are central to capture both the dynamics of trade and industry structure. The model allows us to study both the sectoral and aggregate effects of changes in trade policy.

We consider two asymmetric countries (Home and Foreign) and S sectors. Households consume final goods, provide labor inelastically, and make the investment decisions. Their income comes from labor, capital rents, profits, and tariff revenue from the government. For now, we assume trade is balanced but relax this restriction in section 6. Final goods and materials are produced using a bundle of intermediate goods from each sector. The technologies for producing final goods and materials are different and markets operate under perfect competition. Final goods are allocated into consumption and investment, while materials are used by heterogeneous intermediate producers. In each sector, intermediate goods are a combination of domestic and foreign goods produced by heterogeneous firms. Foreign goods incur an ad valorem tariff that is collected by the local government and rebated lump sum to consumers. Heterogeneous firms use capital, labor, and materials to produce intermediates that are sold at home or exported. Within each sector, firms differ on their productivity levels, fixed export costs, and iceberg costs. Between sectors, firms also differ on their fixed production and entry costs. The benchmark model assumes no international borrowing or lending, therefore exports equal imports in both countries.

3.1 Households

Households in each country maximize the present value of utility by choosing, consumption, and sector investment and capital. They own the firms producing locally and get the tariff revenue from the government.

$$Max_{\{C_t^i, K_{t+1}^i, I_t^i\}_{t=0}^{\infty}} \quad E_t \sum_{t=0}^{\infty} \beta^t U(C_t^i)$$

$$s.t. \quad P_t^i C_t^i + \sum_s P_t^{i,s} I_t^{i,s} = W_t^i L_t^i + \sum_s R_t^{i,s} K_t^{i,s} + \Pi_t^i + T_t^i \tag{2}$$

$$K_{t+1}^{i,s} = (1-\delta) K_t^{i,s} + I_t^{i,s} - \frac{\phi^s}{2} \left(\frac{I_t^{i,s}}{I_{t-1}^{i,s}} - 1 \right)^2 \tag{3}$$

From the first order conditions (F.O.C) we have the usual Euler equation.

$$U'(C_t^i) = \beta E_t U'(C_{t+1}^i) \left(\frac{R_{t+1}^i}{P_{t+1}^i} + 1 - \delta \right) \tag{4}$$

3.2 Production of final goods (consumption and investment) and materials

Consumption, investment, and material inputs are produced using constant elasticity of substitution (CES) technologies that combine intermediates from the s intermediate sectors. These aggregation technologies are specific for consumption, materials, and investment goods. In all cases, the representative firm operates in perfect competition and is profit maximizing.[3] The production of the consumption good is determined by the solution to

$$\max_{X_i^{c,s}} P_i^c C_i - \sum_s P_i^s X_i^{c,s},$$

subject to

$$C_i = \left(\sum_s \left(\omega_i^{c,s}\right)^{\frac{1}{\theta}} \left(X_i^{c,s}\right)^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}},$$

where $X_i^{c,s}$ is the quantity of the intermediate s used to produce the consumption good. From the FOC we obtain the demand for intermediates as a function of sector prices, $X_i^{c,s} = \omega_i^{c,s} \left(P_i^s\right)^{-\theta} \left(P_i^c\right)^{\theta-1} D_i^c$, where $D_i^c = P_i^c C_i$ denotes the total nominal expenditure on consumption. From the problem above we also obtain the consumption price $P_i^c = \left(\sum_s \omega_i^{c,s} (P_i^s)^{1-\theta}\right)^{\frac{1}{1-\theta}}$.

Similarly, the production of sector-specific materials follows from solving

$$\max_{X_i^{M_s,s}} P_i^{M_s} M_i^s - \sum_{s'} P_{i,t}^{s'} X_i^{M_s,s'},$$

subject to

$$M_{i,t}^s = \left(\sum_{s'} \left(\lambda_i^{M_{s,s'}}\right)^{\frac{1}{\sigma_{m,s}}} \left(X_{i,t}^{M_{s,s'}}\right)^{\frac{\sigma_{m,s}-1}{\sigma_{m,s}}} \right)^{\frac{\sigma_{m,s}}{\sigma_{m,s}-1}},$$

where $X_i^{M_{s,s'}}$ are the intermediates from sector s' used in the production of materials for sector s. From the solution of this problem we obtain that the demand for sector intermediates is $X_i^{M_{s,s'}} = \lambda_i^{M_{s,s'}} \left(\frac{P_i^{M_s}}{P_i^{s'}}\right)^{\sigma_m} \frac{D_i^{M_s}}{P_i^{M_s}}$, where $D_i^{M_s} = P_i^{M_s} M_i^{M_s}$ is the total nominal expenditure of sector s on material, and the price of these materials is $P_i^{M_s} = \left(\sum_{s'} \lambda_{s'}^{i,M_s} (P_{s'}^i)^{1-\sigma_{m,s}}\right)^{1/1-\sigma_{m,s}}$.

Finally, the production of sector-specific investment goods is given by the solution to

$$\max_{X_i^{K_{s,s'}}} P_i^{K_s} I_i^s - \sum_{s'} P_{i,t}^{s'} X_i^{K_{s,s'}},$$

[3] To simplify the notation we omit the time subscript.

subject to

$$I^s_{i,t} = \left(\sum_{s'} \left(\omega_i^{K_{s,s'}} \right)^{\frac{1}{\sigma_s}} \left(X_{i,t}^{K_{s,s'}} \right)^{\frac{\sigma_s - 1}{\sigma_s}} \right)^{\frac{\sigma_s}{\sigma_s - 1}},$$

where $X^{K_{s,s'}}$ is the quantity of intermediate good s' used in the production of investment goods specific to sector s. From the FOCs we obtain the demand for intermediates, $X_i^{K_{s,s'}} = \omega_i^{K_{s,s'}} \left(\frac{P_i^{K_s}}{P_i^{s'}} \right)^{\sigma_s} \left(\frac{D_i^{K_s}}{P_i^{K_s}} \right)$, where $D_i^{K_s}$ is the nominal expenditure on s-specific investment goods, $D_i^{K_s} = P_i^{K_s} I_i^{K_s}$, and the price of investment, $P_i^{K_s} = \left(\sum_{s'} \omega_{s'}^{i,K_s} (P_{s'}^i)^{1-\sigma_s} \right)^{\frac{1}{1-\sigma_s}}$.

The total demand for intermediates from sector s is given by

$$X_i^s = X_i^{c,s} + \sum_{s'} X_i^{K_{s',s}} + \sum_{s'} X_i^{M_{s',s}}.$$

3.2.1 Production of intermediate goods

Intermediate producers in sector s combine domestic and foreign differentiated inputs, from that sector, to produce a bundle of intermediate goods, X_s^i. For instance, to produce manufacturing intermediates, firms use heterogeneous domestic and imported manufacturing inputs, and combine them using a CES aggregator, as in equation 5. Firms produce in a perfect competitive environment and maximize profits. Domestic and Foreign heterogeneous inputs, $Y_{i,i}^s, Y_{i,j}^s$, arise from the differences in firm characteristics, such as productivity levels, a (idiosyncratic) and past export status, ex. Imports of foreign inputs pay a tariff that is proportional to the price, $\tau_s > 1$. The optimization problem of X_s^i producers is given by:

$$\max_{Y_{i,i}^s, Y_{i,j}^s} P_i^s X_i^s - \sum_{ex} \int P_{i,i}^s(a, ex) Y_{i,i}^s(a, ex) \phi(a) da - \tau_{i,j}^s \sum_{ex^*} \int P_{i,j}^s(a, ex^*) Y_{i,j}^s(a, ex^*) \phi(a) da,$$

subject to

$$X_i^s = \left(\sum_j (\omega_{i,j}^s)^{\frac{1}{\theta_s}} \sum_{ex} \int \left(Y_{i,j}^s(a, ex) \right)^{\frac{\theta_s - 1}{\theta_s}} \phi(a) da \right)^{\frac{\theta_s}{\theta_s - 1}}. \tag{5}$$

Inputs, Y^s, are produced by heterogeneous firms that can be characterized by their idiosyncratic productivity a, export status ex. $Y_{i,i'}^s(a, .)$ denotes the use in economy i of the s-specific input a produced in economy i'; the export status ex is in one of three possible states, 'no exporter', 'new exporter', or 'old exporter'. Similarly, ex^* denotes the export status exporters from economy j selling inputs to the producers of intermediates in economy i; hence, ex^* can only take the states of 'new exporter' or 'old exporter'. From the FOC we obtain the demands for domestic and foreign heterogeneous inputs, $Y^s_{i,i}(a, ex) = \omega^s_{i,i}(P^s_{i,i}(a, ex))^{-\theta_s}(P^s_i)^{\theta_s - 1}D^s_i$ and $Y^s_{i,j}(a, ex^*) = (\omega^s_{i,j})(\tau^s_{i,j}P^s_{i,j}(a, ex^*))^{-\theta_s}(P^s_i)^{\theta_s-1}D^s_i$, where $D^s_i = P^s_i X^s_i$, and the sector prices are

$$P^s_i = \left[\omega^s_{i,i}\sum_{ex}\int(P^s_{i,i}(a, ex))^{1-\theta_s}\phi(a)da + (1-\omega^s_{i,i})\sum_{ex^*}\int(\tau^s_{i,j}P^s_{i,j}(a, ex^*))^{1-\theta_s}\phi(a)da\right]^{\frac{1}{1-\theta_s}} \tag{6}$$

Finally, $\tau^s_{i,j} \geq 1$ denotes the tariffs to s-specific inputs exported from j to i. These tariffs are sector- and country-pair-specific.

3.3 Heterogeneous Producers

In each country i and sector s, a mass of heterogeneous firms produce a differentiated good (input) using capital, labor, and materials. Firms are monopolistically competitive and choose domestic and foreign prices to maximize profits subject to their demand from home and abroad. Producers differ in productivity, fixed export costs, and iceberg costs.

Firm heterogeneity in productivity comes from an independently distributed (iid) shock, a, with marginal distribution $\phi(a)$. After paying a fixed entry cost, f^s_e, firms are randomly assigned to a sector. Firms pay a fixed production cost, f^s_p, to remain active and exit the market with an exogenous probability n_s. All fixed costs are expressed in labor units.

We follow Alessandria et al. (2021) in modelling export trade frictions as a combination of fixed and variable costs that have an investment component. Each firm is characterize by a fixed export cost, f_x, and an iceberg cost, ξ^s. As in the canonical sunk export cost model, the fixed export cost takes one of two values depending on the past export status. The last source of heterogeneity between firms within a sector is the iceberg cost, ξ^s, that can take one of three values. If the firm does not export $\xi^s = \infty$; otherwise, if the firm exports for the first time its iceberg cost is high, ξ^s_H, if it survives and exports again, it pays a lower iceberg costs, ξ^s_L. This leads new exporters to enter with a low export intensity and low initial profits. Paying the fixed cost to continue to export is also an investment in lowering the marginal future export cost. This process for iceberg and fixed costs is a parsimonious way to model a multi-period investment in building export distribution capacity.

