Banco de México

Working Papers

N° 2021-25

Tariffs and Macroeconomic Dynamics

Marco Hernández Vega
Banco de México

December 2021

Documento de Investigación
2021-25

Working Paper
2021-25

Tariffs and Macroeconomic Dynamics

Marco Hernández Vega[†]
Banco de México

Abstract: This paper studies the macroeconomic impact of higher tariffs using a two-country DSGE model with endogenous trade and heterogeneous firms. The analysis consists of two scenarios. First, we assume that one country increases tariffs while the other does not. Second, both countries raise tariffs. In the first case, the country that did not raise tariffs suffers an economic contraction due to lower external demand. In turn, the one that imposed higher tariffs ends with a slight gain in output triggered by a surge in internal consumption originated from the transfer of tariff revenue to households. In the second case, however, both countries suffer a significant drop in exports, reducing dividends and wages paid, and decreasing consumption and output.
Keywords: Endogenous Trade, Firm Heterogeneity, Firm Dynamics, Tariffs
JEL Classification: F12, F13, F17, F41, F62

Resumen: Este artículo estudia el impacto macroeconómico de aranceles más altos utilizando un modelo DSGE de dos países con comercio endógeno y empresas heterogéneas. El análisis consta de dos escenarios. Primero, asumimos que un país aumenta los aranceles mientras que el otro no. Segundo, ambos países aumentan los aranceles. En el primer caso, el país que no los subió sufre una contracción económica causada por una menor demanda externa. A su vez, el que impuso mayores tarifas termina con una leve ganancia en el producto provocada por un repunte del consumo interno originado por la transferencia de ingresos arancelarios a los hogares. No obstante, en el segundo caso, ambos países sufren una caída significativa de las exportaciones, reduciendo los dividendos y salarios pagados, y disminuyendo el consumo y el producto.
Palabras Clave: Comercio Endógeno, Empresas Heterogéneas, Dinámica de las Empresas, Aranceles

[†] Dirección General de Investigación Económica. Email: auhernandez@banxico.org.mx.

1 Introduction

In recent years, the U.S. enacted several measures favoring protectionism, particularly in the form of higher import tariffs. For example, in June 2018, an up to 25 percent tariff was enforced on imports from China with a value of roughly 34 billion dollars. Also, in August 2019, the U.S. announced a 10 percent tariff on 300 billion dollars of Chinese goods. In October of the same year, it applied an up to 25 percent tariff on 7.5 billion dollars of European Union goods. As a result, most of these countries retaliated in kind by also raising tariffs on U.S. goods.

Notwithstanding all the efforts towards trade liberalization in the last decades, protectionism was never entirely abandoned. Countries usually implement some protective measure against specific imports to shield a particular sector or industry (for example, farming or the steel industry), to preserve jobs or for political gain, see Grossman and Helpman (1994), and Maggi and Goldberg (1999). However, such a drastic turn towards protectionism had not occurred since WWII, which bears question about the possible macroeconomic consequences of this new trade policy.

Several recent works attempt to answer such a question. Analyzing the short-run effect of tariffs imposed by the U.S. and the retaliation by countries affected by them, Fajgelbaum et al. (2019) find a significant fall in trade flows as a result of U.S. implementation of tariffs and the consequent retaliation. Besides, their empirical evidence points to a full pass-through of tariffs to final import prices and a loss for U.S. consumers of approximately 0.29 percent of GDP together with a fall in aggregate real income of close to 0.04 percent of GDP. Finally, these authors argue that the U.S. economy would have obtained a small gain without retaliation from trade partners.

In turn, Barattieri et al. (2018) empirical results suggest that a temporary increase in trade barriers reduces output, boosts inflation, and, at most, has a very modest positive effect on the trade balance in the short run. They modify Ghironi and Melitz (2005) model with an exogenous non-traded sector and nominal rigidities to assess the transmission channel of tariffs. The authors find that protectionism is not a good tool for small open economies to support macroeconomic expansion.

Erceg et al. (2018) study the short-run impact of an increase in tariffs together with export subsidies in transitional dynamics using a New Keynesian open-economy DSGE model with nominal rigidities and different exchange rate regimes. They show that when both tariffs and subsidies are implemented, demand for domestically produced goods rises to expand aggregate demand and inflation even in a flexible exchange rate regime. Their results contrast with the traditional view that increasing tariffs lead to a strong appreciation of the exchange rate, which fully cancels the described impact.

