NBER WORKING PAPER SERIES

TRADE INTEGRATION, INDUSTRY REALLOCATION, AND WELFARE IN COLOMBIA

George A. Alessandria
Oscar I. Avila-Montealegre

Working Paper 31378
http://www.nber.org/papers/w31378

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
June 2023

This paper was supported by a grant from the STEG initiative. This a preliminary version of a paper prepared for conference on ”Transformational Recovery: Seizing Opportunities from the Crisis” and the IMF Economic Review. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Trade Integration, Industry Reallocation, and Welfare in Colombia
George A. Alessandria and Oscar I. Avila-Montealegre
NBER Working Paper No. 31378
June 2023
JEL No. F15,F4

ABSTRACT

We study empirically and theoretically the dynamic effects of the unilateral reduction in import tariffs undertaken by Colombia from 1989-1993, with a particular emphasis on the transition and including any anticipation effects. We develop an asymmetric two-country, multi-sector heterogeneous firm model with a dynamic exporting decision, input-output linkages, capital accumulation, and trade in financial assets. The model is calibrated to match Colombian exporter dynamics, sectoral trade openness, tariffs, imbalances, and input-output linkages in the late 1980s. We introduce an anticipated phased out reform into the model and relate the predicted path of sectoral and aggregate activity to the data. Our multi-sector dynamic exporting model predicts much larger gains from these reforms than models that abstract from exporter dynamics, sectoral heterogeneity, trade in financial assets, or capital accumulation. It also captures the key macroeconomic features in terms of a temporary expansion in growth featuring a large, but short-lived investment boom financed by international borrowing, more so when the reforms are expected to be short-lived.

George A. Alessandria
Department of Economics
University of Rochester
Harkness 204
Rochester, NY 14627
and NBER
george.alessandria@rochester.edu

Oscar I. Avila-Montealegre
Banco de la Republica
oscar.avila03@gmail.com

1 Introduction

Since the Great Recession, there has been a decrease in support for trade policy reform and further trade integration, with numerous prospective trade agreements being shelved and existing agreements scaled back. The movement towards deglobalization has gained 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.[1]

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 argue that the gains are larger and more immediate than is found in previous studies.

We study the sectoral and aggregate effects of the change in import tariffs in Colombia from 1989 to 1993, 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, albeit slowly. 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 develop a two-country, multi-sector heterogeneous firm model with exporter dynamics, input-output linkages, capital accumulation, and trade in financial assets to analyze the effects of Colombia's unilateral trade reform. The richness of the model allows us to more closely relate to the sectoral activities and reforms as well as the aggregate dynamics during the transition. 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 model with exporter dynamics than in either static trade models or existing trade models with exporter dynamics and much less sectoral

[1] Alessandria et al. (2021b) and Atkin and Khandelwal (2020) review how trade barriers vary with income.

heterogeneity.[2]

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 phase-out, they gave rise to relatively 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. Importantly, it allows for reductions in imported input tariffs to benefit downstream sectors. The heterogeneity in reforms along with the heterogeneity in sectors expands the gains compared to existing two-sector models.

Our model considers two countries (Colombia and the Rest of the World (ROW)) that differ in size, sector-export technologies, import tariffs, and S sectors that are connected through input-output linkages. Households consume final goods, provide labor inelastically, accumulate sector-specific capital, and invest in firms. They can borrow and save internationally using a non-contingent bond. 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 sector specific materials to produce domestic and foreign intermediates. Within each sector, these firms differ in their productivity levels, iceberg costs, and fixed export costs and make dynamic export decisions as in Roberts and Tybout (1997).

Our benchmark calibration considers two countries and six sectors: agriculture, services, and four manufacturing sectors split between consumption goods, capital equipment, fuels, and industrial supplies. The sectoral detail is chosen to be consistent with easily available

[2]By dynamic trade models we mean models in which trade dynamics are the result of forward looking decision by firms rather than models with capital and static trade decisions. The types of models we consider lead to trade elasticities that vary by the horizon considered.

trade data by the Broad Economic Categories (BEC) classification in the Penn World Tables. The countries differ in size (labor endowment) and export barriers, captured by the iceberg costs, fixed costs, and tariffs, which differ by sector. We calibrate the model to match aggregate, sector, and firm-level moments in manufacturing sectors in Colombia prior to the reform 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 input-output structure allows us to explore how changes in input tariffs affect other industries. The manufacturing census provides a valuable data source for firm and export dynamics and has been used by other authors in the literature.[3]

Our model yields an estimate of the welfare gains from the reforms as well as the source of these gains. We find that the reforms boosted welfare by nearly 5 percent and increased long run consumption by almost 6 percent. About 60 percent of the welfare gain and almost 85 percent of the long-run increase in consumption are related to lower tariffs on capital goods and equipment. While the lower tariffs on imported capital goods and equipment have large but delayed effects on economic activity,[4] we find cuts to tariffs in other sectors were more important for boosting consumption in the early years of the reform. We also find that collapsing our model into a traditional two sector model with highly-tradable goods and less tradable service leads to much smaller estimates of the gains. We attribute these smaller gains to a smaller role for reforms on capital goods in the production in other sectors both through the input-output structure and capital accumulation.

We find that studying the dynamics of export participation, trade reforms and the aggregate economy is crucial for quantifying the benefits of reforms. Regarding exporter dynamics, we find that abstracting from the investment decisions that firms make in export market access leads to smaller and more back-loaded gains. That is, modelling exporters as making a static export decision results in a welfare gain that is less than sixty percent of our benchmark model. Concerning the dynamics of reforms, we find that a longer phase-

[3]See Roberts and Tybout (1997), Eslava et al. (2005), Das et al. (2007), Fernandes (2007), Eslava et al. (2010), Eslava et al. (2013), Mariscal et al. (2017), Brooks and Dovis (2020), Alessandria and Avila (2020) and Kohn et al. (2023).

[4]This is consistent with other trade models with investment such as Baldwin (1992), Alessandria and Choi (2014), Ravikumar et al. (2019), and Brooks and Pujolas (2018).

out reduces the gains from the reform, which is not surprising. Moreover, we observe that the dynamics of the economy, particularly in terms of investment and the trade balance, are strongly influenced by expectations about the speed and duration of the reform. Our benchmark analysis takes the observed path of sectoral tariffs as perfectly credible and only captures a modest share of the investment boom and trade balance reversals. However, when we treat the reform as either non-credible or with a longer but still credible phase-out, our model better captures the dynamics of the trade balance and investment. Specifically, these alternative expectations capture the investment decline and trade surplus in the first year of the reform and rapid reversal in subsequent years. Finally, regarding international borrowing and lending, we find that the ability to borrow and lend greatly enhances the benefits of the reform. Given the very large investment boom and trade deficit in Colombia, we believe this is an important feature for models of trade reform to incorporate.

Our paper relates to a large empirical and quantitative literature studying the effects of changes in trade policy on trade and the aggregate economy. It builds on applied general equilibrium models (see the survey of Kehoe et al. (2017)) by introducing firm exporter dynamics in the spirit of Roberts and Tybout (1997). With Caliendo and Parro (2015) and Ossa (2015), a largely static literature of multi-sector trade models has developed for policy analysis that introduces an extensive margin of trade using the Eaton-Kortum (EK) framework. Recent work has introduced capital accumulation and trade imbalances into EK environment (Ravikumar et al. (2019)), finding larger gains with these two margins. 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), and Baier et al. (2014)) and is closely related to the slow expansion of the extensive margin of exports. Starting with Alessandria and Choi (2007) and Alessandria and Choi (2014), a more nascent literature has developed general equilibrium models of slow trade adjustment from firm-level investments in market access and studied the dynamics responses to aggregate shocks. With the exception Steinberg (2020), this work abstracts from the rich sectoral heterogeneity in trade and trade policy. This prior work also generally focuses on counterfactuals, rather than the type of factual considered here.

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 ROW, as defined above. 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. We also decompose the sources and timing of benefits as relates to the sector tariffs. In section 6 we present the welfare implications of modifying some assumptions of the model, such as the number of sectors, international borrowing, and the input-output structure. Finally, in section 7 we conclude.

2 Background

We begin with a summary of some key aspects of the Colombian economy related to the changes in international trade, trade policy, and the aggregate economy from the mid-80s onward. At the aggregate level, trade grew in a sustained way following a large, relatively sudden unilateral trade liberalization from 1989-92 that lowered average tariffs by almost 20 percentage points and substantially reduced dispersion in tariffs. 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

After hovering around 30 percent of GDP in the 1980s, Colombia's trade share of GDP, measured in real terms as the sum of exports and imports divided by real GDP, grew substantially from 1989 onward (Figure 1).[5] There are several episodes of trade growth, with sharp growth in the first 5 years through 1994, a plateauing from 1994 to 2002 followed by another expansion that ultimately more than doubles real trade as a share of GDP. This growth in trade reflects substantial changes in trade policy, as described by Shome (1995) and Ocampo (2002). There is a substantial change in trade policy from 1989 to 1992 with the trade-weighted import tariff falling from about 22.5 percent to 7.5 percent. This measure

[5] Owing to the large decline in the relative price of goods to services following the reform, the share of trade in real terms is influenced by the base year. For our purposes, we rescale the trade share so that nominal and real trade shares are equal in 1989.

of tariffs understates the extent of the reforms as high tariff and low trade industries had even larger declines in tariffs. These reforms followed a large reduction in non-tariff barriers (see Attanasio et al. (2004) and Alessandria and Avila (2020)). Unlike earlier tariff and licensing reforms in the 70s and 80s, these tariff and licensing reforms were maintained with only slight further reductions in the 2000s and 2010.[6]

A key feature of the reform was that tariffs were originally planned to phase-out gradually between 1990 and 1994. Prior to these tariff cuts, reforms were aimed at replacing an extensive licensing and quota system with substantial exemptions with import tariffs that did not change imports. The next step was a phase-out that was meant to allow for some time to adjust, but this phase-out was accelerated in several steps so that most tariff were lowered by January 1992. Likewise, the government had several import surcharges in place that added up to 18% to imports that were largely removed by the start of 1992. The acceleration of reforms started in earnest with the election of President Gavirra in August 1990 and then in response to macroeconomic environment. Finally, it should be noted that the trade reforms were just one of many reforms that included changes in rules on export subsidies, foreign direct investment, privatization, monetary policy, a new constitution, as well as substantial oil discoveries.

2.2 Sector Reforms

Owing to very different levels of protection, the trade reform from 1989-1993 was quite heterogeneous across sectors. Figure 2 plots the median as well as the 90-th and 10-the percentiles of import tariffs over time using 29 3-digit ISIC manufacturing sectors. 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

[6] Ocampo (2002), Shome (1995), Roberts (1996), Edwards and Steiner (2000), Attanasio et al. (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. In this latter reform, the first stages sought to replace non-tariff measures with import tariffs that were neutral on imports.

median tariff further from 1994 onwards without changing the standard deviation, but are all relatively modest. Since 2000, the median tariff has hovered around 5 percent. These heterogeneous reforms have expanded trade and exporting in an uneven manner across sectors (see Figure 3). 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 our model.

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. These dynamics suggest that the trade elasticity increases with time from the reform, supporting our choice of a dynamic model. Second, the Colombian trade balance shifted quite dramatically from surplus to deficit. Third, growth in GDP per worker accelerated temporarily. And fourth, the investment rate increased substantially. The second through fourth observations change considerably with the 1999 economic crisis.

These four aspects of the evolution of the economy are summarized in the four panels of Figure 4, measured in real and nominal terms with a vertical line in 1989 to denote the start of the reforms. 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 of GDP and then fell sharply. The total swing was about 10 percentage points and these large trade deficits were very similar each year 1993 to 1998, before a large reversal in 1999. 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 6-7 percentage points and then falling back in 1996. A key aim of our analysis will be to relate the trade reforms to the dynamics of these fours series.

3 Model

We now develop a two-country multi-sector model with heterogeneous firms in each sector making dynamic exporting decisions. The model extends the two-sector heterogeneous firm dynamic exporting model of Alessandria and Choi (2014) along several dimensions. Specifically, we allow for asymmetric economies, multiple tradable sectors, input-output linkages, and asymmetric trade policies. In each sector, there are many heterogeneous producers entering, growing, starting and stopping to export, and exiting. We follow Alessandria et al. (2021a) and allow for a flexible exporting technology that captures the tendency of new exporters to export on a small scale through the accumulation of a better export distribution technology. 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 (Colombia and the ROW) and S sectors. Households consume final goods, provide labor inelastically, make the sector-specific investment decisions and borrow and lend internationally. Their income comes from labor, capital rents, profits, bonds, and tariff revenue. We assume trade is balanced in the initial steady state but allow for international borrowing and lending during the transition. We follow Schmitt-Grohe and Uribe (2003) by introducing adjustment costs on bonds to ensure net foreign assets are stationary.[7]

Consumption, investment, and materials are produced using a bundle of locally produced sector specific goods. The technologies for producing consumption, investment, and materials are different and markets for these bundles are perfectly competitive. In each sector, the sector specific bundle is made with a combination of imperfectly substitutable domestic and foreign goods produced by heterogeneous firms active in that sector. Foreign goods incur an ad valorem tariff that is collected by the local government and rebated lump sum to consumers. There are a range of fixed and variable costs of trade that lead the set of

[7]These adjustment costs ensure that net foreign assets in the new steady state are the same across all experiments, which facilitates the comparison across static and dynamic models. We chose these adjustment costs to have small effects on the welfare gains and provide sensitivity. They also simplify the computation.

products available in each country to differ and change over time. Heterogeneous firms use capital, labor, and materials to produce intermediates that are sold at home or exported. Within each sector, firms differ in their productivity levels, fixed export costs, and iceberg costs. Between sectors, firms also differ in their fixed production and entry costs.