The static optimization problem of a heterogeneous good producer in sector s and country i, iid productivity a, and past export decision ex is given by:

$$Max_{P^s_{i,i},P^s_{j,i}} \quad P^s_{i,i}Y^s_{i,i} + ex'\left(P^s_{j,i}Y^s_{j,i} - W^i f^{s,i}_{ex}\right) - W^i l^i_s - R^i k^i_s - P^{M,i}_s m^{s,i} - W^i f^{s,i}_p$$

$$s.t. \quad Y^i_s = (a)^{\frac{1}{\theta_s - 1}}(k^{s,i})^{\alpha^i_s}(l^{s,i})^{\mu^i_s}(m^{s,i})^{1-\alpha^i_s-\mu^i_s} \tag{7}$$

$$Y^i_s = Y^s_{i,i} + ex'\xi^{s,i}Y^s_{j,i} \tag{8}$$

$$Y^s_{i,i} = (P^s_{i,i})^{-\theta_s}(P^i_s)^{\theta_s - 1}D^i_s \tag{9}$$

$$Y^s_{j,i} = (\tau^j_s P^s_{j,i})^{-\theta_s}(P^j_s)^{\theta_s - 1}D^j_s \tag{10}$$

where ex is an indicator variable that summarizes the past exporting decision; similarly ex' defines the current export status. Y^i_s is the production of a heterogeneous firm in country i and sector s; $k^{s,i}, l^{s,i}, m^{s,i}$ are its demands for capital, labor and materials, respectively; and α^i_s and μ^i_s determine the capital and labor shares. Total output for each firm is allocated between domestic demand and foreign demand, $Y^s_{i,i}, Y^s_{j,i}$, as in equation 8. Notice that to deliver $Y^s_{j,i}$ units of input abroad, the firm needs to produce $\xi^{s,i}Y^s_{j,i}$ units, that's why ξ is called an iceberg cost. From the F.O.C and the monopolistic competition structure, we have the the prices for each destination (Home and Foreign) are a markup over the marginal cost of producing:

$$P^s_{i,i} = \frac{\theta_s}{\theta_s - 1}MC^i_s(a)^{\frac{1}{1-\theta_s}} \tag{11}$$

$$P^s_{j,i} = \frac{\theta_s}{\theta_s - 1} \xi^{s,i} MC^i_s(a)^{\frac{1}{1-\theta_s}} \quad (12)$$

$$MC^i_s = \left(\frac{R^i}{\alpha^i_s}\right)^{\alpha^i_s} \left(\frac{W^i}{\mu^i_s}\right)^{\mu^i_s} \left(\frac{P^{M,i}_s}{1 - \alpha^i_s - \mu^i_s}\right)^{1-\alpha^i_s-\mu^i_s} \quad (13)$$

3.3.1 Productivity Thresholds

To characterize the equilibrium in dynamic heterogeneous models it is necessary to determine the productivity thresholds for producers and exporters, and the free entry condition. These thresholds are given by the margin (indifference) between producing or not, exporting or not, and entering or not. Once these margins are determined it is possible to find the masses of firms that produce and export, and the aggregate levels of production, capital, exports, and prices, among others. For a given firm, profits before fixed costs are given by:

$$\pi^i_s(a, ex) = \Pi^{s,i}_0(a) \left[(P^i_s)^{\theta_s-1} D^i_s + ex'(\xi^{s,i})^{1-\theta_s}(\tau^j_s)^{-\theta_s}(P^j_s)^{\theta_s-1} D^j_s\right] \quad (14)$$

where $\Pi^{s,i}_0(a) = \frac{1}{\theta_s}\left(\frac{\theta_s}{\theta_s-1} MC^i_s\right)^{1-\theta_s}$

Assuming that the marginal producer does not export, the productivity threshold for a producer is given by:

$$a^{s,i}_p = \frac{W_i f^{s,i}_p}{\Pi^{s,i}_0 (P^i_s)^{\theta_s-1} D^i_s} \quad (15)$$

Ceteris Paribus, higher fixed production costs increase the productivity threshold; while higher Markov productivity reduces it. To find the thresholds for the marginal exporters, first define the value of an active producer:

$$V^i_s(ex', a, ex) = \pi^i_s(a, ex) - W^i f^{s,i}_p - ex' W^i f^{s,i}_{ex} + n^i Q^i EV^{s,i}(ex') \quad (16)$$

where $Q^i = \beta U^i_{c'}/U^i_c$ is the stochastic discount factor, and EV is the expected value of producing next period. Marginal exporters are indifferent between exporting or not, which means the following conditions hold:

$$V_s^i(1, a_{ex}^{s,i}, ex) = V_s^i(0, a_{ex}^{s,i}, ex) \tag{17}$$

where $a_{ex}^{s,i}$ is the productivity threshold for an exporter with past export status ex. Replacing equation 16 into equation 17, give us the following conditions for the marginal exporters:

$$W_i f_{0,i}^s = \frac{\Pi_{0,i}^s a_{0,i}^s (\xi_{0,i,j}^s)^{1-\theta_s} D_j^s}{(\tau_{j,i}^s)^{\theta_s} (P_j^s)^{1-\theta_s} \omega_{j,i}^s} + n_i Q_i \left(EV_i^s(1) - EV_i^s(\infty) \right). \tag{18}$$

Similarly,

$$W_i f_{1,i}^s = \sum_{j \neq i} \frac{\Pi_{0,i}^s a_{1,i}^s (\xi_{1,i,j}^s)^{1-\theta_s} D_j^s}{(\tau_{j,i}^s)^{\theta_s} (P_j^s)^{1-\theta_s} \omega_{j,i}^s} + n_i Q_i \left(EV_i^s(1) - EV_i^s(\infty) \right).$$

To find the productivity thresholds we first must get the expected values of a non-exporter firm, $EV(\infty)$, a new exporter, $EV(0)$, and a continuation exporter, $EV(1)$. The expected values come from integrating equation 16 over different values for the Markov productivity and the iceberg costs. The mathematical appendix includes a detailed description of this procedure.

Free entry and masses of firms Upon entry, new firms cannot immediately produce, instead they have to wait one period to start producing. After paying the fixed entry fee they get randomly and uniformly assigned into a sector. Hence, in equilibrium the entry cost should be equal to the expected average discounted value of entering:

$$W_i f_{e,i} = Q_i \sum_s \frac{EV_i^s(\infty)}{S}. \tag{19}$$

This firm allocation rule implies that the mass of firms that enters in each sector is the same, $N_{E,i,t}^s = \frac{N_{E,i,t}}{S}$. Every period a fraction of firms dies exogenously, and a new fraction enters the economy according to $N^s_{E,i,t} = (1 - n_i)N^s_{i,t-1}$. Every period, the evolution of the number of firms is given by the survivors and the entrants, $N^s_{i,t} = n_i N^s_{i,t-1} + N^s_{E,i,t-1}$. Finally we can divide firms into non-exporters $N^s_{0,i,t} = N^s_{i,t} - N^s_{x,i,t}$, and exporters $N^s_{x,i,t} = N^s_{x1,i,t} + N^s_{x0,i,t}$, where $N^s_{x1,i,t} = n_i n^s_{1,i,t} N^s_{x,i,t-1}$ are continuation exporters, and $N^s_{x0,i,t} = n^s_{0,i,t}(N^s_{E,i,t-1} + n_i N^s_{0,i,t-1})$ are new exporters.

3.4 Competitive Equilibrium

A competitive equilibrium is a set of prices and allocations such that the representative consumer maximizes her utility subject to her budget constraint; producers of final goods, materials, intermediates and heterogeneous inputs, maximize profits; and all markets clear. Market clearing implies that labor is allocated to the production of heterogeneous inputs and the fixed costs of entry, production, and export. Also, that aggregate capital is distributed among heterogeneous producers, according to their demands. As an equilibrium condition we assume that tariff revenue is rebated to the households as a lump sum transfer, and firms distribute their profits to the representative domestic consumer. Finally, given that the two countries are assumed to be in external financial autarky, nominal exports equal nominal imports.

4 Calibration

For the benchmark model we assume that the world economy is populated by two countries that primarily differ by size, measured by population. The smaller economy is matched to Colombia. We limit the differences in parameters across countries while still being consistent with gross and net trade flows in each sector. Each economy has four sectors, agriculture, services, and two manufacturing sectors. We split the manufacturing sectors based on their trade balance. We explore the effects of more or less sectors in section 6.

We divide the set of parameters into three groups. The first group contains the parameters that are taken from the literature. This set of parameters is presented in table 2. The second group corresponds to the parameters that come directly from the data, such as the sector shares for producing final goods and materials, that come from the Input-Output tables, Table 3. The last group of parameters includes the values that are targeted to match sector moments, these parameters include the iceberg and fixed costs, and are presented in table 4.

The first set of parameters are largely standard. We set the period of the model to one year. We choose the discount factor to yield a four percent interest rate. The depreciation rate of capital is set to equal 15 percent. We model Colombia as being 1/20 the size of the rest of the world. We set the capital share of production to equal 60 percent and the labor share in production to equal 30 percent, this targets an Investment/GDP around 20%. The elasticity of substitution across domestic and foreign varieties is set to 2.0. The survival rate of firms is set to 0.95. For the benchmark economy we assume that the technologies for producing final goods and materials are close to Cobb Douglas, meaning that the elasticities of substitution between sectors are, $\theta = \sigma_s = 1.1$. This assumption implies that for the second set of parameters we can use directly the Input-Output data for the sector shares for producing final goods, ω_s, and materials, $\lambda_{s,s'}$.

For the third set of parameters, we use 1990 as our benchmark year. We use the official tariffs reported by Garay et al. (1998) for the early 90s and from customs for the most recent period, figure 7. The second column of Table 6 reports the initial and final tariffs we put into the model and figure 8 plots the paths for these series. We target the following sector values: trade openness, trade balance, export participation, exporter premium, and the share and size of new exporters. To match these six moments (per sector), we find the sector values of six parameters (per sector), that is, fixed costs (production, new exporters, and old exporters), iceberg costs (new exporters and old exporters), and domestic home bias. To calculate the targeted data moments, we use information from the National Statistics Department of Colombia (DANE). This information includes data from the input-output tables, national accounts, and the manufacturing census. The latter provides a valuable source of information that has been widely use in the literature of firm and export decisions[4]. This panel allows to calculate some micro-moments for the manufacturing sector, such as export participation, export intensity, and share of new exporters. Given the lack of information

[4]For instance see Roberts and Tybout (1997), Eslava et al. (2005), Eslava et al. (2010), Eslava et al. (2013), Mariscal et al. (2017), and Alessandria and Avila (2020)

at the firm level for agriculture and services we made some additional assumptions. For example, we assume that export participation in services is close to zero, while in agriculture is similar to the one observed in the manufacturing consumer's goods sector.

The calibrated parameters are reported in table 4, and table 6 describes the initial and final sector moments from the model, such as trade openness, trade balance, export participation, exporter premium and the share of new exporters. For the initial period, all of these moments are targeted and matched. In 1990, Colombia runs a big trade surplus in agriculture, that is offset by a trade deficits in industrial supplies, and capital and transportation, the other manufacturing sectors show small trade surpluses.