This work contributes to the literature by analyzing the macroeconomic impact of revenue tariffs using Ghironi and Melitz (2005) model with heterogeneous firms and endogenous trade and assuming that the proceeds from tariffs are distributed to households via a lump-sum transfer.

This study follows Caliendo et al. (2015) in the sense that it uses revenue tariffs.[1] The authors argue that tariffs are imposed on the customs value of imports, which, of course, is already inclusive of variable and fixed export costs. This implies that when tariffs increase, not only do they affect profits, but they also have an impact on entry. Using a static trade model in the spirit of Melitz (2003), Caliendo et al. (2015) prove that revenue tariffs do have a positive impact on fixed costs and ultimately lead to a bigger welfare loss than when the effect of tariffs is introduced as a rise in iceberg trade costs. The authors explain that such a result is because increasing iceberg trade costs does not reduce entry, while revenue tariffs do.[2]

The analysis encompasses two scenarios: first, a no-retaliation scenario where one country raises tariffs and the other does not. Second, a retaliation scenario where both countries increase tariffs.

The results in the no-retaliation scenario are as follows: when country A raises tariffs, it causes a significant drop in the number of exporting firms in country B. Since only the most productive firms can export, the export productivity cut-off level rises, leading to a fall in net-off tariff export prices and profits. Firms that can no longer export sell domestically, resulting in higher domestic production and profits. However, the negative effect in export profits dominates so that aggregate firm profits in country B fall, causing a reduction of household income that is reflected by a contraction in consumption and real GDP. In contrast, household income in the country that rose tariffs is higher due to the lump-sum transfer from tariffs increasing consumption of domestically produced goods and boosting domestic production and profits. As a result, GDP rises in this country. These results are in line with those of Fajgelbaum et al. (2019) in the sense that the country that increases tariffs observes a slight boost in GDP while the other country contracts.

When both countries raise tariffs, however, the fall in the number of exporting firms and the increase in the cut-off export productivity is higher than in the previous scenario for both countries. Despite that household expenditure switches towards domestically produced goods driving domestic profits up, the drop in export profits overcomes this effect reducing total profits within each country. Such dynamics translate into lower household income so that consumption and output plunge in both economies.

[1] This strategy differs from the approach followed by Haaland and Venables (2016), Barattieri et al. (2018) and Erceg et al. (2018) who introduce tariffs as variable costs of production.

[2] Also, another departure of this works versus that of Haaland and Venables (2016), for example, is that here the interest is on the transitional dynamics of macroeconomic variables and not in determining the optimal tariff as in the cited work.

It is important to note that since the model is calibrated for the U.S. economy and an identical trade partner, the results may be sensible to a different calibration. In particular, the magnitude and persistency of firms' dynamics and consumption could change if the model is calibrated for countries with different sizes (asymmetric equilibrium). In addition, the model does not consider other factors that may affect the results. For example, an increase in trade policy uncertainty reduces investment, particularly of exporting firms and output (see Caldara et al. (2020)), labor market frictions, price rigidities, etc.

The article is organized as follows: In the next section, we briefly describe Ghironi and Melitz (2005) model and how revenue tariffs are introduced in the model. The third section describes the impact of higher tariffs in the scenarios described above. The fourth section concludes.

2 The Model

In order to assess how the imposition of tariffs may influence the transitional dynamics of macroeconomic variables, we use Ghironi and Melitz (2005) model augmented with *ad valorem* revenue tariffs as in Caliendo et al. (2015). According to these authors, introducing revenue tariffs is a more realistic approach than rising iceberg trade costs or introducing tariffs into variable production costs excluding mark-ups and without fixed costs as in Costinot and Rodríguez-Clare (2014). Here, we briefly describe the model and show only the relevant equations while details of the model are shown in Appendix A and Appendix B. Also, we point the reader to Ghironi and Melitz (2005) for a more detailed description of the model.