3.1 Households

Households in each country i maximize the present value of utility by choosing, consumption ($C_{i,t}$), sector capital ($K^s_{i,t+1}$), and bonds ($B_{i,t}$). Bonds are non-contingent discount bonds, where the discount price is q_t, denominated in units of consumption goods from country b, P^b_t, which could be Colombia or the ROW. They supply labor inelastically (L^i), own the firms producing locally, and get the tariff revenue from the government. Bonds and capital are subject to quadratic adjustment costs. There are two types of adjustment costs on bonds. The first is on the change in bonds and the second is on the deviation from a country-specific long-run asset holdings ($B_{i,ss}$). The former help to discipline the short run dynamics of the trade balance while the latter ensure stationarity. Capital adjustment costs, together with habit formation in the utility function help us to replicate better the dynamics of consumption and investment in the short run. All of these features are relatively standard in international macroeconomic models.

The Household in country i solves the following standard problem:

$$Max_{\{C_{i,t},K^s_{i,t+1},B_{i,t}\}^{\infty}_{t=0}} \quad E_t \sum_{t=0}^{\infty} \beta^t U(C_{i,t}, C_{i,t-1})$$

s.t.

$$P^c_{i,t}C_{i,t} + \sum_s P^{K,s}_{i,t} I^s_{i,t} + q_t P^b_t B_{i,t} + \frac{\phi_b}{2}(B_{i,t} - B_{i,ss})^2 + \frac{\phi_{bb}}{2}(B_{i,t} - B_{i,t-1})^2$$

$$= W_{i,t}L_{i,t} + \sum_s R^s_{i,t}K^s_{i,t} + \Pi_{i,t} + T_{i,t} + P^b_t B_{i,t-1}$$

where the utility function is $U(C_{i,t}, C_{i,t-1}) = \frac{(C_{i,t}-\phi_c C_{i,t-1})^{1-\sigma}-1}{(1-\sigma)}$ and allows for habit in consumption. The law of motion for capital in sector s is given by

$$K^s_{i,t+1} = (1-\delta)K^s_{i,t} + I^s_{i,t} - \frac{\phi_k}{2}\left(K^s_{i,t+1} - K^s_{i,t}\right)^2 \tag{1}$$

which includes a quadratic adjustment cost and the depreciation rate, δ.

3.2 Production of consumption, 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 is perfectly competitive and is profit maximizing. As these decisions are static, we omit the time subscript to simplify the notation. 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

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

where $X_i^{c,s}$ is the quantity of the intermediate s used to produce the consumption good, $\omega^{c,s}$ is the weight on the composite bundle from sector s, and θ_c is the elasticity of substitution across sector bundles in consumption. From the FOC we obtain the demand for intermediates as a function of sector prices, $X_i^{c,s} = \omega_i^{c,s}\left(P_i^s\right)^{-\theta_c}\left(P_i^c\right)^{\theta_c - 1} D_i^c$, 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 $P_i^c = \left(\sum_s \omega_i^{c,s}(P_i^s)^{1-\theta_c}\right)^{\frac{1}{1-\theta_c}}$. Similar problems are solved for sector-specific investment and materials, with parameters $\{\omega_i^{K,s}, \theta_K\}$, and $\{\omega_i^{M,s,s'}, \theta_M\}$.

The total demand for intermediates from sector s is given by

$$X_i^s = X_i^{c,s} + \sum_{s'} X_i^{K,s} + \sum_{s'} X_i^{M,s,s'}.$$

where, $X_i^{K,s}$ is demand of inputs from sector s to produce investment and $X_i^{M,s,s'}$ are the sector-specific demands of inputs from sector s to produce materials in sector s'.

3.2.1 Production of sector intermediate goods

Intermediate producers in sector s combine domestic and foreign differentiated inputs from that sector to produce a bundle of intermediate goods, X_i^s using a CES aggregator, as in equation 2. Firms are perfectly competitive and maximize profits. Demand for domestic and foreign heterogeneous inputs depend on firm characteristics, such as productivity levels, a (idiosyncratic), past export status, ex, and production location. Imports of foreign inputs incur an advalorem tariff, $\tau_{i,j}^s > 1$, that is sector- and country-pair-specific. For completeness, we define $\tau_{i,j}^s = 1$. The optimization problem of X_i^s producers is given by:

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

subject to

$$X_i^s = \left(\sum_j (\omega_{i,j}^s)^{\frac{1}{\theta_s}} N_{ex,j}^s \sum_{ex} \int \left(Y_{i,j}^s(a, ex)\right)^{\frac{\theta_s - 1}{\theta_s}} \phi(a) da \right)^{\frac{\theta_s}{\theta_s - 1}}. \tag{2}$$

where $\omega_{i,j}^s$ denotes the taste for country j products in country i in sector s and θ_s is the elasticity of substitution across varieties. $Y_{i,j}^s(a, ex)$ denotes the use in economy i of the s-specific input a produced in economy j with export status ex.

At the start of each period a firm is in one of two possible exporter states, 'no exporter', or 'old exporter.' The mass of firms of each type are denoted by $N_{ex,i}^s$ and it is assumed that the productivity shocks are iid, which allows us to only need to keep track of past export status. Based on the decisions of the firms within the period some firms will become new exporters and others will stop exporting. Foreign firms that do not pay an export cost in this period face an infinite shipping cost and thus have prices that are prohibitive. From the FOC we obtain the demand in country i for inputs from each producer in country j

$$Y_{i,j}^s(a, ex) = \omega_{i,j}^s (\tau_{i,j}^s P_{i,i}^s(a, ex))^{-\theta_s} (P_i^s)^{\theta_s - 1} D_i^s, \tag{3}$$

where $D_i^s = P_i^s X_i^s$is total spending in sectory s in country i, and the sector prices are

$$P_i^s = \left[\sum_j \omega_{i,j}^s \sum_{ex} N_{ex,j}^s \int (\tau_{i,j}^s P_{i,j}^s(a, ex))^{1-\theta_s} \phi(a) da \right]^{\frac{1}{1-\theta_s}}. \quad (4)$$

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 firm value subject to their demand from home and abroad. Within a sector, producers differ in productivity, fixed export costs, and iceberg costs. To simplify notation, we present the problem of producers in the stationary steady steady state.

There are two sources of exogenous heterogeneity in firms. First, firm are heterogeneous in productivity owing to an independently distributed (iid) shock, a, with marginal distribution $\phi(a)$. Second, there is an exogenous survival shock such that firm's survive into the next period with an exogenous probability n_i. Firms pay a fixed production cost, $f_{i,p}^s$, to remain active each period. Firms are created by paying a fixed entry cost, $f_{i,e}^s$, and then are randomly assigned to a sector in the following period. All fixed costs are expressed in labor units.

We follow Alessandria et al. (2021a) in modelling export trade frictions as a combination of fixed and variable costs that have an investment component. Each firm is characterized by a fixed export cost, $f_{i,x}^s$, and an iceberg cost, ξ_i^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_i^s, that can take one of three values. If the firm does not export $\xi_i^s = \infty$; otherwise, if the firm exports for the first time its iceberg cost is high, $\xi_{i,H}^s$, if it survives and exports again, it pays a lower iceberg costs, $\xi_{i,L}^s$. 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, productivity a, past export decision ex, and current export decision ex' is given by:

$$\pi_i^s(a, ex, ex') = Max_{P_{i,i}^s, P_{j,i}^s, k_i^s, l_i^s, m_i^s} \quad P_{i,i}^s Y_{i,i}^s + ex' P_{j,i}^s Y_{j,i}^s - W^i l_i^s - R^i k_i^s - P_i^{M,s} m_i^s$$

$$s.t. \quad Y_i^s = (a)^{\frac{1}{\theta_s - 1}} (k_i^s)^{\alpha_i^s} (l_i^s)^{\mu_i^s} (m_i^s)^{1-\alpha_i^s-\mu_i^s} \tag{5}$$

$$Y_i^s = Y_{i,i}^s + ex' \xi_i^s Y_{j,i}^s \tag{6}$$

$$Y_{i,i}^s = \omega_{i,j}^s (\tau_{i,j}^s P_{i,i}^s)^{-\theta_s} (P_i^s)^{\theta_s - 1} D_i^s \tag{7}$$

$$Y_{j,i}^s = \omega_{j,i}^s (\tau_s^j P_{j,i}^s)^{-\theta_s} (P_j^s)^{\theta_s - 1} D_j^s \tag{8}$$

Y_s^i is the production of a heterogeneous firm in country i and sector s; k_i^s, l_i^s, m_i^s 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, $Y_{i,i}^s, Y_{j,i}^s$, as in equation 6. Notice that to deliver $Y_{j,i}^s$ units of input abroad, the firm needs to produce $\xi_i^s Y_{j,i}^s$ units. From the F.O.C and the monopolistic competition structure, we have the prices for each destination as a markup over the marginal cost of producing: $P_{i,i}^s = \frac{\theta_s}{\theta_s - 1} MC_i^s (a)^{\frac{1}{1-\theta_s}}$, $P_{j,i}^s = \frac{\theta_s}{\theta_s - 1} \xi_i^s MC_i^s (a)^{\frac{1}{1-\theta_s}}$, where $MC_i^s = \left(\frac{R_i}{\alpha_i^s}\right)^{\alpha_i^s} \left(\frac{W_i}{\mu_i^s}\right)^{\mu_i^s} \left(\frac{P_i^{M,s}}{1-\alpha_i^s-\mu_i^s}\right)^{1-\alpha_i^s-\mu_i^s}$.

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:

$$\pi_i^s(a, ex, ex') = \Pi_{i,0}^s(a) \left[(P_i^s)^{\theta_s - 1} D_i^s + ex'(\xi_i^s(ex))^{1-\theta_s} (\tau_j^s)^{-\theta_s} (P_j^s)^{\theta_s - 1} D_j^s \right] \tag{9}$$

where $\Pi_{i,0}^s(a) = \frac{a}{\theta_s} \left(\frac{\theta_s}{\theta_s - 1} MC_i^s \right)^{1-\theta_s}$.

Assuming that the marginal producer does not export, the productivity threshold for a producer is given by $a_{i,p}^s = \frac{W_i f_{i,p}^s}{\Pi_{i,0}^s (P_i^s)^{\theta_s - 1} D_i^s}$. *Ceteris Paribus*, higher fixed production costs increase the productivity threshold. To find the thresholds for the marginal exporters, first define the value of an active producer:

$$V_i^s(a, ex) = \max_{ex'} \pi_i^s(a, ex, ex') - W_i f_{i,p}^s - ex' W_i f_{i,ex}^s + n_i Q_i E V_i^s(a', ex') \tag{10}$$

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. This is a discrete choice decision and marginal exporters are indifferent between exporting or not, which means the following conditions hold:

$$V_i^s(a_{i,ex}^s, ex; ex' = 1) = V_i^s(a_{i,ex}^s, ex; ex' = 0) \tag{11}$$

where we equate the value of exporting with the value of not exporting and $a_{i,ex}^s$ is the productivity threshold for an exporter with past export status ex. Replacing equation 10 into equation 11, gives us the following conditions for the marginal exporters:

$$W_i f_{i,0}^s = \sum_{j \neq i} \frac{\Pi_{i,0}^s a_{i,0}^s (\xi_{i,j,0}^s)^{1-\theta_s} D_j^s}{(\tau_{j,i}^s)^{\theta_s} (P_j^s)^{1-\theta_s} \omega_{j,i}^s} + n_i Q_i \left(E V_i^s(1) - E V_i^s(\infty) \right). \tag{12}$$

Similarly,

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

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 10 over different values for the iceberg costs. The mathematical appendix includes a detailed description of this procedure.

Free entry and masses of firms Firms are created by paying a fixed cost in units of labor. 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:

$$W_i f_{i,e} = Q_i \sum_s \frac{EV_i^s(\infty)}{S}. \tag{13}$$

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

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, we assume that there is no initial external borrowing ($B_{i,ss} = 0$). Along the transition, we allow borrowing and lending subject to our adjustment costs, with bonds being in net zero supply, $B_{COL,t} + B_{ROW,t} = 0$. We denominate the bonds in the consumption price of Colombia.