A couple of things are worth mentioning from the calibration results. First, to match the trade deficits in the manufacturing sector the iceberg costs at home are bigger than in the ROW, making domestic firms more difficult to export. The opposite happens in agriculture, which is the sector that runs the higher trade surplus. Second, the iceberg costs for services are big to match the low export participation and trade openness. Third, comparing within sectors, iceberg costs are smaller for continuation exporters to match the size of new exporters. Finally, even though we're matching similar moments in terms of export participation, new exporters, size of new exporters, exporter premium, we observe parameter heterogeneity coming from differences in trade openness and trade balance.

5 Quantitative Results

We now examine the effects of the tariff reform on sectoral and aggregate economic activity. We first compare the predictions of the model to the change in industry performance. Then we consider the aggregate implications. With these findings, we perform some counterfactuals to understand the source of the welfare gains in the model by the changes in average and sectoral tariffs. We also relate the findings in our multi-sector model to a one sector model.

5.1 Full Trade Reform

In figure 9 we plot the path of trade openness in the model and the data. The model is a close match to the sectoral data; however, the model generates a lower response in aggregate trade openness. The gap between the model and the data in the aggregate could reflect other shocks or changing production/consumption patterns absent from our model.

Figure 10 plots the dynamics of consumption for our main experiment and some alternative reforms. Table 8 reports welfare gains as well as the short-run and long-run changes in consumption. As in prior work in models with firm dynamics, the reform leads to a substantial increase in consumption that overshoots the long run level. On impact consumption jumps 2.1 percent then rises for one more period before reverting to a long run increase of 1.47 percent. The welfare gain from this path of consumption is 1.63 percent.

5.2 Counterfactual Experiments

Now we use the model answer some questions regarding tariff-time-heterogeneity. In particular, 1) what are the welfare effects of reducing tariff heterogeneity?; 2) which sector contributes the most to welfare gains?; and 3) what are the welfare effects of having different timing in the tariff drop? Obviously, questions 1) and 3) can only be answered by a model like the one presented in this paper.

We first consider the effect of harmonizing tariffs. We start from the observed sector-tariffs and we eliminate tariff-heterogeneity such that tariff revenue remains the same, this means that the new tariff at home is 34.1% Eliminating tariff heterogeneity has a positive effect on welfare, increasing long run consumption by 0.87% and overall welfare by 0.90%, as seen in figure 10 during the first periods consumption increases by more than in the long run. Eliminating tariff-heterogeneity also reduces sector trade imbalances and increases trade openness. These results imply that heterogeneous tariffs generate an additional source of inefficiency in the economy and eliminating the heterogeneity has a positive effect on welfare.

Second, we explore the contribution of each sectors change in trade policy on welfare gains. To do this we first homogenize initial and final tariffs. The new tariffs are such that tariff-revenue remains the same as the implied by the initial and final tariffs observed in the data provided by Garay et al. (1998). Then, we perform a trade liberalization one sector at a time and compare the welfare gains from each case. By considering the same tariffs we reduce one source of heterogeneity and we can compare the results more easily. Figure 11 show the consumption paths for each case. As seen in figure 11 and table 9 the welfare gains from liberalizing a particular sector are always positive and in all cases are front loaded. Liberalizing all sectors at the same time increases welfare by 2%. MM_2 contributes 70% of the gains and corresponds to the sector with the highest initial trade deficit. In other words, liberalizing the sector with the least comparative advantage has the biggest effects on welfare.

Finally, we analyze the effects of liberalizing each sector gradually, in particular we assume that the economy drops tariffs linearly during 4 or 8 years. The proposed Colombia trade reform originally was planned to phase out over 4 years but was accelerated early in the reform. We compare the welfare gains relative to the case in which we liberalize the sector immediately. As seen in the last two columnns of table 9, the welfare gains are lower when the economy liberalizes the sectors gradually, and the more gradual the lower the gains. The lower welfare gains from gradual reforms primarily reflect the smaller present value of the change in tariffs. We also observe some heterogeneity between sectors. For instance, liberalizing MM_2 immediately or during 4 years generates a 4% difference in terms of its contribution to welfare gains; however, this same calculation for AG generates a 8% difference. This means that welfare gains are more front loaded in agriculture than in MM_2. These results show the importance of tariff-sector-time heterogeneity for welfare gains.

5.3 A one sector model

The model with multiple traded sectors allows us to introduce comparative advantage into a dynamic exporting model. Now we explore the effect of eliminating that by modelling a single sector and studying a reform that matches the long run behaviour of aggregate trade openness from our benchmark model. We find the welfare gain to be smaller and involve more overshooting than our benchmark model.

The calibrated parameters are reported in table 7, the aggregate targets are: 1) trade openness of 30%; 2) export participation of 10% and 3) share of new exporters 25%. The model matches this moments perfectly. Under this scenario we find that tariffs change from

32% to 26.2%. This variation in tariffs generates overall welfare gains of 0.64%, which are almost half from the ones originated in the four sector model.

6 Sensitivity

In this section we explore the aggregate implications of some of the model's key assumptions, such as the number of sectors, the input-output structure, the production technology for consumption and investment goods, sector-heterogeneity, and the ability to borrow/lend with a riskless bond. The parameters for these alternative are available upon request. After showing the importance of these margins we reconsider the effects of the reform in Colombia. We expect this to be the benchmark in subsequent drafts.

6.1 Changing the number of sectors, removing the input-output structure, and allowing trade of a riskless bonds

Inspired by the multi-sector literature, we consider different extensions to the benchmark model and analyze their implications on welfare, short-run (SRC) and long-run consumption (LRC). Following Caliendo and Parro (2015) we examine the effects of removing the input-output structure, and of adding or dropping sectors. We also consider the implications of allowing households to borrow in foreign markets and of removing firm's dynamics. In all cases, we re-calibrate the model to target the same aggregate and sector moments in 1990 and we perform a trade liberalization so that the change in the import share is approximately 40%.

Table 10 reports the results for the model with three, S_3, four, S_4, six, S_6, and seven sectors, S_7, under five different scenarios. In the first one, we consider the input-output structure from the data; in the second, we add bonds, starting with a zero trade balance; in the third, we remove the input-output structure with no bonds; in the fourth we eliminate firm dynamics as in Backus et al. (1992), denoted BKK.

It is important to clarify that, due to firm-data availability, every time we add a sector we do it by splitting manufacturing into more sub-sectors. We also order the sub-sectors according to their value added. For example, if we have two sub-sectors: MM1 and MM2, MM2 is the one with more value added.

As shown in table 10, a unilateral trade liberalization increases welfare, and raises consumption by more in the short run than in the long run. These results hold for all the scenarios and are consistent with other dynamic trade models, such as Alessandria et al. (2021) and Alessandria and Avila (2020). The overshooting behavior may seem surprising given one's intuition that we are modelling a form of an adjustment cost that should burn up resources along the transition. However the high tariffs lead to an over-investment in building new plants and under-investment in export capacity. Along the transition, the savings from disinvesting in plants swamps the costs from investment in export capacity.

We also find that welfare gains are bigger when: 1) we add more sectors; 2) we allow households to borrow in the foreign markets; or 3) we include input-output linkages. We also notice that increasing the number of sectors has decreasing returns on welfare, since moving from three to four sectors has bigger gains than moving from six to seven. On the other hand, including bonds allows households to increase short run consumption by more, while running an aggregate trade deficit. As in Caliendo and Parro (2015), we observe that removing input-output linkages or dropping sectors decreases welfare gains. By including input-output linkages the sectors not only benefit from cheaper imported inputs but also from the growing demand from other sectors.

With respect to the benchmark scenario, adding one sector increases welfare by 30%, S_4, while adding three sectors, S_6, by 33%. Similarly, moving from three sectors to one sector reduces welfare gains by 17%. If we only focus only on long run changes, we overestimate the welfare gains of adding sectors. As already mentioned, more sectors generate different patterns of comparative advantage and may increase welfare gains.

As an additional check of comparative advantage forces, in table 11 we report the welfare gains for a drop in tariffs one sector at a time in the six-sector model In this table we also report the initial trade balance in each sector, which serves as a proxy of comparative advantage. As in the three sector case, we observe that liberalizing sectors with higher trade deficits have a stronger effect on welfare. We also use the six sector model to compare some model implications with the data, as the four panels of figure 11 show, both in the model and in the data, at the sector level, there is a positive correlation between initial and final trade openness, and between initial and final trade balance.

Eliminating firm dynamics lead to much smaller gains than in our benchmark model. In this case we remove the entry, production, and export decisions. Instead of considering heterogeneous producers, we assume one representative firm in each each country that produces a differentiated input. This input is used at home and exported. We keep everything else equal and consider two scenarios: three and six sectors. In both cases, a unilateral trade liberalization decreases short run consumption and increases long run gains. Consumption drops in the short run due to lower lump-sum transfers from the government. Higher returns on capital and labor are not enough to compensate the drop in tariff revenue. Compared with the benchmark case welfare gains are smaller in the model with no dynamics. Dynamic decisions at the firm level have a direct effect on wages and other sources of income, like profits. By removing these decisions we reduce the effects of a trade liberalization.

6.2 Changing the technology for producing investment goods

Since the seminar work of Boileau (1999) it has been recognized that capital goods involve more traded inputs than consumption goods. We now explore the effects of this channel by allowing for different technologies in producing investment and consumption goods. In particular, we assume that consumption goods are relatively more intensive in services and in manufacturing goods with high value added. For Colombia, the latter sectors are have no comparative advantage with respect to the ROW and run larger trade deficits so that tariffs here have an outsized effect on the relative price of investment to consumption.

$$C^i = \left(\sum_s (\omega_s^{C,i})^{\frac{1}{\theta}} (X_s^{C,i})^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{20}$$

$$I^i = \left(\sum_s (\omega_s^{I,i})^{\frac{1}{\theta}} (X_s^{I,i})^{\frac{\theta-1}{\theta}} \right)^{\frac{\theta}{\theta-1}} \tag{21}$$

The new market clearing condition for the producers of bundles of intermediate goods is:

$$X_s^i = X_s^{C,i} + X_s^{I,i} + \sum_{s'} X_{s',s}^{M,i} \tag{22}$$

Given the new technology functions for consumption and investment goods we re-calibrate the model to target the same moments as in the previous scenarios and perform a trade liberalization that generates a change in the log import share of 40%.

The welfare implications for the three, four and six sector versions of the model are reported in table 10. As in the previous cases, having more sectors with different comparative advantage patterns generates bigger welfare gains. However, splitting the production technologies of consumption and investment alters the timing of the gains from trade. In particular, with more trade intensive in capital goods, the welfare gains are more concentrated in the long run as more of the gains come from capital deepening.

6.3 An updated reform

In this section we re-consider the phased-in trade reform in a six sector version of our most general model. That is we allow for separate technologies for sectoral investment and consumption aggregators as well as trade in financial assets. This version of the model follows an alternative sectoral calibration organized by the Broad Economic Categories (BEC). We consider this sort of sectoral detail given the Penn World Tables makes this detail of trade data easily accessible. We show the trade reform captures the dynamics of sectoral trade as well as the salient macroeconomic features described earlier.