2.1 Households' Intratemporal Problem and Firms' Domestic Profits

Suppose the world consists of two equal-sized countries denominated A and B, with a unitary mass of atomistic households per country, there is no money and no nominal rigidities which implies all prices are fully flexible. Each household inelastically supplies labor L, L^* at nominal wages W, W^* respectively. In each country, there is a continuum of goods Ω so that in every period there exists a number of varieties available for consumption, $\Omega_t \subset \Omega$ in A and $\Omega_t^* \subset \Omega^*$ in B.[3] Since countries are symmetric, we show only the equations for A noting that for each of these there is an analogous equation for B.

Households behave identically in both countries and have Dixit-Stiglitz preferences with symmetric elasticity of substitution $\theta > 0$. Household's demand for variety ω is given by $\hat{c}_t(\omega) =$

[3]We use an * to differentiate B variables from A variables.

$(\tilde{p}_t(\omega)/P_t)^{-\theta}C_t$, where C_t is the basket of goods consumed by the household aggregated over Ω_t, P_t is A's aggregate price index and $\tilde{p}_t(\omega)$ is the nominal price of variety ω, inclusive of iceberg trade costs and tariffs if imported.

Production takes place under monopolistic competition. Upon entry, firms must pay a sunk entry cost f_E in units of effective labor. Afterward, firms draw their relative productivity level z from the known distribution of productivities $G(z)$.[4] Once their productivity is known, it remains fixed forever. Firms can then decide whether to begin production or exit.

Each firm produces a single variety ω using labor as the only factor of production. Profit maximization implies that the optimal real price for each good sold domestically is a mark-up over marginal cost given by $\hat{p}_{D,t} = \frac{\theta}{\theta-1}\frac{w_t}{z_t Z_t}$ where w_t is the real wage, z is the relative firm's productivity and Z_t is a measure of aggregate productivity. Hence, real profits are $\hat{d}_{D,t} = \frac{1}{\theta}\hat{p}_{D,t}^{1-\theta}C_t$.

2.2 Firms' Export Profits with Revenue Tariffs

Firms in country A with high enough relative productivity can sell their goods domestically or in the export market. To enter the export market firms must pay on a period by period basis a fixed cost $f_{X,t}$, an iceberg trade cost τ_t, and an *ad valorem* revenue tariff $\psi_t^* > 0$ imposed by country B. Let $p_{X,t}$ be the tariff inclusive real price set by A's exporting firms, so that $\rho_{X,t} = \frac{p_{X,t}}{1+\psi_t^*}$ is the net-of-tariff real price received by the firm. Then, exporters' real profits in A are obtained from solving:

$$\max d_{X,t} = Q_t \left[\rho_{X,t} - Q_t^{-1}\frac{\tau_t w_t}{z Z_t}\right] Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} \tag{1}$$

where Q_t is the bilateral consumption based real exchange rate that translates B units of consumption into A's units, and $Y_{X,t}$ is the amount produced of variety ω to be exported to country B.[5]

Note that these profits are obtained using the net-of-tariff revenue of the firm, $\rho_{X,t}Y_t$. In contrast, if the tariffs were introduced as a part of the variable costs, then profits become:

$$\max \bar{d}_{X,t} = Q_t \left[p_{X,t} - Q_t^{-1}\frac{\tau_t w_t (1+\psi_t^*)}{z Z_t}\right] Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} \tag{2}$$

In this case, profits are computed using revenue paid by consumers $p_{X,t}Y_t$. As a result, profits

[4]Following Ghironi and Melitz (2005) this is a Pareto distribution with shape parameter k and lower bound of z_{min}.

[5]Since firms behave monopolistically the amount of production is enough to satisfy its demand so $Y_{X,t} = (\rho_{X,t}(\omega)(1+\psi_t^*)/P_t^*)^{-\theta}Y_t^*$ with Y_t^* standing for the aggregate demand in country B.

obtained in equation 2 are different from profits gained in equation 1. By the same token, the zero export profit condition that determines which firms can export would also be different in both cases. In particular, exporting becomes more expensive with revenue tariffs than with tariffs in variable costs (see Caliendo et al. (2015)).