4 Calibration

We assume that the world economy is populated by two countries that primarily differ by size, measured by population, production costs, exporting technologies, and import tariffs. The smaller economy is matched to Colombia, while the rest of the world (ROW) represents a nearly closed economy with low levels of trade and export participation.[8] For simplicity, we assume that in the initial steady state the countries are in financial autarky, meaning that total exports and imports are the same. The structure of adjustment costs on bonds leads the economies to end up with no net borrowing in the final steady state, however, during the transition they can run trade deficits or surpluses. We limit the differences in input-output parameters across countries while still being consistent with gross and net sectoral trade flows. Each economy has six sectors: agriculture, services, and four manufacturing sectors: consumer goods, fuels, industry supplies, and capital equipment. This sectoral mix aligns with the Broad Economic Categories (BEC) classification system.[9] This level of sectoral detail is chosen as the Penn World Tables (PWT) makes this detail of trade data easily accessible. We explore the effects of 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 1. 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 and are reported in Table 2. The last group of parameters includes the values that are targeted to match sector moments from Colombia, these parameters include the iceberg costs $(\xi^s_{i,0}, \xi^s_{i,1})$, fixed costs $(f^s_{i,0}, f^s_{i,1}, f^s_{i,p})$, and home bias (ω^s_i), and are presented in panels a and b of Table 3.

The first set of parameters are largely standard and assumed to be the same in both countries. We set the period of the model to one year. We choose the discount factor, β, to

[8] Mix (2023) shows a rest of the world with many heterogeneous countries and firms making separate destination-specific dynamic export decisions can be well approximated with a single rest of the world when considering own or global reforms.

[9] Owing to the similarity in the pattern of trade and tariffs, we combine the capital and transport categories into one sector.

yield a four percent interest rate. The depreciation rate of capital is set to equal 10 percent. Using the PWT we find that between 1980 to 1989 Colombia accounts for 0.67% of World's GDP, to replicate that share we use the population gap in the model and find Colombia has 1/15th the population of the ROW.[10] In practice, Colombia is a much smaller share of the world population, but our model contains large scale effects as in Ramondo et al. (2016). In the appendix, we show that Colombia's country size has a small effect on the gains.

The transition is influenced by several parameters. Specifically, the adjustment cost on capital, ϕ_k and bonds (ϕ_b, ϕ_{bb}) and preferences parameters (σ, ϕ_c) matter. For preferences we set $\sigma = 2$ and habit to $\phi_c = 0.75$, consistent with Justiniano et al. (2010). Normally, one would choose the adjustment cost parameters to match business cycle fluctuations. As our model is not well-suited to these types of simulations we choose the parameters to allow some ability to be consistent with the dynamics of investment and the trade balance following the change in trade policy.

We assume that the heterogeneous firms have the same production function $\{\alpha, \mu\}$, although they use different bundles of materials. We assume the productivity distribution is the same in each sector and is Pareto, with slope $\eta = 2.5$, within the range of estimates. We set the capital share of production $\alpha = 0.31$ to generate an investment share of GDP of 20 percent as in Colombia in the period leading up to the reform. The labor share in production, $\mu = 0.24$, is set so that the ratio of gross output to value added is 1.8 as in Colombia.

The elasticity of substitution across domestic and foreign varieties is set to $\theta^s = 3.0$. We maintain a common elasticity of substitution in each sector to avoid issues related to aggregation of heterogeneous elasticities that are well-known from Ossa (2015). The monopolistic power generates positive profits, therefore the factor shares are not exactly equal to the implied coefficients of the Cobb-Douglas production function. Moreover, as fixed costs in production and exporting are in labor units, our labor share of income is much higher than one would expect owing to the production function, and is about 63.4 percent. The share of income from capital and profits is 33.5 percent, while tariff revenue is equal to 3.1 percent.

[10] In the model population and technology gaps map into GDP differences. We focus on the former as the main drivers, and normalize sectoral productivity to 1.

The survival rate of firms is set to $n = 0.90$. For the benchmark economy we assume that the technologies for producing final goods and materials are close to Cobb-Douglas but allow some substitution, meaning that the elasticities between sectors are, $\theta_C = \theta_K = \theta_M = 1.1$. The results do not change significantly if we lower those elasticities to 1, as is common in most applied work. This assumption implies that for the second set of parameters we can use directly the Input-Output data for the sector shares for producing consumption goods, $\omega^{C,s}$, capital goods, $\omega^{K,s}$, and materials, $\omega^{M,s,s'}$.

For the third set of parameters, we consider 1990 as our benchmark year. For the manufacturing sectors we use the official tariffs reported by Garay et al. (1998) for the early 90s and from customs for the most recent period, Figure 5. We do not have information of tariffs for agriculture and services. For the former we assume the same tariffs as for manufactured consumption goods, while for the latter we consider that tariffs are 0% and they do not change over time. Panel e of Table 3 reports the initial and final tariffs we put into the model, and Figure 5 plots the paths for these series.

For the the trade barriers, production costs, and tastes in Colombia, we target sector values in Colombia. Specifically, by sector we target 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 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.[11] 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 at the firm level for agriculture and services, we assume that agriculture behaves similarly to the manufacturing consumer's goods sector, while for

[11] 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)

services we assume that a small fraction of firms within the sector make all the exports (big firms), and have a high exporter premium. In appendix D.1 we consider an additional case in which a large fraction of firms export, but each firm exports a smaller share of sales. In both cases, we guarantee that sectoral trade is consistent with the data. We do not model services as a non-tradable since according to the 1990 Input-Output tables reported by DANE, sector trade openness was around 4%, while the share of services exports over total exports was 7% and the share of imports was 14%.

For the rest of the world, we don't have firm participation data to Colombia. Instead, we assume the ratio of export entry costs to continuation costs and the two iceberg costs are consistent with the estimates from Alessandria et al. (2021a). With these assumptions, we then solve a symmetric version of the economy assuming home bias is common across goods and set to ω=0.90. We then vary the six sectoral parameters and country size to match Colombia's sectoral and relative size (as discussed previously).

The calibrated parameters for Colombia are reported in the panel a. of Table 3, while the initial and final sector moments from the model are reported in panels c and d, 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 by solving for the steady state values in the model. In 1990, Colombia runs a big trade surplus in agriculture, that is offset by a trade deficits in industrial supplies, and capital equipment, the other manufacturing sectors show small trade surpluses, while services show a deficit. The fixed and iceberg costs for the ROW economy are in panel b of Table 3.

A couple of things are worth mentioning from the calibration results. First, variable and fixed trading costs are higher in Colombia than in the ROW. To match the observed moments, the model requires big costs for Colombia that offsets the effects of the foreign demand from the ROW. Second, the iceberg and fixed exporting costs for services are quite high 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 the trade balance.

Given the general equilibrium structure of the model it is not possible to identify one particular moment with a given parameter, however, from the calibration results we observe that some parameters are more correlated with specific moments. For instance, home bias is inversely related to the trade balance, while fixed export costs for old exporters are negatively related to export participation.

5 Quantitative Results

We now examine the effects of the unilateral tariff reform on sectoral and aggregate economic activity. First, we describe the benchmark trade liberalization which includes the observed tariff changes during the early 1990s, and then we consider some alternative scenarios in which we modify the trade reform in terms of sector and timing.

Specifically, we assume the economy is in steady state at the start of 1990 and then the government introduces a fully credible, surprise gradual decline in import tariffs (a phase-out) at the start of the year that matches the path of tariffs in that it takes three years for tariffs to reach their long-run level. We solve for the transition of the economy and study the dynamics following the reform to highlight the effects from the trade reforms and abstract from other subsequent reforms and shocks, internal and external. Our aim is not to explain the data fully, but rather to relate the effects of a unilateral trade reform in a multi-sector model with rich sectoral linkages and exporter dynamics to the data.

We first compare the predictions of the model to the change in industry activity. Then we consider the aggregate implications. We then perform some counterfactuals to decompose the welfare gains in the model by the changes in tariff dispersion, average tariffs, and sectoral tariffs. We show that there is a small benefit to tariff harmonization. We also show that the main gains come from liberalizing the capital equipment sector, although these are back-loaded. We then consider alternative timings of the reforms to show, not surprisingly that faster reforms lead to larger welfare gains. While the gains from different timing of trade reforms that eventually change tariffs permanently are not too different, the path of investment and the trade balance can be strongly influenced by the path, announced or expected. These non-credible reforms yield swings in the trade balance and investment that are more pronounced than our benchmark and more consistent with the data.

5.1 Full Trade Reform

The trade reform is consistent with the dynamics of sectoral trade as well as the salient macroeconomic features described earlier. Panel a of Figure 6 plots the heterogeneous reform across sectors that we feed into the model. Panel b plots the sectoral path of trade openness. Panel c plots the sectoral trade balance as a share of sector gross output. Sectoral trade balances do change somewhat, particularly for the capital 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 sectors fall in importance, although the capital equipment sector has some non-linear dynamics in the model. Figures 7 and 8 show that the model is somewhat consistent with the growth in sectoral trade openness and the dynamics of sectoral trade balance. Perhaps the largest discrepancy is in the trade balance in services which is predicted to move to surplus but remains in deficit.

From Panels c and d of Table 3 we can compare the long run changes in sectoral activity. The tariff cuts lead to an increase in trade across sectors, showing some asymmetries in the quantitative response. Trade in consumption goods and capital equipment increases more than 80%, while trade in agriculture jumps around 30%. In terms of trade imbalances, the trade balance widens for agriculture, fuels, industrial materials, and especially for capital equipment. For manufactured consumption goods the trade balance goes from surplus to deficit (the tariff cut makes imports cheaper). Trade expansion comes in hand with an increase in export participation in all sectors, and a reduction in the size of new exporters. The tariff cut makes it more difficult to produce at home, which moves up the productivity threshold for active producers. Given that the economy ends up with more productive firms, a higher share of them export to the rest of the world.

Figure 9 shows the model generates macroeconomic features that are consistent qualitatively with data, although some magnitudes are off. Panel a shows there is a temporary decline in the investment share of GDP in the first year of the reform as households expect the price of capital to fall in the future, followed by a substantial expansion that falls short of the boom in the data. Trade as a share of GDP gradually expands at a slightly faster rate than the path of the data, and matches the aggregate trade up to the early 2000s. Further liberalizations and trade agreements, and changes in technology, may explain the behavior after that. Panel c, shows that the reform leads to a small trade surplus initially that is reversed, just as in the data. As the investment boom is smaller than the data, the trade deficit is also smaller. Panel d shows that there is a short run boost in economic growth, measured as real GDP per worker. We create real variables in the model keeping the prices constant from the base year (initial steady state).

The trade reform leads to a welfare gain[12] of 4.68 percent and a long-run increase in consumption of 5.62 percent (first row of Table 4). Figure 10 plots the dynamics of consumption in the black line for our main experiment and some alternative reforms. During the transition, owing to the habit in consumption and the importance of capital accumulation, consumption grows more gradually than in other dynamic exporting models, which tend to be characterized by an over-shooting of consumption.

5.2 Alternative Reforms Across Industries and Time

Now we use the model to answer some questions regarding how tariffs influence the aggregate economy. In particular, we would like to know 1) which sectors contribute the most to the welfare gain? and at what horizon? 2) what are the welfare effects of reducing tariff heterogeneity? and 3) what are the welfare effects of altering the timing and credibility of the trade reform?

Sector-by-sector reforms: The welfare gains from liberalizing one sector at a time are reported in panel a of Table 4. Figure 11 plots the counterfactual paths of consumption for each reform. In terms of the contribution, about two-thirds of the welfare gains (2.99% vs 4.68%) are from reducing import tariffs on capital equipment, which is the sector with the highest initial trade deficit and has the overall most elastic final demand. Owing to the

[12]The welfare gain is measured by the compensating differential that yields the same present value of utility as the reform.

nature of capital accumulation though, the benefits of these reforms are more back-loaded as they contribute relatively more to long-run consumption (84 percent: 4.72% vs 5.62%). Indeed, over the first five years of the transition the combined reforms in industrial supplies and consumption goods increase consumption by about twice as much as those in capital equipment. The second most important reforms are to industrial supplies. These reforms account for about one-quarter of the welfare gain and they are more front-loaded, as they increase welfare by more than the long-run contribution to consumption (1.16% vs 0.99%). The cut to import tariffs on consumer goods are even more front-loaded, boosting welfare by 0.38 percent but actually reducing long-run consumption by about -0.30 percent. The cuts in import tariffs in agriculture add 0.16 percent to welfare but only boost long-run consumption by 0.02 percent. The overshooting of consumption from non-capital tariff reforms is familiar from most dynamic trade models (see Alessandria and Choi (2014)).

Tariff Harmonization: A key focus of the trade reform was to reduce tariff heterogeneity and so we next consider the effect of harmonizing tariffs. We start from the observed sector-tariffs and we eliminate tariff-heterogeneity (in all sectors) such that tariff revenue remains the same, which implies that tariffs increase for capital equipment and fuels, and drop for the rest. Eliminating tariff heterogeneity has a small positive effect on welfare, increasing overall welfare by about 0.05 percent. The benefits are front-loaded, since consumption falls about 0.21 percent in the new steady state, as reported in Panel c of Table 4. 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, albeit small effect on welfare.