The BEC has 6 sectors of trade in goods. Owing to the similarity in the pattern of trade and tariffs, we combine the capital and transport categories into one sector. We are left with Agriculture, Food Beverage, Fuels, Industrial Supplies, Consumer goods, Capital/Transport and Services. We concentrate on the dynamics in the 15 years following the reform to highlight the effects from the trade reforms and abstract from other subsequent reforms and shocks.

Specifically, we assume the economy is in steady state in 1989 and the government proposes a fully credible, surprise declining path of import tariffs over the next 4 years that closely mimics the data. Figure 13 panel a plots the heterogeneous reform across sectors. Panel b plots the sectoral path of trade openness. Panel c plots the sectoral trade balance as a share of sector trade. Sectoral balances do change somewhat, particularly for the transport equipment sector which moves even more strongly into deficit. Panel d plots the ratio of each industries gross output share to its initial share. The changes are relatively minor. The service and agriculture sectors rise in importance for production while the deficit setors fall in importance, although the Transport/Capital sector has some non-linear dynamics in the model. Figure 14 shows the model can match the growth in sectoral trade. The main miss seems to be for trade in consumption goods.

Figure 15 compares the key macroeconomic features induced by this reform in the model with the data. Panel a shows there is a substantial but temporary expansion in the investment share of GDP that is of comparable magnitude and timing with the data. The scale of the investment boom is dependent on the adjustment costs, which are hard to discipline for such a shock. Panel b plots a gradual expansion in trade, which is only slightly faster than the path of the data. Panel c, shows that the investment boom is accompanied by a substantial trade deficit. Panel d shows that there is a short-run boost in economic growth.

7 Conclusions

We develop a two-country, multi-sector heterogeneous firm dynamic exporting model with input output linkages, capital accumulation, and trade in financial assets. The model fills the gap between the multi-sector static trade models and the two sector heterogeneous firm dynamic exporting. It allows us to consider the transition from heterogeneous reforms in trade policy across heterogeneous sectors.

We use the model to study the unilateral trade policy reforms in Colombian in the early 1990s. We estimate these reforms increased welfare by about 2 percent. These reforms also generated a short-run investment boom financed through international borrowing. We decompose these gains between those from tariff harmonization and lowering average tariff. A sizeable share of the gains from reform are related to harmonizing tariffs.

We relate the estimated welfare gains from our model to other models that abstract from key margins related to trade dynamics, sectoral heterogeneity, capital flows and investment. With respect to dynamic models of trade, our multi-sector model yields larger gains from trade reform since it introduces both comparative advantage and tariff harmonization effects. Relative to multi-sector static trade models, consistent with previous work we find substantially larger welfare gains as well as a different timing of the benefits of reform. The model also includes a strong force for large initial trade deficits following the reform, more so when we model a realistic production structure for capital goods which tends to magnify but delay the benefits of reform.

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A Mathematical Appendix

A.1 Expected value of a non-exporter

$$EV^{s,i}(a_z^{s,i},\infty,0)=\rho_z^{s,i}\Bigg(\int_{a_{p,z}^{s,i}}^{a_{H,0,z}^{s,i}}\Big(\Pi_0^{s,i}(aa_z^{s,i})(P_s^i)^{\theta_s-1}D_s^i-W^if_p^{s,i}+n^iQ^iEV^{s,i}(a_z^{s,i},\infty,0)\Big)\phi(a)da+$$

$$\int_{a_{H,0,z}^{s,i}}^{\infty}\Big(\Pi_0^{s,i}(aa_z^{s,i})\left((P_s^i)^{\theta_s-1}D_s^i+(\xi_H^{s,i})^{1-\theta_s}(\tau_s^j)^{-\theta_s}(P_s^j)^{\theta_s-1}D_s^j\right)-W^if_p^{s,i}-W^if_0^{s,i}+$$

$$n^iQ^iEV^{s,i}(a_z^{s,i},\xi_H^{s,i},1)\Big)\phi(a)da\Bigg)+$$

$$(1-\rho_z^{s,i})\Bigg(\int_{a_{p,z'}^{s,i}}^{a_{H,0,z'}^{s,i}}\Big(\Pi_0^{s,i}(aa_{z'}^{s,i})(P_s^i)^{\theta_s-1}D_s^i-W^if_p^{s,i}+n^iQ^iEV^{s,i}(a_{z'}^{s,i},\infty,0)\Big)\phi(a)da+$$

$$\int_{a_{H,0,z'}^{s,i}}^{\infty}\Big(\Pi_0^{s,i}(aa_{z'}^{s,i})\left((P_s^i)^{\theta_s-1}D_s^i+(\xi_H^{s,i})^{1-\theta_s}(\tau_s^j)^{-\theta_s}(P_s^j)^{\theta_s-1}D_s^j\right)-W^if_p^{s,i}-W^if_0^{s,i}+$$

$$n^iQ^iEV^{s,i}(a_{z'}^{s,i},\xi_H^{s,i},1)\Big)\phi(a)da\Bigg)$$

Assuming that $\phi(a)=\eta a^{-\eta-1}$, follows a Pareto distribution with parameter $\eta>1$, the previous equation can be written as:

$$EV^{s,i}(a_z^{s,i},\infty,0)=\rho_z^{s,i}(\Pi_0^{s,i}a_z^{s,i}\Psi_{p,z}^{s,i}(P_s^i)^{\theta_s-1}D_s^i-W^if_p^{s,i}n_{p,z}^{s,i}+(1-n_{H,0,z}^{s,i})n^iQ^iEV^{s,i}(a_z^{s,i},\infty,0)+$$

$$\Pi_0^{s,i}a_z^{s,i}(\xi_H^{s,i})^{1-\theta_s}(\tau_s^j)^{-\theta_s}(P_s^j)^{\theta_s-1}D_s^j\Psi_{H,0,z}^{s,i}-W^if_0^{s,i}n_{H,0,z}^{s,i}+n^iQ^in_{H,0,z}^{s,i}EV^{s,i}(a_z^{s,i},\xi_H^{s,i},1))+$$

$$(1-\rho_z^{s,i})(\Pi_0^{s,i}a_{z'}^{s,i}\Psi_{p,z'}^{s,i}(P_s^i)^{\theta_s-1}D_s^i-W^if_p^{s,i}n_{p,z'}^{s,i}+(1-n_{H,0,z'}^{s,i})n^iQ^iEV^{s,i}(a_{z'}^{s,i},\infty,0)+$$

$$Pi_0^{s,i}a_{z'}^{s,i}(\xi_H^{s,i})^{1-\theta_s}(\tau_s^j)^{-\theta_s}(P_s^j)^{\theta_s-1}D_s^j\Psi_{H,0,z'}^{s,i}-W^if_0^{s,i}n_{H,0,z'}^{s,i}+n^iQ^in_{H,0,z'}^{s,i}EV^{s,i}(a_{z'}^{s,i},\xi_H^{s,i},1))$$

Where $\Psi_{p,z}^{s,i}=\frac{\eta(a_{p,z}^{s,i})^{1-\eta}}{\eta-1}$, $\Psi_{H,0,z}^{s,i}=\frac{\eta(a_{H,0,z}^{s,i})^{1-\eta}}{\eta-1}$, $n_{p,z}^{s,i}=(a_{p,z}^{s,i})^{-\eta}$, and $n_{H,0,z}^{s,i}=(a_{H,0,z}^{s,i})^{-\eta}$.

A.2 Expected value of an exporter with high iceberg cost

$$EV^{s,i}(a_z^{s,i}, \xi_H^{s,i}, 1) = \rho_z^{s,i}\Bigg(\Pi_0^{s,i} a_z^{s,i} (P_s^i)^{\theta_s - 1} D_s^i \Psi_{p,z}^{s,i} - W^i f_p^{s,i} n_{p,z}^{s,i} +$$

$$\Pi_0^{s,i} a_z^{s,i} (\tau_s^j)^{-\theta_s} (P_s^j)^{\theta_s - 1} D_s^j \Big(\rho_\xi^i (\xi_H^{s,i})^{1-\theta_s} \Psi_{H,1,z}^{s,i} + (1 - \rho_\xi^{s,i})(\xi_L^{s,i})^{1-\theta_s} \Psi_{L,z}^{s,i}\Big) +$$

$$n^i Q^i EV^{s,i}(a_z^{s,i}, \infty, 0)\Big(\rho_\xi^{s,i}(1 - n_{H,1,z}^{s,i}) + (1 - \rho_\xi^{s,i})(1 - n_{L,z}^{s,i})\Big) -$$

$$W^i f_1^{s,i}\Big(\rho_\xi^{s,i} n_{H,1,z}^{s,i} + (1 - \rho_\xi^{s,i}) n_{L,z}^{s,i}\Big) +$$

$$n^i Q^i \Big(n_{H,1,z}^{s,i} EV^{s,i}(a_z^{s,i}, \xi_H^{s,i}, 1) + n_{L,z}^{s,i} EV^{s,i}(a_z^{s,i}, \xi_L^{s,i}, 1)\Big)\Bigg) +$$

$$(1 - \rho_z^{s,i})\Bigg(\Pi_0^{s,i} a_{z'}^{s,i} (P_s^i)^{\theta_s - 1} D_s^i \Psi_{p,z'}^{s,i} - W^i f_p^{s,i} n_{p,z'}^{s,i} +$$

$$\Pi_0^{s,i} a_{z'}^{s,i} (\tau_s^j)^{-\theta_s} (P_s^j)^{\theta_s - 1} D_s^j \Big(\rho_\xi^i (\xi_H^{s,i})^{1-\theta_s} \Psi_{H,1,z'}^{s,i} + (1 - \rho_\xi^{s,i})(\xi_L^{s,i})^{1-\theta_s} \Psi_{L,z'}^{s,i}\Big) +$$

$$n^i Q^i EV^{s,i}(a_{z'}^{s,i}, \infty, 0)\Big(\rho_\xi^{s,i}(1 - n_{H,1,z'}^{s,i}) + (1 - \rho_\xi^{s,i})(1 - n_{L,z'}^{s,i})\Big) -$$

$$W^i f_1^{s,i}\Big(\rho_\xi^{s,i} n_{H,1,z'}^{s,i} + (1 - \rho_\xi^{s,i}) n_{L,z'}^{s,i}\Big) +$$

$$n^i Q^i \Big(n_{H,1,z'}^{s,i} EV^{s,i}(a_{z'}^{s,i}, \xi_H^{s,i}, 1) + n_{L,z'}^{s,i} EV^{s,i}(a_{z'}^{s,i}, \xi_L^{s,i}, 1)\Big)\Bigg)$$