This is also true in this model, unless there is a full rebate of tariffs to households in line with Caliendo et al. (2015) who shows that a full rebate of tariffs assuming the household uses these resources to acquire more goods produced abroad makes the difference between equation 1 and 2 immaterial. To show this, multiply equation 1 by $1+\psi_t^*$ and note that the amount collected from each exporting firm to be distributed to households in the other country is $\psi_t^* p_{X,t} Y_{X,t}$. Then, export profits become:

$$(1+\psi_t^*)d_{X,t} = (1+\psi_t^*)\left[Q_t\left(\rho_{X,t} - Q_t^{-1}\frac{\tau_t w_t}{zZ_t}\right)Y_{X,t} - \frac{w_t f_{X,t}}{Z_t}\right] + \psi_t^* p_{X,t} Y_{X,t} \tag{3}$$

The revenue paid by the household is now $p_{X,t}Y_{X,t}$ which implies:

$$d_{X,t} = Q_t\left[p_{X,t} - Q_t^{-1}\frac{\tau_t w_t}{zZ_t}\right]Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} \tag{4}$$

Now, in the case of tariffs introduced in the variable costs the rebate will be $\frac{\tau_t w_t(\psi_t^*)}{zZ_t}Y_{X,t}^*$:

$$\hat{d}_{X,t} = Q_t\left[p_{X,t} - Q_t^{-1}\frac{\tau_t w_t(1+\psi_t^*)}{zZ_t}\right]Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} + \frac{\tau_t w_t(\psi_t^*)}{zZ_t}Y_{X,t}^* \tag{5}$$

$$= Q_t\left[p_{X,t} - Q_t^{-1}\frac{\tau_t w_t}{zZ_t}\right]Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} \tag{6}$$

As a result of the rebate, the profits of the exporting firms are similar whether revenue or cost tariffs are used as shown by equation 4 and 6.

Solving the profit maximization problem, as described by equation 1, the optimal price set by the exporting firm is:

$$\hat{\rho}_{X,t} = \frac{\hat{p}_{X,t}}{1+\psi_t^*} = \frac{\theta}{\theta-1}Q_t^{-1}\frac{w_t\tau_t}{zZ_t} \tag{7}$$

Then, net-of-tariff real profits are:

$$\hat{d}_{X,t} = \frac{1}{\theta} Q_t \frac{\hat{\rho}^{1-\theta}}{(1+\psi_t^*)^\theta} Y_t - \frac{w_t f_{X,t}}{Z_t} \tag{8}$$

2.3 Average Productivity and Firms' Entry and Exit

In every period, there is a mass N_t of firms producing domestically. Since each firm produces a single variety, the share of exporting firms $\frac{N_{X,t}}{N_t}$ is $1 - G(z_{X,t})$ and, as in Ghironi and Melitz (2005), $z_{X,t} = inf\{z : d_{X,t} > 0\}$.

Following Melitz (2003), because of the Pareto distribution assumption, the average productivity of all firms in A is $\tilde{z}_D = uz_{min}$; and the average productivity of country A's exporting firms is $\tilde{z}_{X,t} = uz_{X,t}$.[6] Finally, define $\hat{\rho}_{D,t}(\tilde{z}_D)$ as the optimal average real prices of goods sold domestically and $\hat{\rho}_{X,t}(\tilde{z}_{X,t})$ as the net-of-tariff price received by country A's exporting firms when selling abroad.

Given this real average prices, the price index for country A becomes $P_t^{1-\theta} = N_{D,t}(\hat{\rho}_{D,t}(\tilde{z}_D))^{1-\theta} + N_{X,t}(\hat{p}^*_{X,t}(\tilde{z}_{X,t}))^{1-\theta}$, where $\hat{p}^*_{X,t}(\tilde{z}_{X,t})$ is the average real price inclusive of tariffs that the consumers pay for goods produced abroad.

From the definition of average productivities, the share of exporting firms in A is given by $\frac{N_{X,t}}{N_t} = \left(\frac{uz_{min}}{\tilde{z}_{X,t}}\right)^k$. Hence, total profits in A become $\hat{d}_t = \hat{d}_{D,t} + \frac{N_{X,t}}{N_t}\hat{d}_{X,t}$.

There is a number $N_{E,t}$ of possible entrants at each t. Once a firm enters, it will start production the next period. All firms face an exogenous death shock δ at every period so that the total number of firms producing at t is given by $N_t = (1-\delta)[N_{t-1} + N_{E,t-1}]$. Following Ghironi and Melitz (2005) all entrants can correctly anticipate future expected profits. Hence, entry in the domestic market will occur until the present discounted value of all future expected profits equals the entry cost $\frac{w_t f_E}{Z_t}$.