We also explore the effects of homogenizing final tariffs at a level consistent with the long-run change in tariff revenue as a share of imports. The welfare gains are bigger, since the new tariff revenue drops, but not as big as our benchmark (4.14% vs 4.68%). The long-run effect on consumption is smaller though (3.24% vs 5.62%), which we attribute to the smaller cuts on capital equipment relative to the benchmark.

Trade Policy Dynamics: Owing to the uncertainty of trade reforms in Colombian history and in this episode, we analyze the effects of different tariff paths and expectations for the transition of the economy. In particular, we consider three additional cases: (i) delaying the tariff change over six years (instead of three as in the base case); (ii) an accelerated reform in which the government has the same path in the first year but then goes to the long-run change in the second year; and (iii) a non-credible reform that is expected to last three years and then be reversed. This latter case is meant to capture the history of temporary reforms in Colombia. Alessandria and Mix (2021) show that expectations of future changes in trade policy can have important effects on the aggregate economy, particularly when trade is intensive in capital goods. Note the change in tariffs in the first year is the same across all cases.

We focus on the dynamic effects of these reforms on several macroeconomic aggregates. Figure 10 plots tariff revenue, consumption, investment, and the trade balance for our benchmark and these three alternative reforms, while Panel b of Table 4 summarizes the welfare effects and changes in steady state consumption, which is the same in baseline and our first three scenarios with permanent reforms owing to the adjustment costs on bonds.

The primary effect of changing the path of the permanent tariff reforms is on the response of investment and the trade balance. Relative to our baseline, phasing in the reform over a longer window reduces welfare by almost 20 percent while accelerating the reform increases welfare by about 13 percent. There is a much larger effect on short run macroeconomic dynamics though. With a longer phase-out, investment falls initially and the country runs a larger trade surplus. When the reform picks up, there is a larger swing in investment and the trade balance. Indeed the trade balance swings from a three percent surplus to three percent deficit. With a faster phase-out of the reform, investment picks up immediately and the trade balance goes directly into deficit.

Given the long history of trade reforms that proved temporary in Colombia and Latin America in general,[13] we consider a temporary reform. Our temporary reform matches the path of tariffs from our benchmark and then reverts to initial levels in year 5 forever. With a temporary reform there is a smaller consumption response and much smaller welfare gain that is about one-third of our baseline scenario. With the temporary reform there is a much

[13] Rebelo and Vegh (1995) describe the effects of non-credible policies on the dynamics of the trade balance and consumption in Latin America.

larger response in investment and the trade balance as households take advantage of the temporary low prices of these inputs. Indeed, in the second year of the reform investment is almost 80 percent above the initial steady state, compared to only 25 percent when the reform is credible. Likewise, the trade deficit is almost 8 percent compared to 3.5 percent in the baseline and is more inline with the data. When the reform ends, investment plunges and there is a substantial reversal of the trade balance.

6 Sensitivity

We now explore the aggregate implications of some of the model's key assumptions. First, we consider some changes that only affect the transition, namely our modelling of habit in consumption and the costs of international capital flows. Second, we consider changes to the technology that also have long-run effects, such as the number of sectors, the input-output structure, the composition of investment and exporter dynamics. The welfare results are reported in Panel d of Table 4 and the path of some cases are plotted in Figure 12 and 13.

6.1 Transitions

The path of the economy, particularly early in the reform, is most affected by the change in the cost of borrowing internationally rather than the habit parameter. Allowing for easier international capital flows brings the model more inline with observed investment and trade balance dynamics and boosts the welfare gains while eliminating international capital flows lowers the welfare gains. Reducing habit leads to different consumption dynamics very early in the reform but dampens investment growth.

International Capital Flows: The swings in the trade balance around the trade reform suggest that international borrowing and lending were an important margin of adjustment to the reform. We now examine the dynamic impact of either i) eliminating cross border capital flows by shutting down the ability to borrow or lend internationally or ii) making it easier to borrow and lend by reducing the interest spread that Colombia incurs when its assets deviate from their steady state target. Under the first scenario, which we denote *No Bond*, the economy cannot run a trade deficit during the transition and the welfare gains are reduced by 22 percent (3.65% vs 4.68%), as it takes longer to build up the capital stock and consumption is constrained. Indeed, consumption is 1-2 percentage points lower on average in the first 15 years of the reform without access to international capital flows.

In the second case, denoted Low Bond adjustment costs or *Low BAC*, we make cross border capital flows less costly and this increases the welfare gain by 17.5 percent (5.50% vs 4.68%). Consumption even overshoots its long-run level. These dynamics are accomplished through larger swings in the trade balance that are used for more investment early in the reform, which bring the model more inline with the observed swings in investment and the trade balance. Owing to the different paths of investment, these two scenarios lead to slightly different paths of openness, with the *No Bond* economy having a slower expansion initially.

No Habit: We now examine the role of the utility function for the transition of our economy. Specifically, we set the habit share to half of our benchmark level, $\phi_c = 0.375$. With less habit, in a case we denote *Low Habit*, there is a stronger initial response of consumption as consumption jumps almost two percent on impact when the reform is announced and is above our benchmark path of consumption initially. This is reflected by a small initial trade deficit followed by a similar path to our baseline, which leads to a slightly smaller expansion of investment.

6.2 Technology

We now consider some changes in the model structure that also change the steady state. Our main goal is to explore how bringing more sectoral detail and exporter dynamics into the analysis of the reforms influences our estimates of the gains from the policy changes. These alternative models are parameterized in a similar way to our benchmark (see table 5). We find that the welfare gains are larger when we model more sectors and include exporter dynamics. By revisiting the reforms through models with alternative technologies for producing inputs and capital, we attribute the larger gains of the model with more sectoral detail to the extra heterogeneity it allows in production structures.

Sectors: We now consider a two sector model that divides the economy into services and goods. These two sectors are distinct by their openness and comparative advantage. In this case, denoted *Two Sectors*, we collapse our five non-service sectors into one. The goods producing sector runs an initial trade deficit, and the tariff cut is concentrated in that sector. Compared to our benchmark, the welfare gains from cutting tariffs are much smaller (0.93% vs 4.68%), as are the changes in steady state consumption (-0.29% vs 5.62%). We attribute the smaller gains with fewer sectors to the increased heterogeneity in the benchmark six sector model. This heterogeneity shows up in several places: sector firm dynamics and tastes, tariff heterogeneity, and the technology for producing inputs, both in terms of the aggregators for consumption and investment and the sector material inputs.

Input-output structure: We now show that reducing the heterogeneity in the source of sectoral material inputs has a relatively minor effect relative to our benchmark case, reducing the effects of the reforms by about 10 percent. Specifically, we consider a modification in the input-output structure of the six-sector model with a roundabout matrix for materials. That is, each sector is assumed to use inputs in upstream sectors in the same proportion. We also adjust trade flows to be consistent with our benchmark. This input-output structure is quite similar to our two sector model. This simpler formulation, denoted *No IO*, has a modest effect on the welfare gain and long-run response of consumption, investment, and trade. Moreover, it yields qualitatively similar dynamics in the first few periods of the reform.

Capital Aggregator: We now show that changing the way inputs are used in the investment aggregator greatly reduces the estimated gains from the reform and yields a model with more similar dynamics to our two sector model. Specifically, we consider a common aggregator for consumption and investment with $\omega_s^C = \omega_s^I$. This case yields a path of the economy that is closest to the two sector model, which had a quite similar aggregator for consumption and investment. Similar to Brooks and Pujolas (2018), Ravikumar et al. (2019), and, Conesa et al. (2021), we find the welfare gains to a cut in trade barriers are smaller but much less back-loaded than when trade is more intensive in capital goods - the long-run change in consumption is only 20 percent of our benchmark (1.13% vs 5.62%), while the welfare gain is about 37 percent of our benchmark (1.73% vs 4.68%). This case suggests it is most important to model how imported goods are used in investment rather than in production.

Static Model: Finally, we examine the role of exporter dynamics for the transition and long-run effects of the reform in our economy. Specifically, we consider a variation of our model with a static export decision in which the fixed and variable costs of exporting are constant over a firm's export experience. We recalibrate this model, which we denote *Static*, to match the export participation and export sales in each sector and then put through the same tariff reforms. To be consistent with the approach in the literature we also eliminate international capital flows. The only dynamic decision is then on capital accumulation.

The static exporting model leads to an estimate of the welfare gain that is only about 55 percent of what we find in our benchmark model (2.62% vs 4.68%), even if the long run change in consumption is almost 75 percent (4.07% vs 5.62%).[14] The static model also yields a smaller long-run response of trade and investment.[15] From Figure 14, we see that the transition in the trade share of GDP is faster, as all the dynamics reflect the phase-out and the variation in the investment share. Without exporter dynamics, there is no longer an incentive to defer investment in the early stages of the reform while export capacity is built. While the trade response is faster, consumption now expands slower and monotonically to the new steady state as more of the gains can be attributed to capital deepening aspects.

7 Conclusions

We develop a two-country, multi-sector heterogeneous firm dynamic exporting model with input-output linkages, capital accumulation, trade in financial assets and asymmetric countries. The model fills the gap between the multi-sector static trade models and the two sector heterogeneous firm dynamic exporting models. Our framework is easily applied to any country with minimal data requirements. It allows us to consider the transition from heterogeneous reforms in trade policy across heterogeneous sectors and over time.

We use the model to revisit the effects of the unilateral trade policy reforms in Colombia in the early 1990s, acknowledging that these reforms were just one of many coincident

[14]The larger gap between welfare gains and long-run consumption response of reforms between static and dynamic exporting models has been noted in previous work.

[15]These responses could be increased by making home and foreign varieties more substitutable, but this would involve changing several additional macroeconomic parameters on the production function making the comparison a little less straightforward.

reforms. We estimate that these trade reforms increased welfare by about 4.5 to 5.5 percent. The trade reforms also generated a short run investment boom financed through international borrowing. We show that models that abstract from firm-level exporter dynamics or use fewer sectors may yield smaller welfare gains.

Our framework allows us to decompose the welfare gains accruing from reforms in specific sectors and access to foreign borrowing and lending. We find that cuts on import tariffs in capital equipment had the largest benefits, but that a sizeable share of these gains are back-loaded. Reforms in other sectors were more important for consumption growth initially. We also find that being able to borrow internationally increased the welfare gains and led to stronger consumption growth initially.

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 an accurate production and investment structure 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.

Our finding of large movements in the trade balance and investment from trade reforms is consistent with a nascent literature on the interaction between gross and net trade flows. Changes in trade barriers may be an important factor to consider in macroeconomic stabilization. Indeed, we find that the amount of investment and international capital flows depend strongly on expectations about the path of reforms. There may be a need to revisit the interaction of trade policy with financial integration to fully capture the benefits of either types of policies. Furthermore, the macroeconomic dynamics of the initial stages of a reform may feed into the ultimate persistence of the reform. We hope our findings about the rich interplay between trade reforms, macroeconomic dynamics, and expectations will encourage more work along these lines.

References

Alessandria, G. and Avila, O. (2020). Trade integration in colombia: A dynamic general equilibrium study with new exporter dynamics. *Journal of Economic Dynamics and Control*, page 103871.

Alessandria, G. and Choi, H. (2007). Do sunk costs of exporting matter for net export dynamics? *The Quarterly Journal of Economics*, 122(1):289–336.

Alessandria, G. and Choi, H. (2014). Establishment heterogeneity, exporter dynamics, and the effects of trade liberalization. *Journal of International Economics*, 94(2):207–223.

Alessandria, G., Choi, H., and Ruhl, K. J. (2021a). Trade adjustment dynamics and the welfare gains from trade. *Journal of International Economics*, 131:103458.

Alessandria, G. A., Johnson, R. C., and Yi, K.-M. (2021b). Perspectives on trade and structural transformation. Working Paper 28720, National Bureau of Economic Research.

Alessandria, G. A. and Mix, C. B. (2021). Trade policy is real news: Theory and evidence. Working Paper 28904, National Bureau of Economic Research.

Atkin, D. and Khandelwal, A. K. (2020). How distortions alter the impacts of international trade in developing countries. *Annual Review of Economics*, 12(1):213–238.

Attanasio, O., Goldberg, P. K., and Pavcnik, N. (2004). Trade reforms and wage inequality in Colombia. *Journal of Development Economics*, 74(2):331–366.

Baier, S. L. and Bergstrand, J. H. (2007). Do free trade agreements actually increase members' international trade? *Journal of international Economics*, 71(1):72–95.

Baier, S. L., Bergstrand, J. H., and Feng, M. (2014). Economic integration agreements and the margins of international trade. *Journal of International Economics*, 93(2):339–350.

Baldwin, R. E. (1992). Measurable dynamic gains from trade. *Journal of Political Economy*, 100(1):162–174.