A.3 Expected value of an exporter with low iceberg cost

$$EV^{s,i} = \rho_z^{s,i}\Bigg(\Pi_0^{s,i} a_z^{s,i}\Bigg((P_s^i)^{\theta_s - 1} D_s^i \Psi_{p,z}^{s,i} +$$

$$(\tau_s^j)^{-\theta_s} (P_s^j)^{\theta_s - 1} D_s^j \Big(\rho_\xi^i (\xi_L^{s,i})^{1-\theta_s} \Psi_{L,z}^{s,i} + (1 - \rho_\xi^{s,i})(\xi_H^{s,i})^{1-\theta_s} \Psi_{H,1,z}^{s,i}\Big)\Bigg)$$

$$-W^i f_p^{s,i} n_{p,z}^{s,i} - W^i f_1^{s,i}\Big(\rho_\xi^{s,i} n_{L,z}^{s,i} + (1-\rho_\xi^{s,i}) n_{H,1,z}^{s,i}\Big)+$$

$$n^i Q^i EV^{s,i}(a_z^{s,i}, \infty, 0)\Big(\rho_\xi^{s,i}(1-n_{L,z}^{s,i}) + (1-\rho_\xi^{s,i})(1-n_{H,1,z}^{s,i})\Big)+$$

$$n^i Q^i \Big(\rho_\xi^{s,i} n_{L,z}^{s,i} EV^{s,i}(a_z^{s,i}, \xi_L^{s,i}, 1) + (1-\rho_\xi^{s,i}) n_{H,1,z}^{s,i} EV^{s,i}(a_z^{s,i}, \xi_H^{s,i}, 1)\Big)\Bigg)+$$

$$(1-\rho_z^{s,i})\Bigg(\Pi_0^{s,i} a_{z'}^{s,i}\Bigg((P_s^i)^{\theta_s - 1} D_s^i \Psi_{p,z'}^{s,i}+$$

$$(\tau_s^j)^{-\theta_s}(P_s^j)^{\theta_s-1} D_s^j \Big(\rho_\xi^i (\xi_L^{s,i})^{1-\theta_s}\Psi_{L,z'}^{s,i} + (1-\rho_\xi^{s,i})(\xi_H^{s,i})^{1-\theta_s}\Psi_{H,1,z'}^{s,i}\Big)\Bigg)$$

$$-W^i f_p^{s,i} n_{p,z'}^{s,i} - W^i f_1^{s,i}\Big(\rho_\xi^{s,i} n_{L,z'}^{s,i} + (1-\rho_\xi^{s,i}) n_{H,1,z'}^{s,i}\Big)+$$

$$n^i Q^i EV^{s,i}(a_{z'}^{s,i}, \infty, 0)\Big(\rho_\xi^{s,i}(1-n_{L,z'}^{s,i}) + (1-\rho_\xi^{s,i})(1-n_{H,1,z'}^{s,i})\Big)+$$

$$n^i Q^i \Big(\rho_\xi^{s,i} n_{L,z'}^{s,i} EV^{s,i}(a_z^{s,i}, \xi_L^{s,i}, 1) + (1-\rho_\xi^{s,i}) n_{H,1,z'}^{s,i} EV^{s,i}(a_{z'}^{s,i}, \xi_H^{s,i}, 1)\Big)\Bigg)$$

B Figures

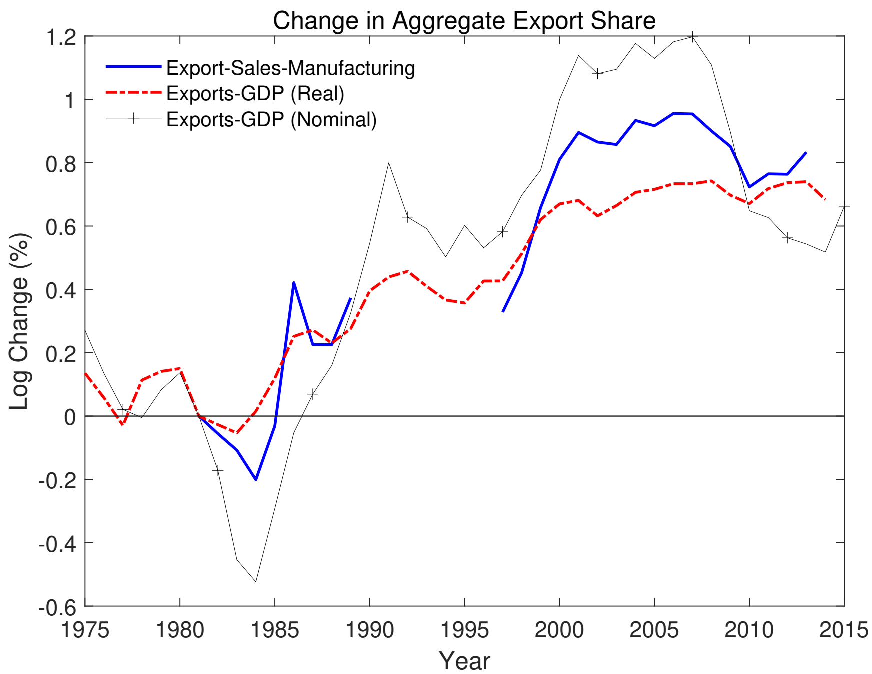

Figure 1: Change in Export Share. Source: National Statistics Department of Colombia (DANE). Authors' calculations.

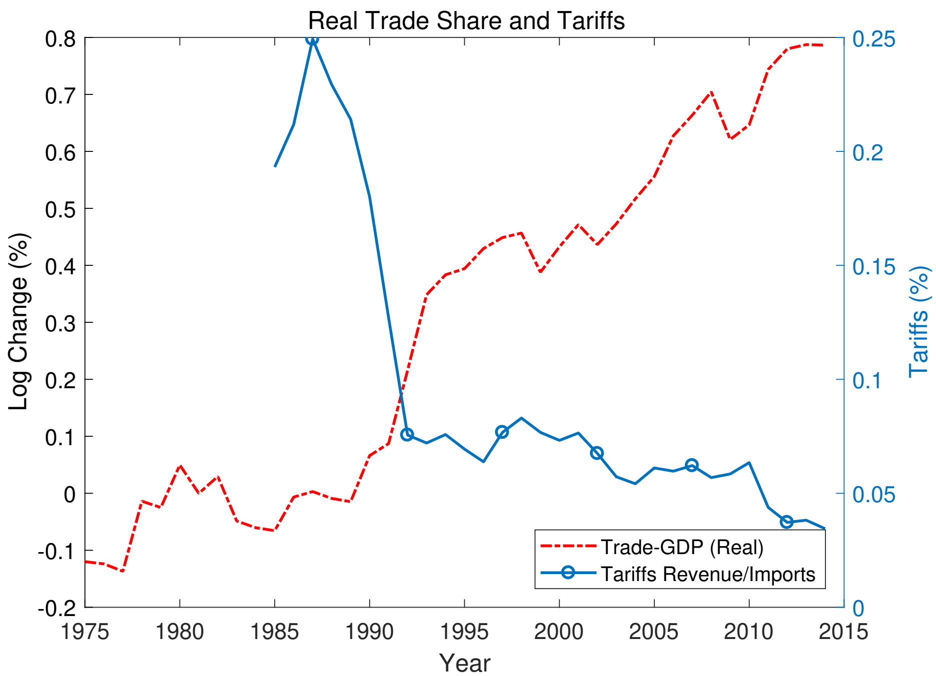

Figure 2: Change in Trade Openness and Tariffs. Source: National Statistics Department of Colombia (DANE). Authors' calculations.

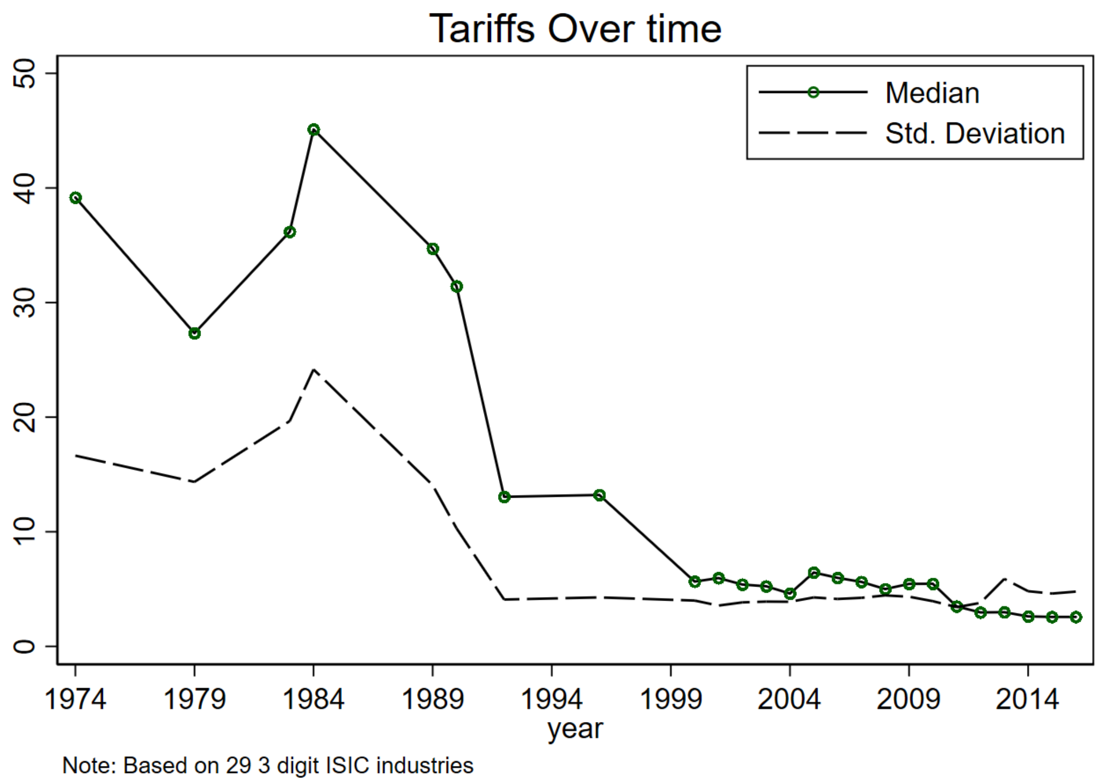

Figure 3: Sectoral Tariff Dynamics.

Figure 4: Change in Trade Openness, Export Participation and Tariffs. The x-axis values correspond to different sectors. Source: National Statistics Department of Colombia (DANE). Authors' calculations.