In turn, entry in the export market requires the net-of-tariff export profits for the cut-off firm to be equal to zero, which implies the following entry condition:

$$\hat{d}_{X,t} = \frac{\theta - 1}{k} \frac{u^{\theta-1}}{(1+\psi_t^*)^\theta} \frac{w_t f_{X,t}}{Z_t} \tag{9}$$

[6] $u = (\frac{k}{k-(\theta-1)})^{\frac{1}{\theta-1}}$.

2.4 Household Intertemporal Problem

The representative household maximizes the present value of utility, discounted at rate $1 > \beta > 0$ with intertemporal elasticity of substitution $\gamma > 0$. At the beginning of each period, the household owns two types of assets: risk-free bonds (B_t) and shares (x_t) in a mutual fund composed by all domestic firms. The first pays a real return $r_t > 0$ which is known with certainty in the previous period. The shares pay dividends equal to the average total profit of all producing firms in A at time t. When acquiring the shares, it is unknown which firms will survive the death shock δ, so the household buys shares from all producing firms plus all new entrants.

As a result, household's income comes from wages earned at t plus interests paid by the bonds, dividends gained from their holdings of shares, and a lump-sum transfer $T_t = \psi_t N^*_{X,t}(\hat{p}^*_{X,t})^{1-\theta} Y^*_{X,t}$ to the household equivalent to a full rebate of tariffs as in Caliendo et al. (2015). This income is used for consumption and to acquire new shares (x_{t+1}) and bonds (B_{t+1}) to carry out in the next period. This translates into the following budget constraint:

$$B_{t+1} + \tilde{v}_t N_{H,t} x_{t+1} + C_t = (1 + r_t) B_t + (\tilde{d}_t + \tilde{v}_t) N_t x_t + T_t + w_t L \tag{10}$$

where $N_{H,t} = N_t + N_{E,t}$ is the total number of domestic firms.

As we saw above from equations 4 and 6, with a full rebate of tariffs and under the assumption that it is used to acquire only foreign goods, profits with ad-valorem revenue tariffs do not differ from those obtained with either a cost tariff or only iceberg costs resulting in similar dynamics. However, it is quite unlikely that households use the rebate exclusively to buy foreign goods. Hence, we assume that a full rebate of tariffs takes place with no restrictions on how consumers use the extra income in line with Barattieri et al. (2018); i.e. consumers can use it either to acquire domestically produced goods or imported goods.

Lastly, as in the baseline case of Ghironi and Melitz (2005) we assume financial autarky which implies balance trade so that in the steady-state $B_{t+1} = B_t = 0$ and $x_{t+1} = x_t = 1$ must hold.[7]

2.5 Calibration

The model is calibrated to the U.S. economy following Ghironi and Melitz (2005). Hence, we set $\beta = 0.99$, and $\gamma = 2$ according to the business cycle literature. We let θ be equal to 3.8 as in Bernard et al. (2003) and $\delta = 0.025$ to enable the model to replicate the 10 percent job loss in the

[7]The full set of equilibrium conditions is described in Appendix B.

U.S. per year. Following Demidova (2008) the shape parameter of the Pareto distribution k is equal to 3.3 so that the standard deviation of the log of plant sales in the model is equal to 0.84, which corresponds to the one obtained by Bernard et al. (2003) in their simulations. In turn, the lower bound of this distribution z_{min} is set to one so that the average productivity of all exporting firms in each country ($\tilde{z}_D$, $\tilde{z}_D^*$) is equal to the mean of the Pareto distribution.

Following Ghironi and Melitz (2005), the iceberg trade costs in countries A and B (τ and τ^*) are equal to 1.3 while the fixed export costs (f_X and f_X^*) are calibrated to match the ratio of exporting firms in the U.S. of 23.5 percent as in Bernard et al. (2003). Without loss of generality, the sunk entry cost to the domestic market (F_E and F_E^*), the labor supply (L and L^*), the aggregate productivity (Z and Z^*) and the real exchange rate (Q) are set equal to 1.