Brooks, W. and Dovis, A. (2020). Credit market frictions and trade liberalizations. *Journal of Monetary Economics*, 111:32–47.

Brooks, W. and Pujolas, P. (2018). Capital accumulation and the welfare gains from trade. *Economic Theory*, 66(2):491–523.

Caliendo, L. and Parro, F. (2015). Estimates of the trade and welfare effects of nafta. *The Review of Economic Studies*, 82(1):1–44.

Conesa, J. C., Delventhal, M. J., Pujolàs, P. S., and Raveendranathan, G. (2021). The cost of trade disruptions at different stages of development.

Das, S., Roberts, M. J., and Tybout, J. R. (2007). Market entry costs, producer heterogeneity, and export dynamics. *Econometrica*, 75(3):837–873.

Edwards, S. and Steiner, R. (2000). On the crisis hypothesis of economic reform: Colombia 1989-91. *Cuadernos de Economía*, 37(112):445–493.

Eslava, M., Haltiwanger, J., Kugler, A., and Kugler, M. (2005). Plant survival, market fundamentals and trade liberalization. *Recuperado el*, 21.

Eslava, M., Haltiwanger, J., Kugler, A., and Kugler, M. (2010). Trade liberalization and worker displacement: Evidence from trade reforms in colombia. Technical report, Mimeo.

Eslava, M., Haltiwanger, J., Kugler, A., and Kugler, M. (2013). Trade and market selection: Evidence from manufacturing plants in colombia. *Review of Economic Dynamics*, 16(1):135–158.

Fernandes, A. (2007). Trade policy, trade volumes and plant-level productivity in colombian manufacturing industries. *Journal of International Economics*, 71(1):52–71.

Garay, L. J. et al. (1998). Colombia: Estructura industrial e internacionalización. *DNP-Colciencias, Consejería Económica y de Competitividad, Ministerio de Comercio Exterior, Ministerio de Hacienda, Santafé de Bogotá*.

Justiniano, A., Primiceri, G. E., and Tambalotti, A. (2010). Investment shocks and business cycles. *Journal of Monetary Economics*, 57(2):132–145.

Kehoe, T. J., Pujolàs, P. S., and Rossbach, J. (2017). Quantitative trade models: Developments and challenges. *Annual Review of Economics*, 9(1):295–325.

Kohn, D., Leibovici, F., and Szkup, M. (2023). No credit, no gain: Trade liberalization dynamics,production inputs, and financial development. *International Economic Review*, 71(1):52–71.

Mariscal, A., Lu, D., et al. (2017). How firms accumulate inputs: Evidence from import switching. In *2017 Meeting Papers*, number 263. Society for Economic Dynamics.

Mix, C. (2023). The dynamic effects of multilateral trade policy with export churning. *International Economic Review*.

Ocampo, J. A. (2002). Trade policy and industrialization in colombia, 1967–91. In *Trade policy and industrialization in turbulent times*, pages 150–187. Routledge.

Ossa, R. (2015). Why trade matters after all. *Journal of International Economics*, 97(2):266–277.

Ramondo, N., Rodríguez-Clare, A., and Saborío-Rodríguez, M. (2016). Trade, domestic frictions, and scale effects. *American Economic Review*, 106(10):3159–84.

Ravikumar, B., Santacreu, A. M., and Sposi, M. (2019). Capital accumulation and dynamic gains from trade. *Journal of International Economics*, 119(C):93–110.

Rebelo, S. and Vegh, C. A. V. (1995). Real effects of exchange-rate-based stabilization: An analysis of competing theories. *NBER Macroeconomics Annual 1995, Volume 10*, 71(1):125–188.

Roberts, M. J. (1996). Colombia, 1977–1985: Producer turnover, margins and trade exposure. In Roberts, M. J. and Tybout, J. R., editors, *Industrial Evolution in Developing Countries: Micro Patterns of Turnover, Productivity, and Market Structure*, chapter 10, pages 227–259. Oxford University Press, Oxford.

Roberts, M. J. and Tybout, J. R. (1997). The decision to export in colombia: An empirical model of entry with sunk costs. *The American Economic Review*, pages 545–564.

Schmitt-Grohe, S. and Uribe, M. (2003). Closing small open economy models. *Journal of International Economics*, 61(1):163–185.

Shome, P. (1995). Comprehensive tax reform: the colombian experience. In *Comprehensive Tax Reform*. International monetary fund.

Steinberg, J. B. (2020). The macroeconomic Impact of NAFTA Termination. *Canadian Journal of Economics*, 53(2):821–865.

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

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

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

$$n^iQ^iEV^{s,i}(a_z^{s,i},\infty,0)\Bigg(\rho_\xi^{s,i}(1-n_{H,1,z}^{s,i})+(1-\rho_\xi^{s,i})(1-n_{L,z}^{s,i})\Bigg)-$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B Tables

Table 1: Parameters: Benchmark

Parameter	Definition	Value
β	Discount factor	0.96
σ	Risk Aversion	2.0
ϕ_c	Habit formation	0.75
δ_s	Capital depreciation	0.1
ϕ_b	Bond adjustment cost (wrt. Steady State)	0.1
ϕ_{bb}	Bond adjustment cost (t-1)	0.20
ϕ_k	Investment adjustment cost	0.04
θ_C	Elast. of subs. between sectors in consumption goods	1.1
θ_K	Elast. of subs. between sectors in investment goods	1.1
θ_M	Elast. of subs. between sectors in materials	1.1
θ_s	Elast. of subs. between domestic and foreign varieties	3.0
η	Parameter Pareto distribution	2.5
L_H	Size Home	10
L_F	Size Foreign	150
α_s	Capital share	0.31
μ_s	Labor share	0.24
n	Exogenous survival rate	0.90
$\tau_{F,s}$	Tariffs imposed by foreign	1.40
a_s	Productivity	1
f_e	Fixed entry cost	0.4167

Table 2: Parameters from Input-Output Tables. Six-sector Model.

$\omega^{M,s,s'}$	AG	SS	MM_{Cons}	MM_{Fuels}	MM_{Ind}	MM_{Cap}	$\omega^{C,s}$	$\omega^{K,s}$
AG	0.38	0.11	0.20	0.02	0.24	0.05	0.11	0.04
SS	0.06	0.49	0.11	0.08	0.22	0.04	0.45	0.52
MM_{Cons}	0.47	0.06	0.34	0.02	0.10	0.01	0.33	0.0
MM_{Fuels}	0.33	0.08	0.07	0.02	0.48	0.02	0.01	0.0
MM_{Ind}	0.22	0.12	0.07	0.04	0.51	0.04	0.07	0.02
MM_{Cap}	0.03	0.11	0.05	0.04	0.38	0.39	0.03	0.42

Note: The first six columns report the sector linkages and the last one the shares for producing final goods (consumption and investment). AG stands for agriculture; SS for services; and MM for manufacturing industries. Within manufacturing $Cons$ corresponds to consumption; $Fuels$ to fuels, Ind to industrial products, and Cap to capital equipment.

Table 3: Calibrated Parameters, Targeted Moments, and Final Moments for Colombia (new steady state). Six Sector Model (Benchmark).

Parameter	AG	SS	MM_{Cons}	MM_{Fuels}	MM_{Ind}	MM_{Cap}
a. Parameters Colombia Targeted						
ξ_0	8.55	40.41	9.44	12.53	11.65	29.91
ξ_1	2.30	4.77	3.13	3.07	2.78	6.67
f_0	0.12	0.13	0.07	0.01	0.04	0.01
f_1	0.28	0.37	0.13	0.02	0.09	0.01
f_p	0.59	3.79	1.05	0.03	0.69	0.63
ω^s	0.43	0.52	0.59	0.27	0.59	0.50
b. Parameters Rest of the World						
ξ_0	5.69	9.03	4.17	3.70	2.76	2.61
ξ_1	4.95	7.85	3.63	3.22	2.40	2.27
f_0	0.06	0.17	0.06	0.02	0.07	0.09
f_1	0.04	0.12	0.04	0.01	0.05	0.06
f_p	5.76	41.87	3.07	0.67	1.67	1.74
ω^s	0.99	0.99	0.99	0.99	0.99	0.99
c. Targeted Moments Colombia						
TB/GO	0.25	-0.01	0.04	0.06	-0.2	-0.74*
TO/GO	0.30	0.04	0.14	0.57	0.41	0.8*
N_x/N	0.20	0.02	0.18	0.35	0.12	0.12
EX^{prem}	3.0	3.5	2.5	2.0	3.8	4.0
N_x^{new}/N_x	0.30	0.38	0.32	0.20	0.30	0.35
EX^{new}/EX	0.075	0.05	0.12	0.035	0.075	0.075
d. Final Moments Colombia (Model)						
TB/GO	0.32	0.00	-0.04	0.28	-0.20	-1.18
TO/GO	0.43	0.05	0.24	0.68	0.91	2.05
N_x/N	0.32	0.04	0.19	0.75	0.44	0.92
EX^{prem}	2.79	3.60	2.63	1.65	4.12	5.87
N_x^{new}/N_x	0.23	0.34	0.31	0.08	0.14	0.06
EX^{new}/EX	0.05	0.04	0.12	0.01	0.02	0.01
e. Tariffs Colombia						
Initial	1.30	1.00	1.35	1.10	1.25	1.25
Final	1.175	1.00	1.175	1.10	1.10	1.05

Note: * Trade balance for MM_{Cap} is a non targeted moment and it is a result from imposing balanced trade in the initial steady state. N_x/N stands for the share of firms that exports; EX^{prem} corresponds to the exporter premium (average sales of exporters relative to average sales of non-exporters); N_x^{new}/N_x is the share of new exporters; and EX^{new}/EX is the share of exports by new exporters. Also, AG stands for agriculture; SS for services; and MM for manufacturing industries. Within manufacturing $Cons$ corresponds to consumption; $Fuels$ to fuels, Ind to industrial products, and Cap to capital equipment.

Table 4: Changes in Welfare and Steady State Consumption for Alternative Reforms or Models

Scenario	$C_{fin}/C_0 - 1$	$\Delta\%W$
Benchmark	5.62	4.68
a. Sector by Sector Benchmark		
AG	0.02	0.16
MM_{Cons}	-0.30	0.38
MM_{Ind}	0.99	1.16
MM_{Cap}	4.72	2.99
b. Paths for Tariffs		
Delaying	5.62	3.75
Accelerating	5.62	5.29
Transitory	0	1.50
c. Homogenizing Tariffs		
Final Tariffs	3.24	3.54
Initial Tariffs	-0.21	0.05
d. Sensitivity		
No Bond	5.62	3.65
Low Bond Adjustment Costs	5.62	5.50
Low Habit	5.62	4.13
Two Sectors	-0.29	0.93
No IO	5.12	4.22
Common Aggregator	1.13	1.73
Static	4.07	2.62

Note: Changes in welfare are calculated as the compensating differential of consumption in the initial steady state that would yield the same change in the present value of utility from the new path of utility with the new tariffs. The first column describes the scenario, the second column is the changes between steady states, and column three is the overall welfare changes.

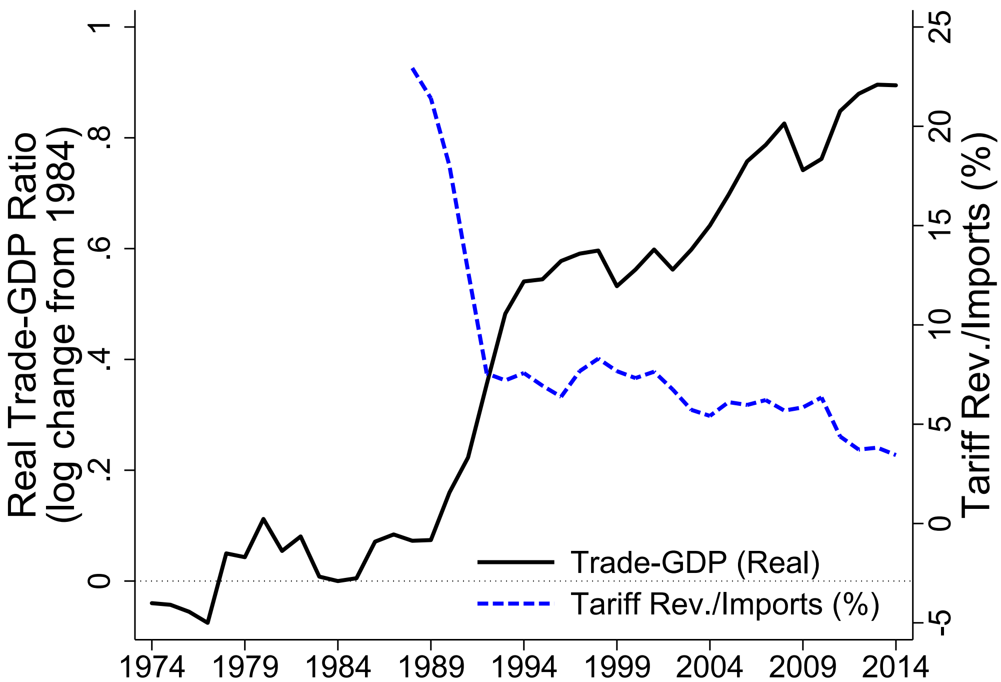
Table 5: Calibrated Parameters Colombia. Alternative Scenarios.