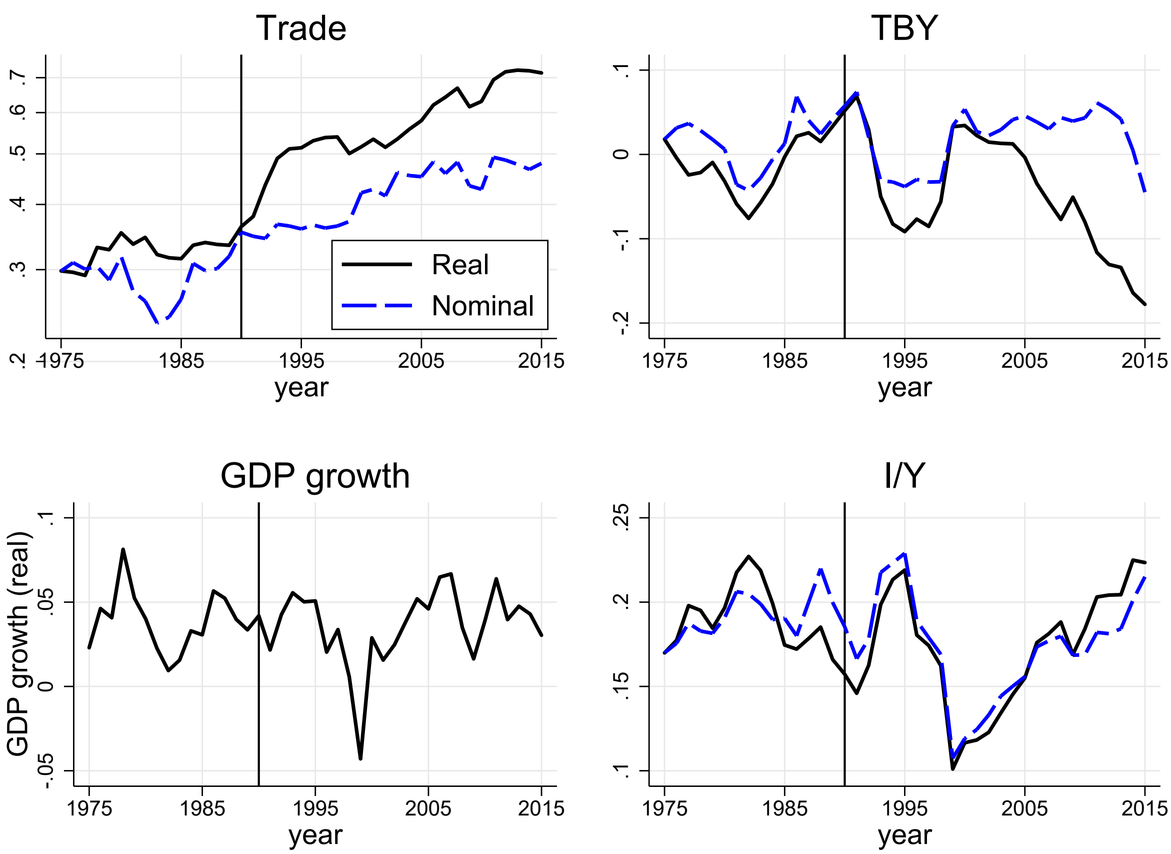

Figure 5: Macro dynamics (Dane)

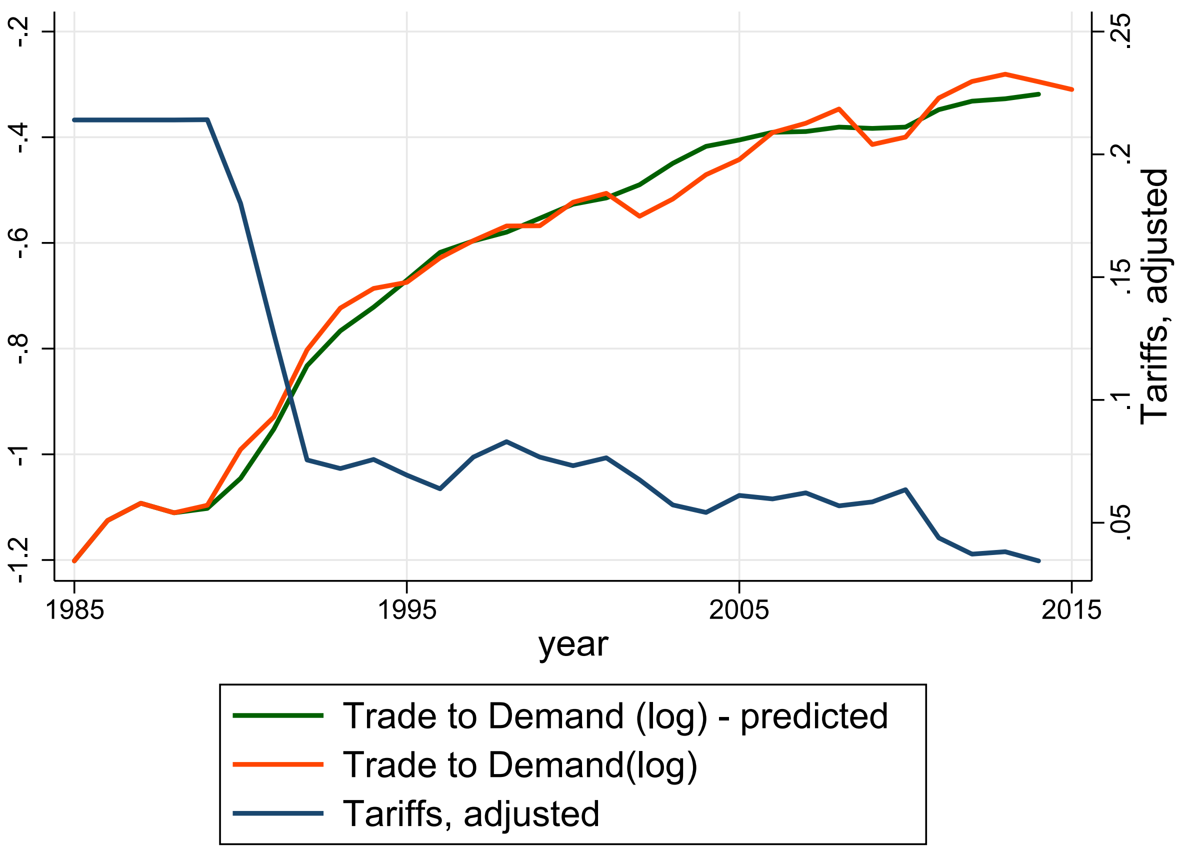

Figure 6: Trade and Tariff Dynamics: Predicted and Actual

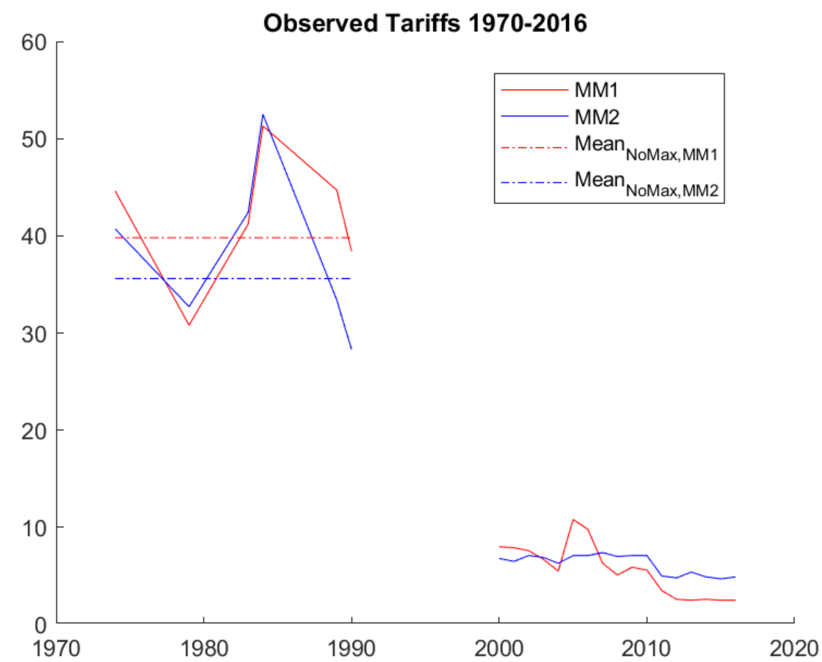

Figure 7: Observed tariffs: Manufacturing sector. Data from Garay et al. (1998) and customs (DIAN).

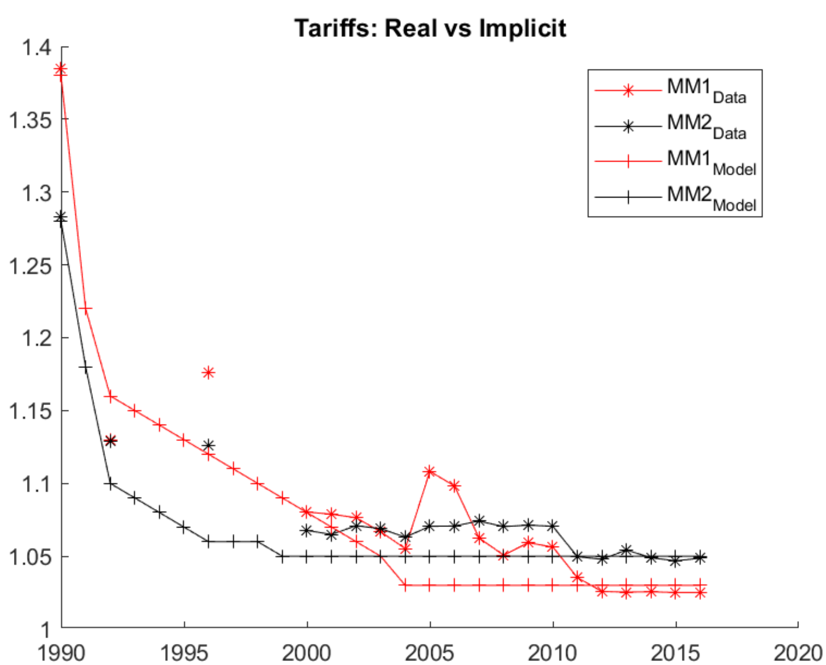

Figure 8: Nominal Tariffs: Model and Data

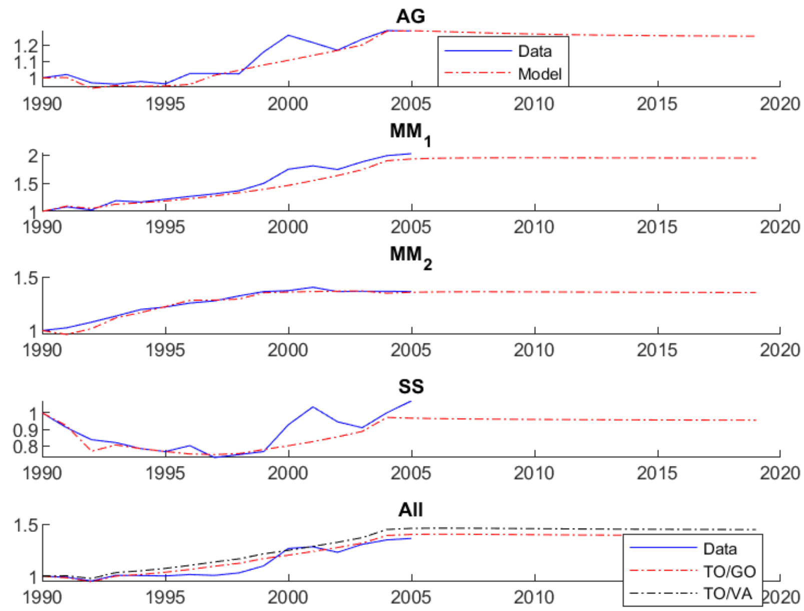

Figure 9: Path of Trade Openness: Model vs Data. Four Sector Model. Heterogeneous Tariffs.