We set the steady-state value of tariffs (ψ and ψ^*) 3.3 percent, which is average of the most favored nation (MFN) *ad valorem* tariffs imposed by the United States in 2018 according to the WTO world tariff profiles of 2019.[8] Finally, $r = r^* = \frac{1}{\beta} - 1$.

The assumption that $Q = 1$ implies that there exists a unique symmetric steady-state. Hence, the model is solved by log-linearizing the system equilibrium conditions assuming log-normality and homoscedasticity of the exogenous shocks. The dynamics of the model are obtained using the method of undetermined coefficients.

In turn, calibrating the persistence of tariffs is not an easy task. Specifically, persistency of the most recently imposed tariffs by the U.S. cannot be estimated yet since they mostly took place in 2018 and 2019, and while some remain active, others have been modified or even suspended. Also, long time-series data for tariffs are hard to come by, although some works have put a lot of effort in putting together long datasets on tariffs (see Furceri et al. (2018) and Barattieri et al. (2018)). Hence, I follow Jacquinot et al. (2020) and Bergin and Corsetti (2020) and assume that the tariff shock follows the process $\psi_t = 0.9\psi_{t-1} + \varepsilon_t$ for all $t > 0$, which implies a persistency of 10 years as in the mentioned works.

3 Results

This section describes the results of the model in two different scenarios. First, we assume that country A raises tariffs and B does not retaliate. This will serve as a basis to see if there are some gains from imposing higher tariffs, and at what horizon, explain why one country would be willing to take such action. Second, both A and B increase tariffs.

Before discussing the transmission channels, it is essential to mention that both countries will

[8] https://www.wto.org/english/res_e/publications_e/world_tariff_profiles19_e.htm.

feel the effects of higher tariffs through changes in the demand for imports after the shock. We assume that the increase of tariffs is unexpected by all agents who from that moment on have perfect foresight.

3.1 The No-Retaliation Scenario

The impact of a 1 percent increase in tariffs is shown in Figure 1.[9] At the time of the shock, the unexpected increase in tariffs to country B's exports causes a significant drop in the number of exporting firms (N_X^*). Since only the most productive firms can sell their goods abroad, this increases the export productivity cut-off (z_X^*), which leads to a fall in the net-of-tariff export price (p_X^*) and in export profits (d_X^*).

Firms that can no longer export sell goods internally, which increases the supply of nontraded goods (Y_D^*). This reduces domestic prices (p_D^*) and profits (d_D^*).[10]

Furthermore, the decline in p_D^* and p_X^* pressures real wages ($w*$) down whilst the fall in N_X^* and d_X^* prevails over the increase in d_D^* cutting down total profits d^*. Hence, the increase in export tariffs causes a reduction in household income that is reflected by a contraction of aggregate consumption (C^*) and in real GDP.