Parameter	AG	SS	MM_{Cons}	MM_{Fuels}	MM_{Ind}	MM_{Cap}
a. No IO						
ξ_0	10.44	44.09	10.62	10.41	13.66	9.55
ξ_1	2.81	5.21	3.52	2.55	3.26	2.13
f_0	0.08	0.10	0.06	0.02	0.03	0.07
f_1	0.19	0.29	0.11	0.05	0.06	0.17
f_p	0.56	3.82	1.08	0.09	0.62	0.64
ω^s	0.43	0.55	0.60	0.44	0.57	0.50
b. Common Aggregator						
ξ_0	9.06	41.62	9.89	12.59	11.79	10.30
ξ_1	2.44	4.92	3.28	3.09	2.82	2.30
f_0	0.10	0.12	0.06	0.01	0.04	0.05
f_1	0.24	0.34	0.12	0.02	0.08	0.12
f_p	0.60	3.88	1.02	0.03	0.74	0.56
ω^s	0.44	0.54	0.59	0.30	0.61	0.50
$\omega^C = \omega^K$	0.09	0.46	0.25	0.01	0.06	0.13
c. Static						
$\xi_0 = \xi_1$	7.95	26.34	11.01	9.33	10.59	31.38
$f_0 = f_1$	0.17	0.17	0.08	0.01	0.05	0.01
f_p	1.54	61.85	2.82	0.05	2.80	2.26
ω^s	0.37	0.75	0.53	0.20	0.60	0.50

Note: AG stands for agriculture; SS for services; and MM for manufacturing industries. Within manufacturing *Cons* corresponds to consumption; *Fuels* to fuels, *Ind* to industrial products, and *Cap* to capital equipment. For scenarios *No IO* and *Common Aggregator* the parameters for the rest of the world are the same as in benchmark, for the *Static* case $\xi_0 = \xi_1$ and $f_0 = f_1$, where ξ_0 and f_0 are equal to the benchmark case.

C Figures

Figure 1: Change in Trade Openness and Tariffs



Note: Source Ocampo (2002) and DANE.

Figure 2: Sectoral Tariff Dynamics

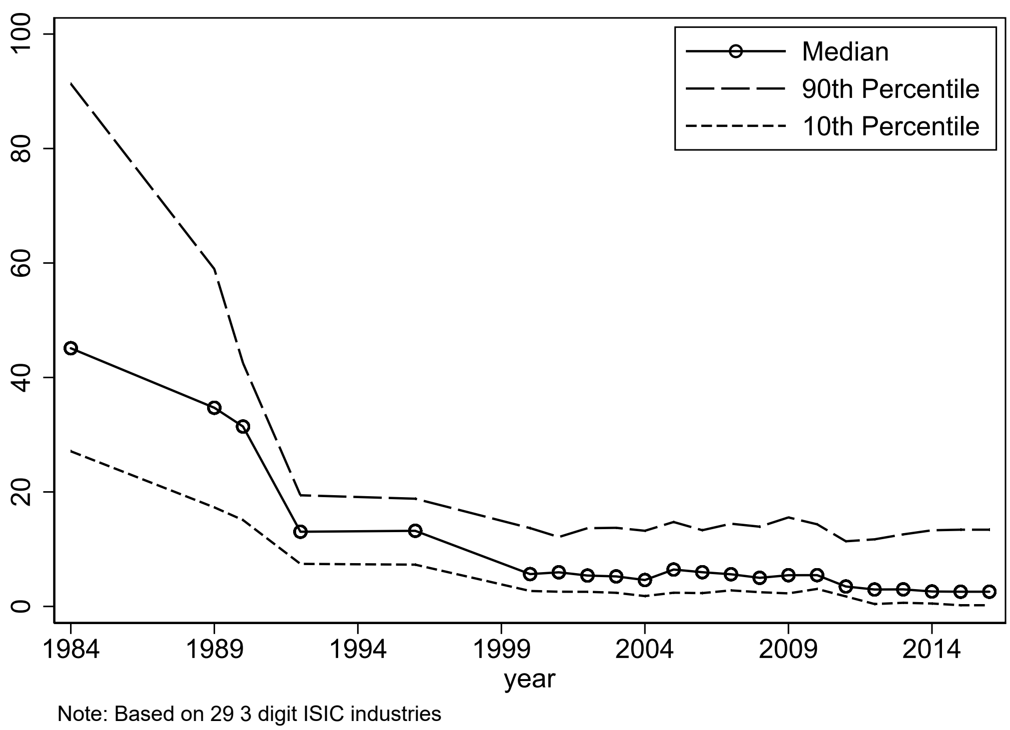
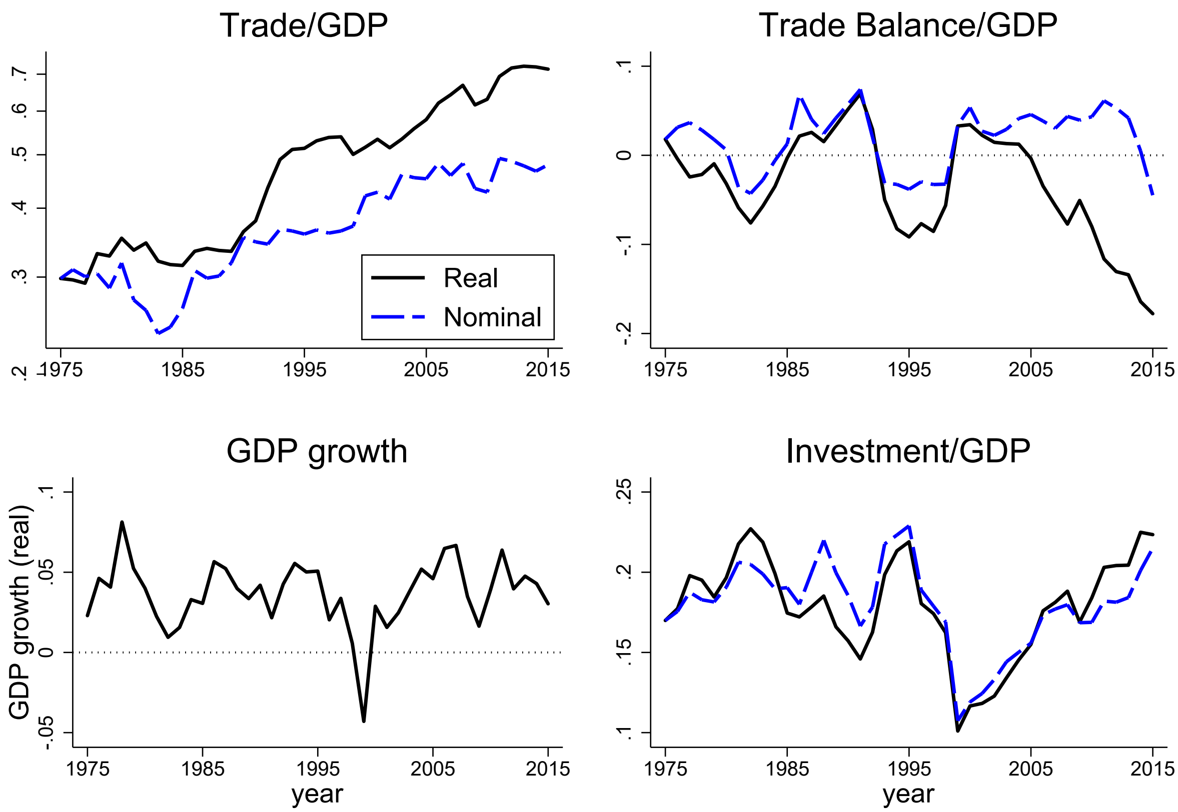


Figure 3: Change in Trade Openness, Export Participation and Tariffs

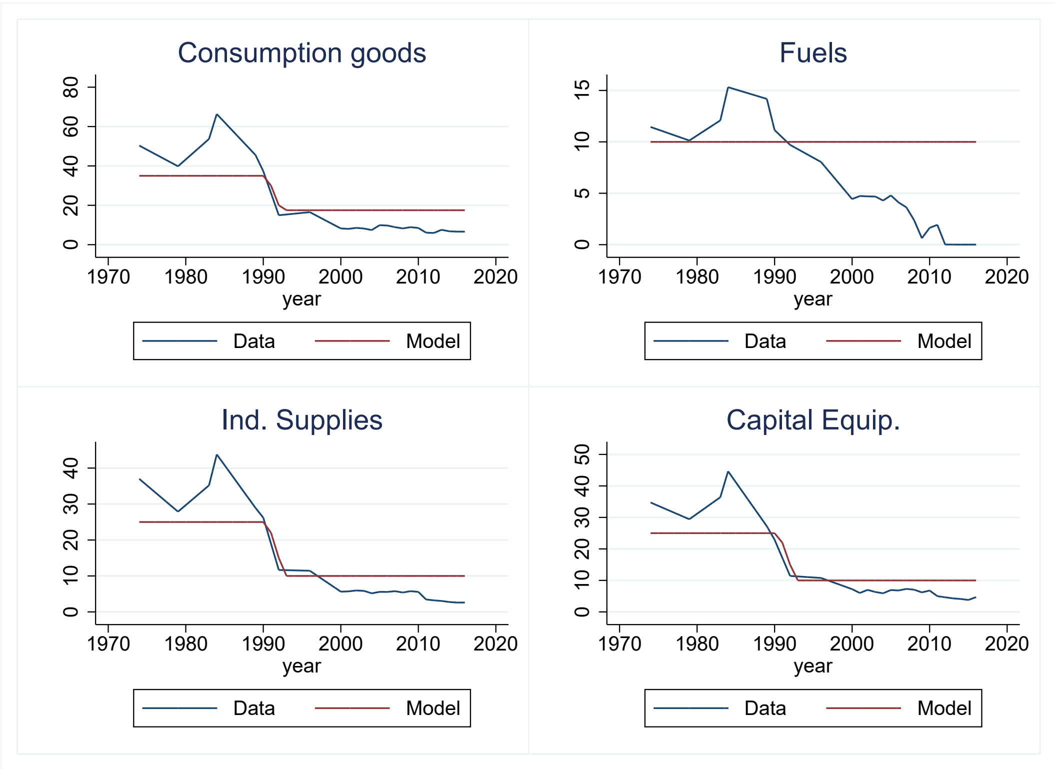
Note: The x-axis values correspond to different sectors. The red line denotes the initial levels. Source: National Statistics Department of Colombia (DANE).