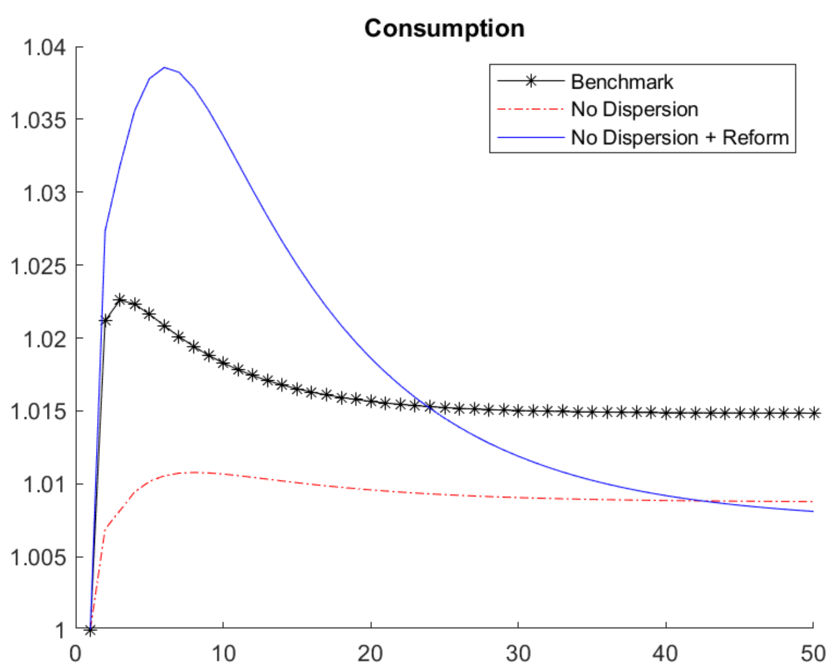

Figure 10: Consumption path for different scenarios relative to the initial steady state.

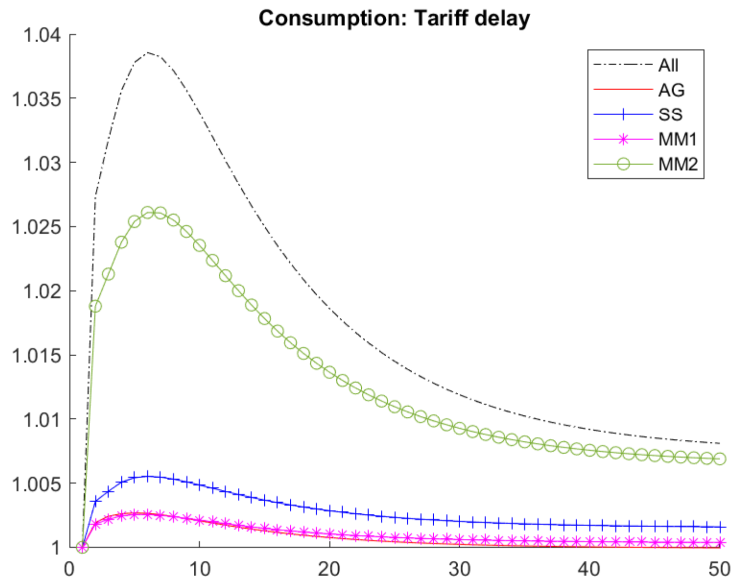

Figure 11: Consumption path. Same sector-tariffs. Liberalizing one sector at a time

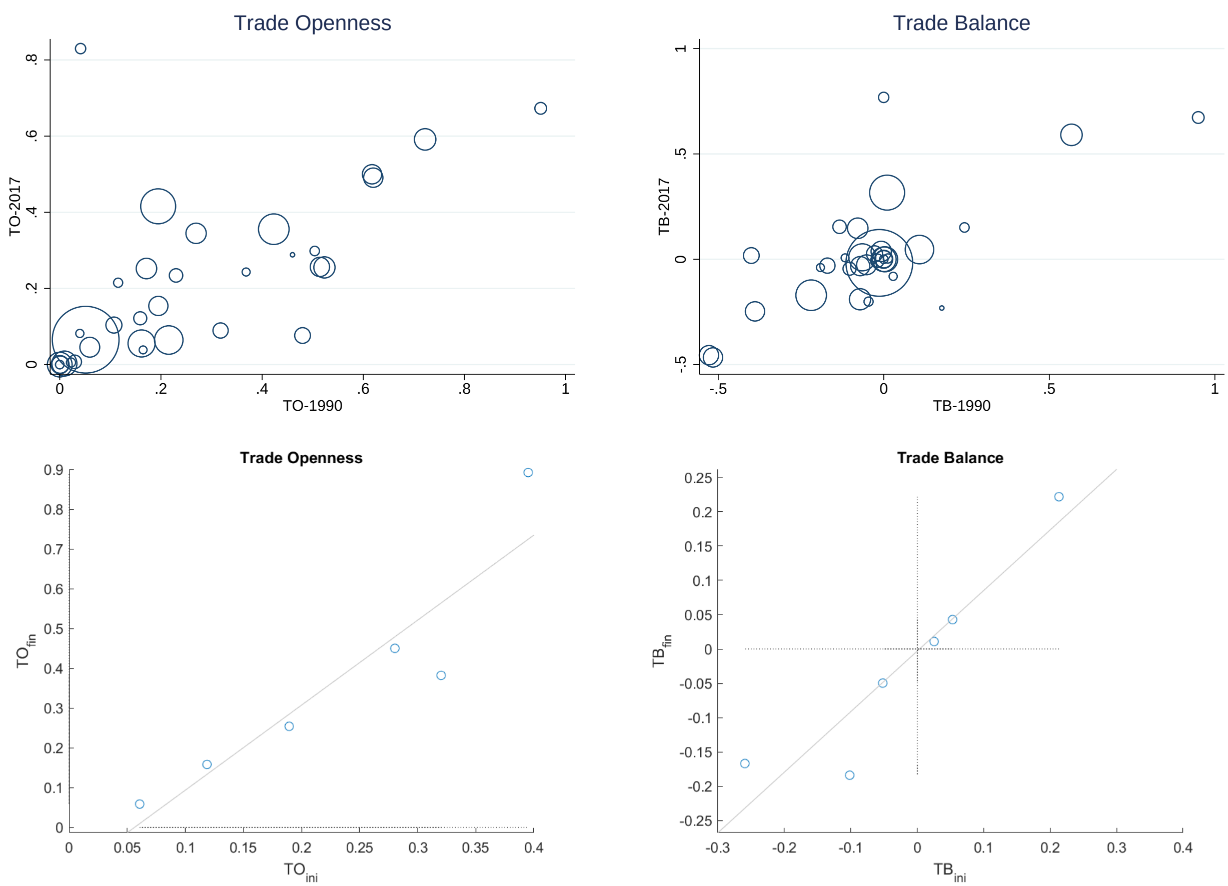

Figure 12: Sector Trade Openness and Trade Balance: Data and Model (1990 vs 2017)