Figure 4: Macro dynamics in Colombia



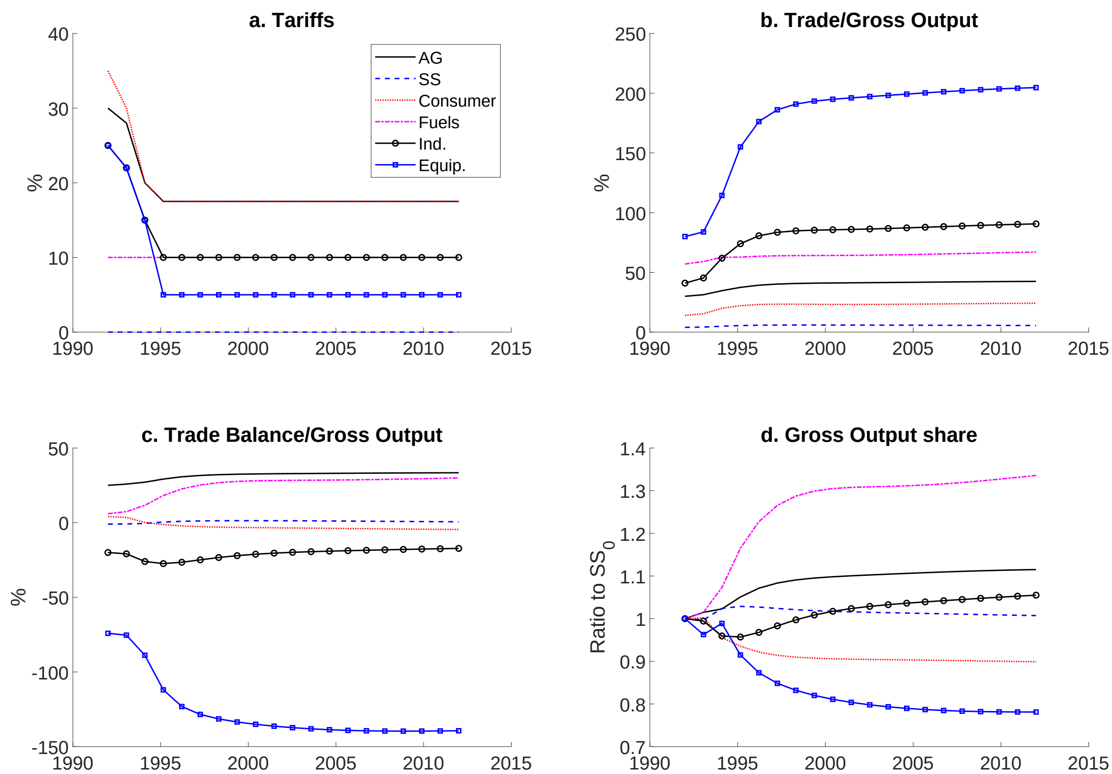
Note: Source: DANE

Figure 5: Sectoral tariffs model and data



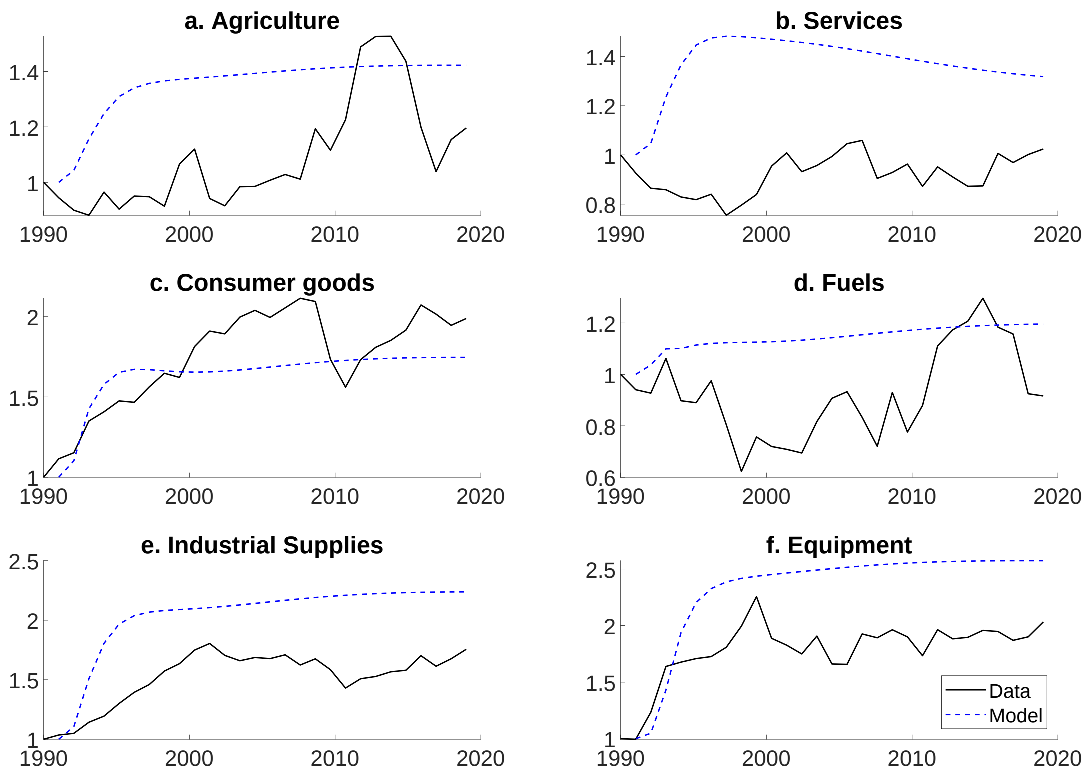
Source: Garay et al. (1998) and customs (DIAN).

Figure 6: Sector tariffs and dynamics in Benchmark model



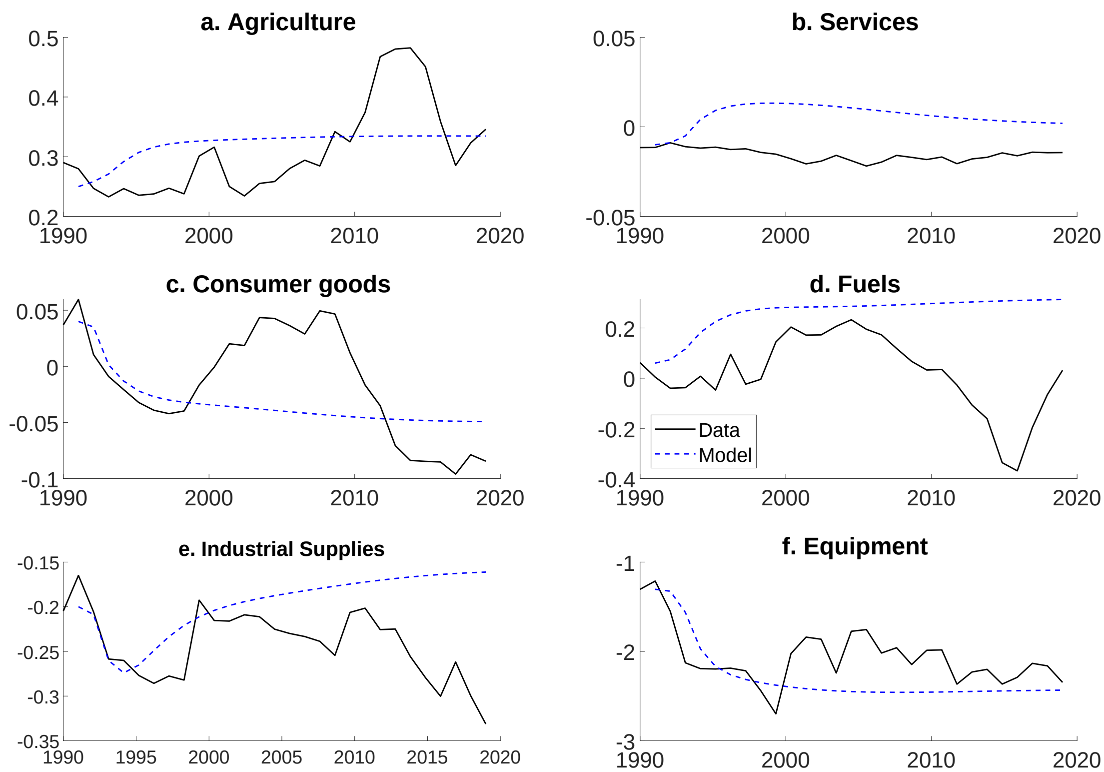
Note: Trade is exports plus imports. Trade balance is exports - imports.

Figure 7: Dynamics of Trade Openness by Sector: Model vs Data



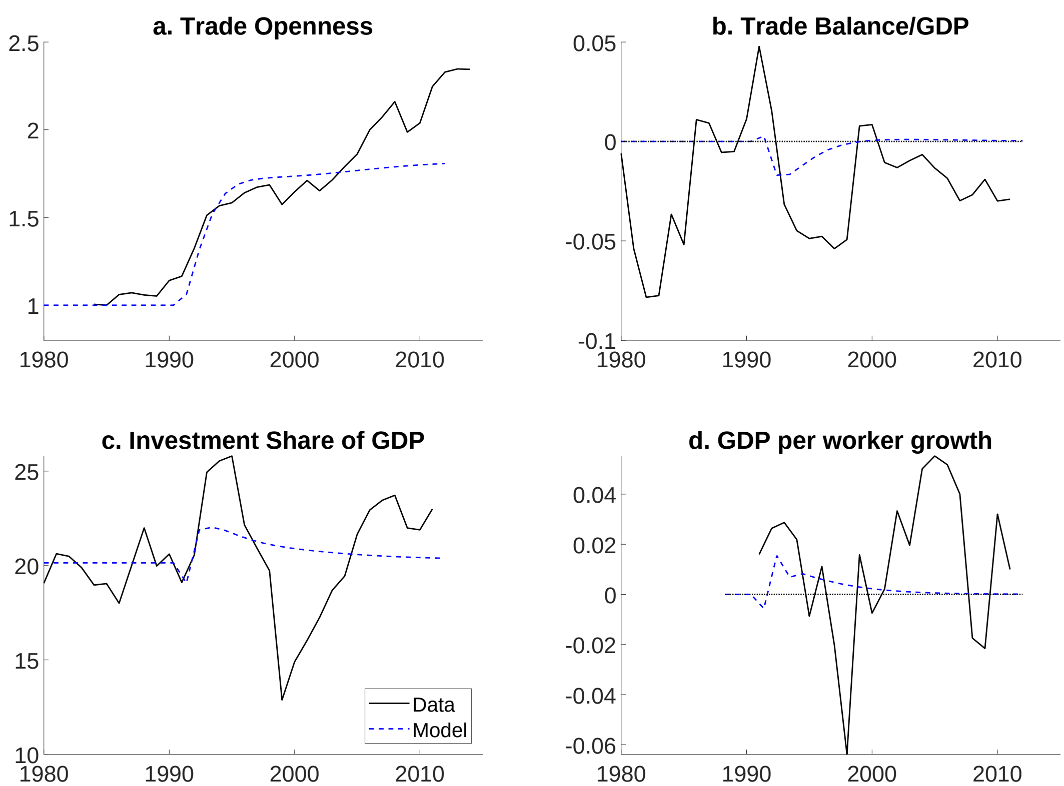
Note: Six Sector Model (Benchmark). Trade Openness = total trade/gross output in each sector.

Figure 8: Trade Balance/Gross Output by Sector: Model vs Data (Colombia).



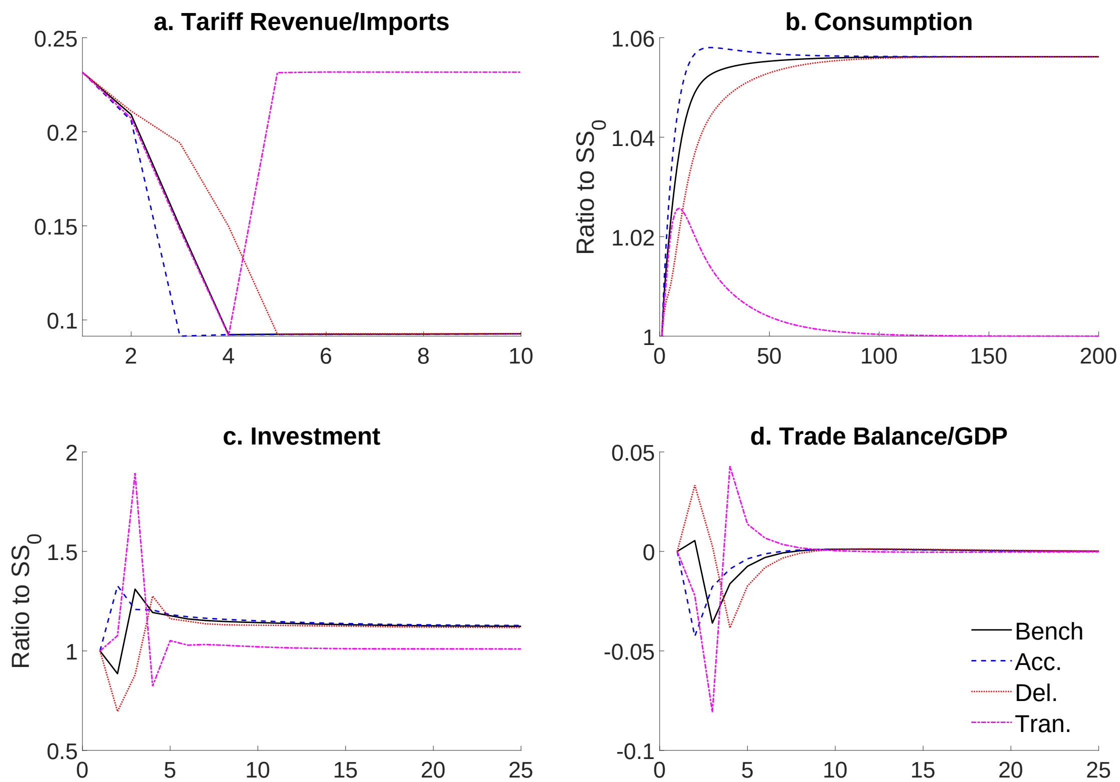
Note: Six Sector Model (Benchmark). Trade balance measured as share of gross output.