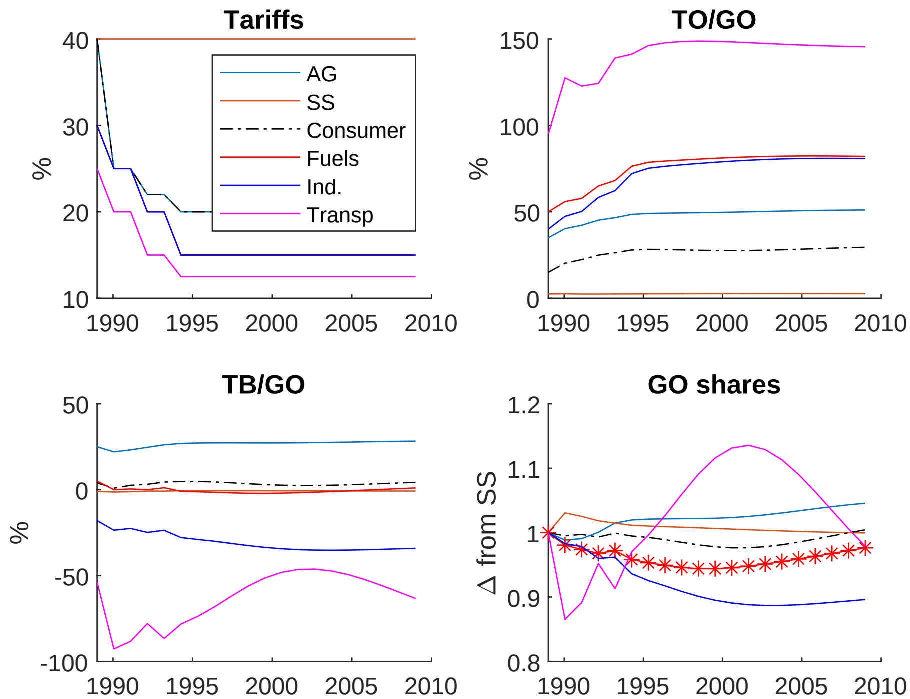

Figure 13: Key Sectors: Model and Data

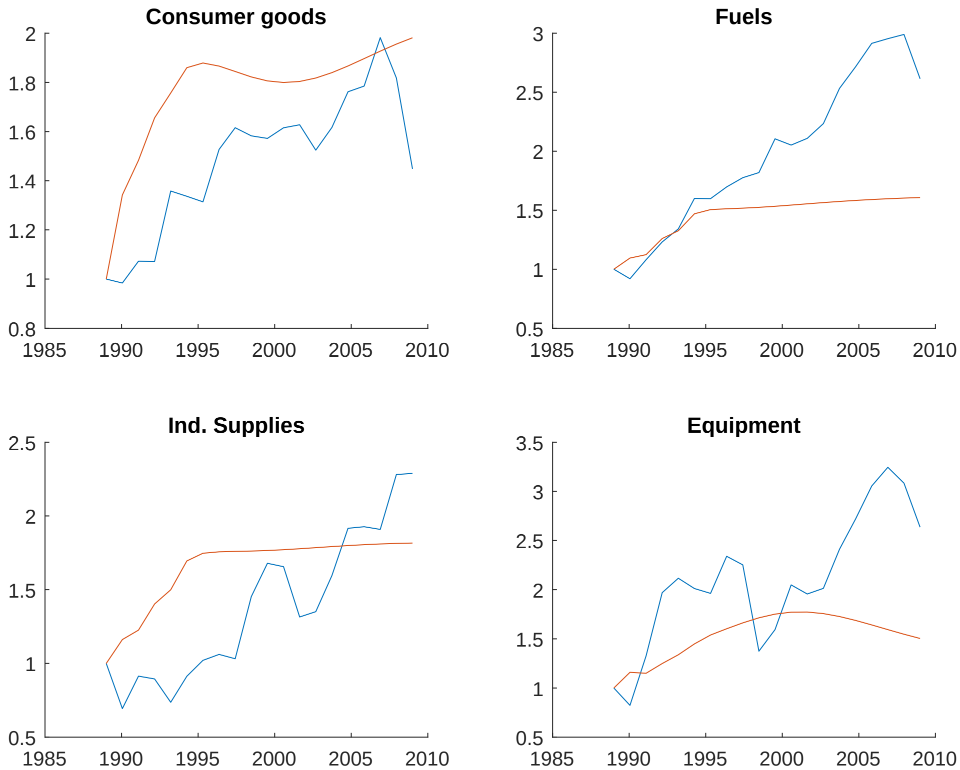

Figure 14: Trade Growth in Key Sectors: Model and Data

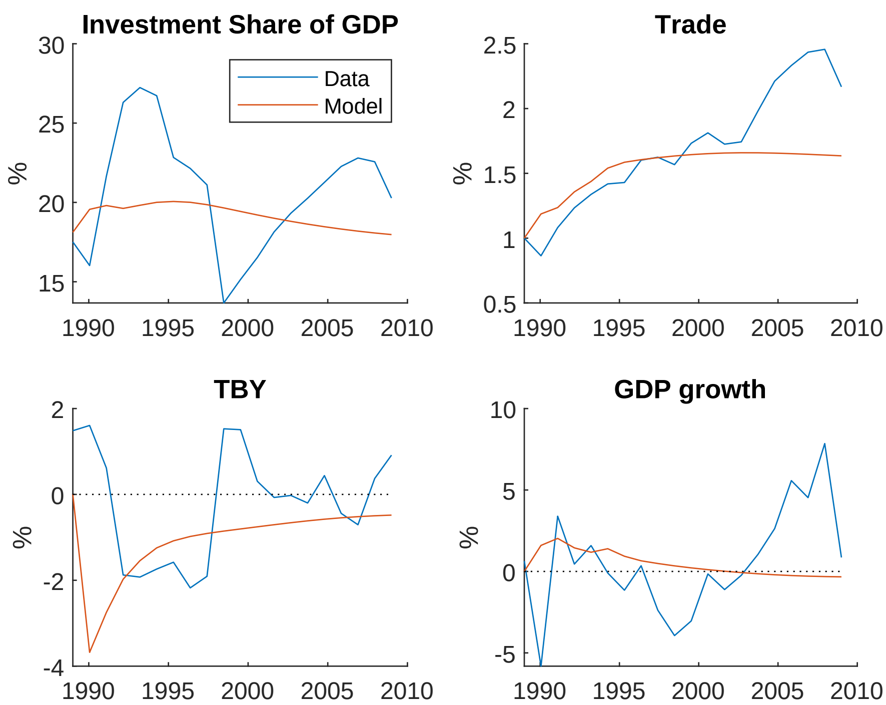

Figure 15: Aggregate Dynamics: Model and Data

C Tables

Table 1: Error Correction Model with extended window

	GDP	Demand
γ	0.199*	0.164**
	(0.0830)	(0.0577)
_cons	-0.170	-0.0890
	(0.101)	(0.0866)
σ_{LR}	-4.538***	-4.532***
	(0.914)	(0.782)
σ_{SR}	-1.510*	-1.491**
	(0.576)	(0.427)
N	27	27
rmse	0.0406	0.0303
r2_a	0.308	0.447

Standard errors in parentheses

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

Parameter	Definition	Value
β	Discount factor	0.96
δ	Capital depreciation	0.1
σ	Elast. of subs. between sectors in final goods	1.01
θ	Elast. of subs. between sectors in materials	1.01
θ_s	Elast. of subs. between domestic and foreign varieties	5.5
η	Parameter Pareto distribution	2
L_H	Size Home	10
L_F	Size Foreign	30
α_s	Capital share (Calibrated)	0.2
μ_s	Labor share (Calibrated)	0.3
n_s	Exogenous exit rate	0.95
$\tau_{H,s}$	Tariffs imposed by home	1.2
$\tau_{F,s}$	Tariffs imposed by foreign	1.15
$a_{L,s} = a_{H,s}$	Markov productivity	1

Table 2: Parameters: Benchmark

$\lambda i, j$	AG	SS	MM1	MM2	Final ω_i
AG	0.38	0.11	0.20	0.31	0.11
SS	0.06	0.49	0.11	0.34	0.44
MM1	0.47	0.06	0.34	0.13	0.34
MM2	0.23	0.10	0.07	0.60	0.11

Table 3: Parameters from Input-Output Tables. Four Sector Model. The first six columns report the sector linkages and the last one the shares for producing final goods.

Parameter	Definition	Value
$\xi^H_{H,AG} = \xi^H_{L,AG}$	Iceberg cost (Home) sector AG	1.22
$\xi^H_{H,SS} = \xi^H_{L,SS}$	Iceberg cost (Home) sector SS	2.32
$\xi^H_{H,MM1} = \xi^H_{L,MM1}$	Iceberg cost (Home) sector MM1	1.40
$\xi^H_{H,MM2} = \xi^H_{L,MM2}$	Iceberg cost (Home) sector MM2	1.45
$\xi^F_{H,AG} = \xi^H_{L,AG}$	Iceberg cost (Foreign) sector AG	1.32
$\xi^F_{H,SS} = \xi^H_{L,SS}$	Iceberg cost (Foreign) sector SS	1.72
$\xi^F_{H,MM1} = \xi^H_{L,MM1}$	Iceberg cost (Foreign) sector MM1	1.36
$\xi^F_{H,MM2} = \xi^H_{L,MM2}$	Iceberg cost (Foreign) sector MM2	1.27
$f_{0,AG}$	Export costs (new) sector AG	2.27
$f_{0,SS}$	Export costs (new) sector SS	0.36
$f_{0,MM1}$	Export costs (new) sector MM1	2.04
$f_{0,MM2}$	Export costs (new) sector MM2	1.28
$f_{1,AG}$	Export costs (old) sector AG	0.84
$f_{1,SS}$	Export costs (old) sector SS	0.40
$f_{1,MM1}$	Export costs (old) sector MM1	0.49
$f_{1,MM2}$	Export costs (old) sector MM2	0.38
$f_{e,s} = f_{p,s}$	Entry and production costs	6.53

Table 4: Parameters: Calibrated (Moment Matching). Four Sector Model

Sector	TB/GO	TO/GO	N_x/N	EX Premium	N_x^{new}/N_x
Initial					
AG	23.5	33.2	18.1	2.28	25
SS	-5.7	6.13	0.1	3.18	99
M1	0.6	15.6	6.8	2.11	24
M2	-24.3	43.8	9.6	1.92	24
Final					
AG	20.3	41.6	28.0	1.79	2.62
SS	0.69	5.84	0.90	4.61	99.5
M1	-3.3	30.4	20.0	1.54	2.97
M2	-24.6	59.1	27.9	1.44	5.24

Table 5: Final Sector Moments in the Model

Sector	Tariff	TB/GO	TO/GO	N_x/N	EX Premium	N_x^{new}/N_x
Initial						
AG	38	23.5	33.2	18.1	2.28	25
SS	-	-5.7	6.13	0.1	3.18	99
M1	38	0.6	15.6	6.8	2.11	24
M2	28	-24.3	43.8	9.6	1.92	24
Final						
AG	3	20.3	41.6	28.0	1.79	2.62
SS	-	0.69	5.84	0.90	4.61	99.5
M1	3	-3.3	30.4	20.0	1.54	2.97
M2	5	-24.6	59.1	27.9	1.44	5.24

Table 6: Sector Tariffs & Moments (Model)

Parameter	Definition	Value
$\xi_H^H = \xi_L^H$	Iceberg cost (Home)	1.88
$\xi_H^F = \xi_L^H$	Iceberg cost (Foreign)	1.88
f_0	Export costs (new)	1.42
f_1	Export costs (old)	0.39
$f_e = f_p$	Entry and production costs	5.28
σ	Elasticity of substitution H & F	3.5

Table 7: Parameters: Calibrated (Moment Matching). One Sector Model with counter factual tariffs.

Scenario	$\Delta\%W$	$\Delta\%SRC$	$\Delta\%LRC$
Benchmark	1.63	2.10	1.47
No Dispersion	0.90	0.69	0.87
No Dispersion + Reform	2.04	2.70	0.73

Table 8: Welfare Gains

Sector	$\Delta\%W$	$\Delta\%SRC$	$\Delta\%LRC$	4 Periods	8 Periods
All	2.04	2.70	0.73		
AG	0.11	0.19	-0.01	91.8%	82.9%
SS	0.31	0.36	0.15	95.6%	87.5%
MM_1	0.13	0.18	0.35	94.2%	85.8%
MM_2	1.46	1.86	0.64	95.9%	87.3%

Table 9: Welfare Gains same sector tariffs. Liberalizing one sector at a time. W stands for Welfare, SRC for Short Run Consumption and LRC for Long Run Consumption. The last two columns report the share of the welfare gain achieved when tariffs are reduced linearly over 4 and 8 years.

Scenario	$\Delta\%W$	$\Delta\%SRC$	$\Delta\%LRC$	$\Delta\%IMShare$
S_3	1.01%	1.50%	0.70%	41.6%
$S_{3,Bond}$	1.04%	2.05%	0.70%	41.6%
$S_{3,NoIO}$	0.84%	1.33%	0.64%	39.8%
$S_{3,Inv}$	1.09%	1.38%	0.97%	41.2%
$S_{BKK,3}$	-0.02%	-0.27%	0.06%	
S_4	1.30%	1.40%	1.28%	40.0%
$S_{4,Bond}$	1.33%	1.98%	1.28%	40.0%
$S_{4,NoIO}$	0.85%	1.44%	0.59%	39.2%
$S_{4,Inv}$	1.23%	1.23%	1.15%	40.3%
S_6	1.33%	1.38%	1.34%	40.0%
$S_{6,Bond}$	1.36%	1.89%	1.34%	40.0%
$S_{6,NoIO}$	1.21%	1.60%	1.04%	40.0%
$S_{6,Inv}$	1.57%	1.45%	1.74%	40.4%
$S_{BKK,6}$	0.10%	-0.20%	0.20%	
S_7	1.36%	1.40%	1.37%	40.3%
$S_{7,Bond}$	1.39%	1.90%	1.37%	40.3%
$S_{7,NoIO}$	1.32%	1.69%	1.17%	39.4%

Table 10: Welfare Gains for Different Scenarios. Tariff drop of 25% in the benchmark case, equivalent to a change in import share of almost 40%. S_i stands for i sectors, W for Welfare, SRC for Short Run Consumption and LRC for Long Run Consumption.

Scenario	$\Delta\%W$	$\Delta\%SRC$	$\Delta\%LRC$	TB_0
τ_{AG}	0.1%	0.13%	0.08%	26%
τ_{MM1}	0.06%	0.08%	0.04%	1%
τ_{MM2}	0.05%	0.07%	0.04%	18%
τ_{MM3}	0.26%	0.27%	0.25%	-8%
τ_{MM4}	0.82%	0.72%	0.89%	-30%

Table 11: Welfare Gains Trade Liberalization Sector by Sector. Tariff drop of 25%. τ_i stands for tariff drop in sector i, W for Welfare, SRC for Short Run Consumption and LRC for Long Run Consumption, and TB_0 for initial trade deficit.