Figure 9: Aggregate Dynamics: Model and Data



Note: Six sector Model (Benchmark)

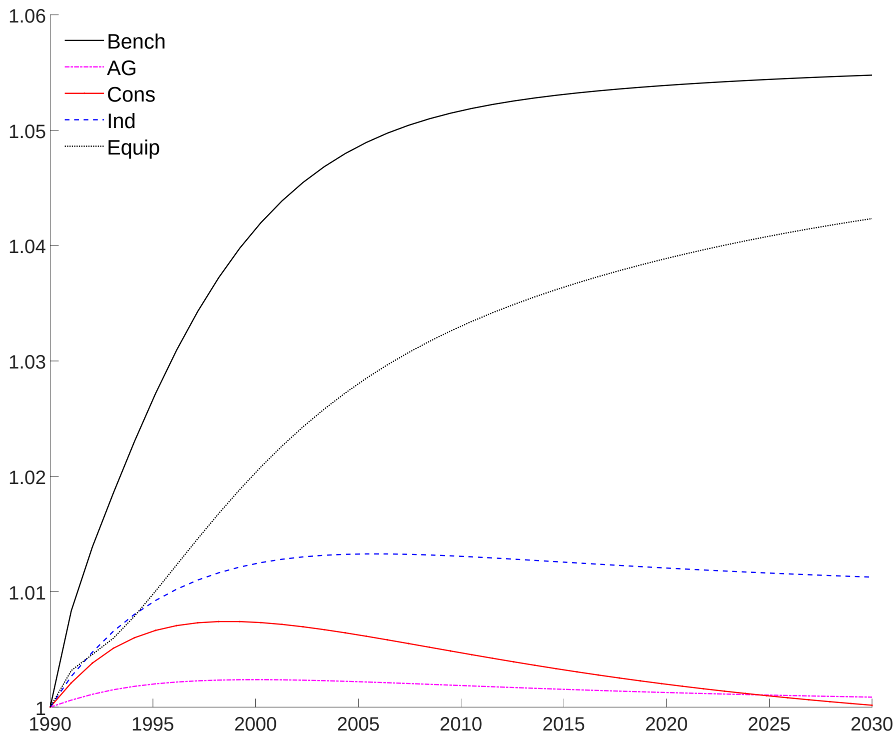
Figure 10: Aggregate Dynamics and Tariff Dynamics.



Note: Bench. stands for benchmark; Acc. for accelerated; Del. for delayed; and Tran. for transitory.

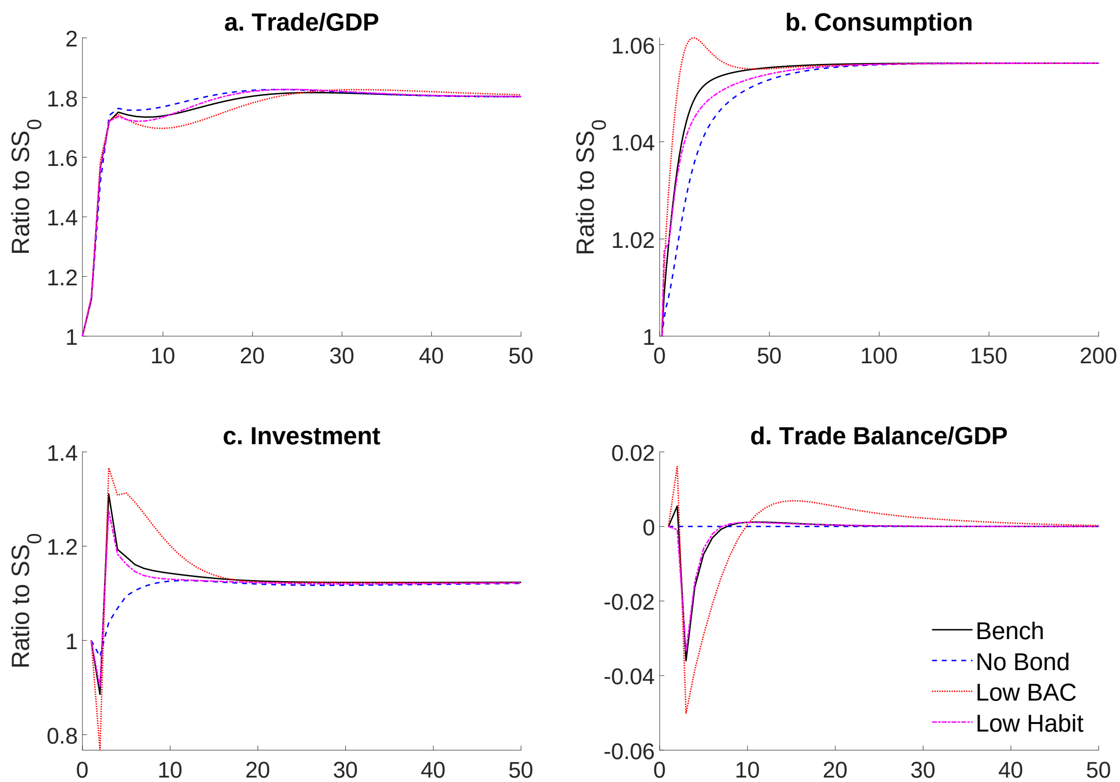
Figure 11: Consumption path liberalizing one sector at a time

(relative to initial steady state).



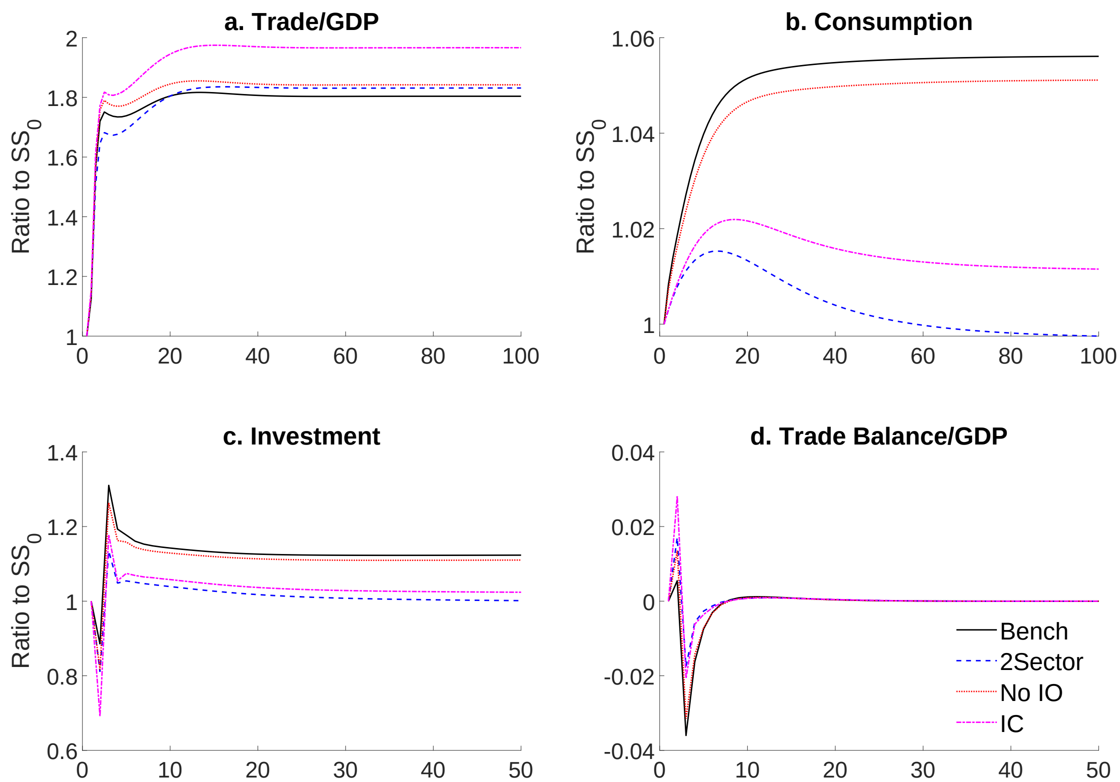
Note: Bench. is all reforms. AG denotes Agriculture. Cons. denotes Consumption goods. Ind. denotes Industrial Supplies; and Equip denotes Capital Equipment.

Figure 12: Macroeconomic Aggregates for alternative model.



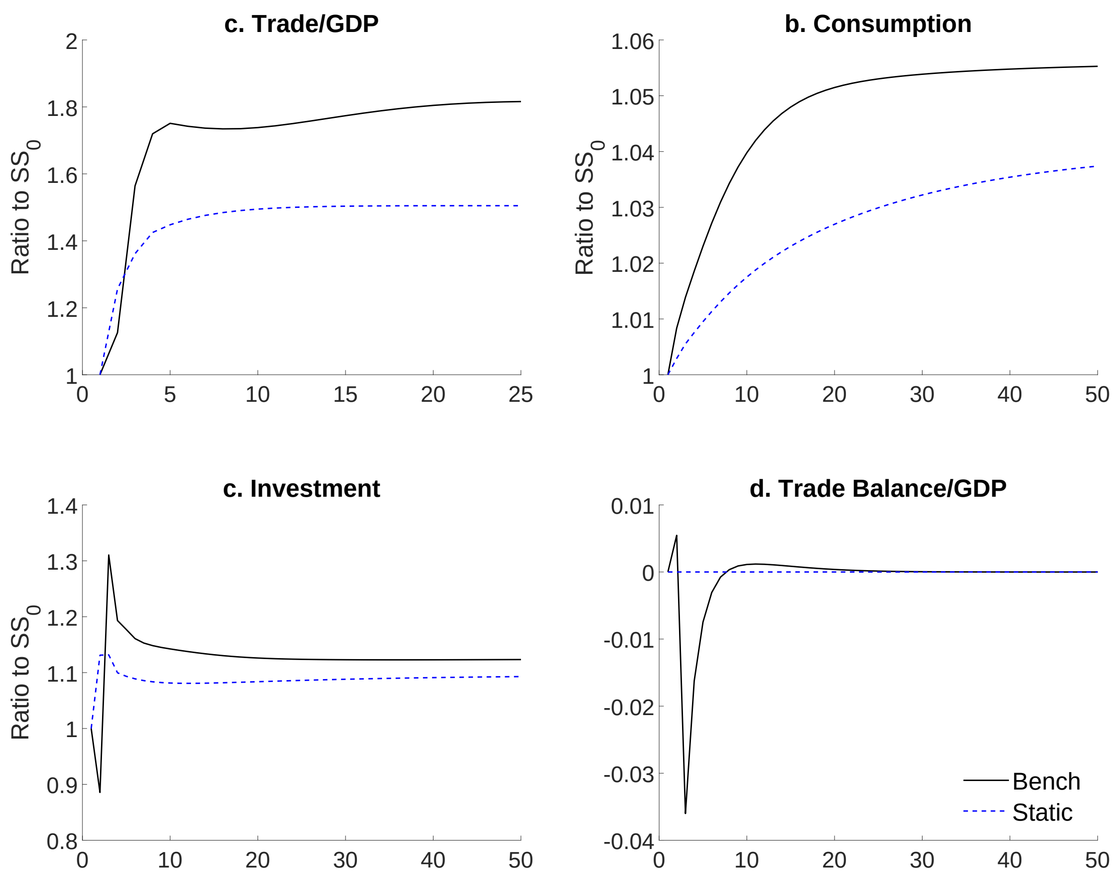
Note: Bench. stands for benchmark; No Bond stands for no financial asset trade; Low BAC stands for Low Bond Adjustment Costs; and Low Habit stands for a case with a habit parameter that is half of our benchmark.

Figure 13: Aggregates Dynamics for Alternative Production Technologies.



Note: Bench. stands for benchmark; 2Sector denotes a Services and Goods Sector; No IO stands for a common input-output structure; IC stands for a common aggregator for Consumption and Investment; and Static stands for no exporter dynamics and financial autarky.

Figure 14: Aggregates Dynamics and Exporter Dynamics.



Note: Bench. stands for benchmark; Static stands for no exporter dynamics and financial autarky.

D Appendix: Alternative Calibrations

We now show that our results in our benchmark model on welfare and steady state consumption are largely invariant to how we model trade in services or Colombia's population size. Results for alternative calibrations are reported in Table 6.

D.1 Services

We consider an alternative calibration for the service sector in which a small fraction of firms account for all of the trade in services. In this scenario, which we call *More Exporters*, we target 30 percent of service firms each exporting a smaller fraction than our benchmark. The remaining of moments are targeted as in the benchmark case. This alternative calibration does not affect our estimates of the welfare gain or long-run consumption response.

D.2 Population

We consider a version in which Colombia is a larger share of world GDP and show that our findings for the welfare gains are quite similar. A reason to consider alternative country sizes is that our two country model does not provide any guidance on how to map large countries that have very high trade barriers, and thus low trade shares, into the model. For instance, as of 2023 Colombia is about 15 percent of the South American population and 5 percent of the Americas. Specifically, we change the population size so that Colombia now accounts for 5 percent of world GDP. This alternative calibration, which we call *Big Colombia*, increase our estimates of the welfare gain and long-run consumption response by less than 10 percent. Making Colombia a smaller share of the world has even smaller effects.

Table 6: Changes in Welfare and Steady State Consumption for Alternative Calibrations

Scenario	Share of World GDP	Exporters (Services)	$C_{fin}/C_0 - 1$	$\Delta\%W$
Benchmark	0.67	0.02	5.62	4.68
Big Colombia	5.0	0.02	6.13	5.05
More Exporters	0.67	0.30	5.62	4.68

Note: Changes in welfare are calculated as the compensating differential of consumption in the initial steady state that would yield the same change in the present value of utility from the new path of utility with the new tariffs. Big Colombia denotes a case that varies the country population to hit the GDP target. More Exporters denotes a case with a small share of exporters in the service sector.