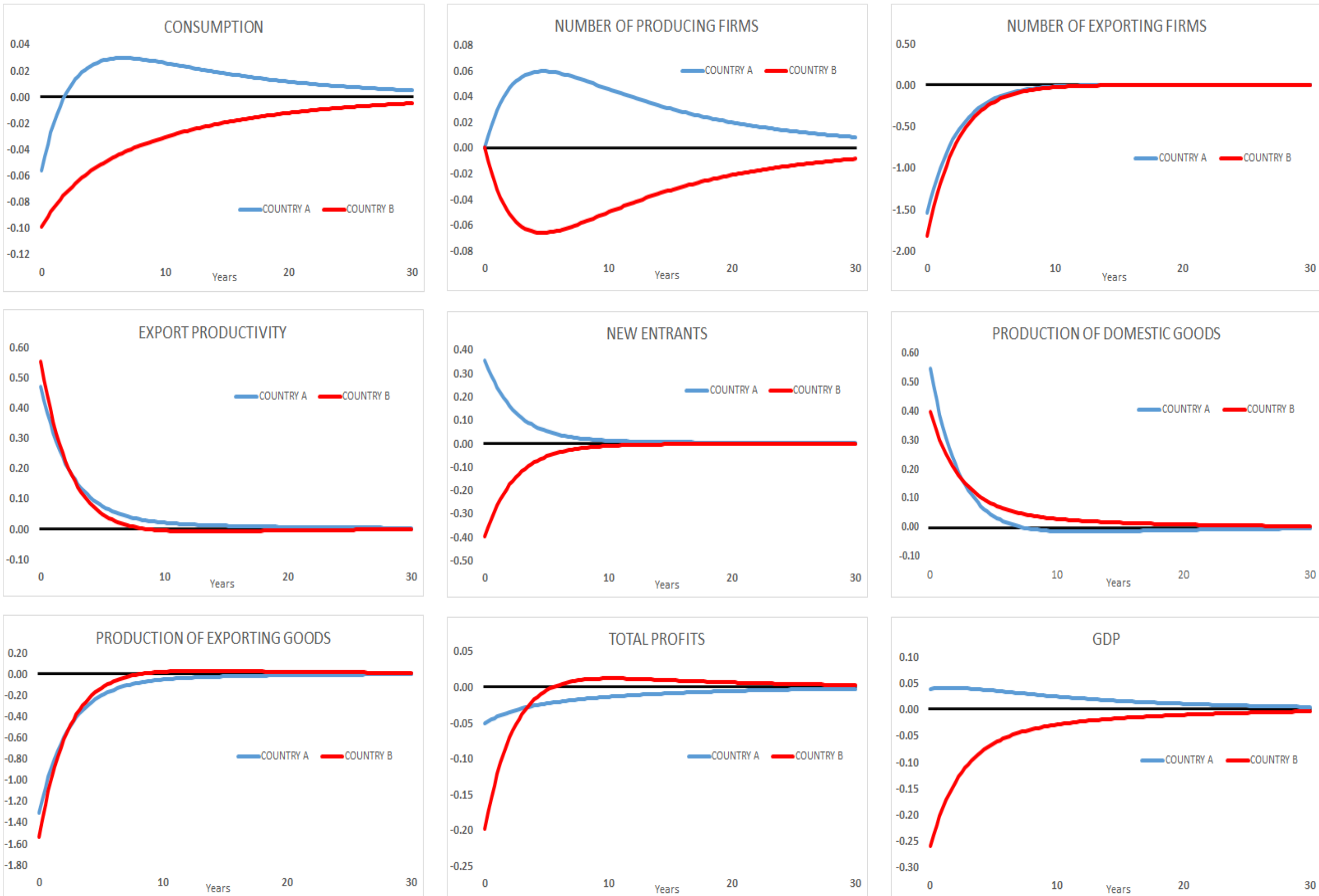
In turn, country A is affected by the increase in tariffs via the deterioration of demand in B. Foreign demand for goods produced in A falls due to a rise in relative export markets (RPX/p_D^* where we denote the tariff-inclusive price as RPX to quickly identify it in the graphs), reducing the number of exporting firms (N_X) and driving the export productivity cut-off (z_X) up. As a result, the production of traded goods (Y_X) drops while export prices (p_X) rise (note that these effects are of a lower magnitude than the ones observed in country B).

In addition, the imposition of higher tariffs pushes the import prices, which raises the demand for domestically produced goods since exports are now relatively more expensive than domestic goods: RPX^*/p_D rises. This reallocation from relatively more productive foreign producers to less productive domestic producers drives domestic prices down. This switch in expenditure towards domestic goods increases production (Y_D) and profits of firms selling domestically (d_D), leading to a rise in GDP.

[9]The complete set of impulse responses is shown in Appendix C.

[10]The number of producing firms (N_t^*) does not change at the time of the shock since this variable is determined by firms and entrants that survived the death shock in $t-1$.

Figure 1: Response to a Temporary Rise in Tariffs to Exports from Country B



In percent deviations from the steady-state

Lower p_D and p_X push real wages (w) down in country A as well. However, consumption falls at the time of the shock because households will initially direct more resources to finance the entrance of new firms at time t (big increase in NE_t). Still, it recovers and becomes positive two years after the shock. Also, the revenue from tariffs prevails over the fall in wages, increasing aggregate consumption (C) and real GDP. Finally, the real exchange rate (Q) depreciates so that the balance trade condition holds at every t.

The fact that income moves in different directions in each country helps explain the difference in the magnitude of the effects across these countries. For instance, the imposition of higher revenue tariffs makes exporting more expensive in country B since both the cut-off productivity and the fixed cost of entry are higher (see equation 9). This, together with the fact that former exporters are now selling domestically, reduces investment in shares and mutual funds in country B so that the number of entrants (N_E^*) drops.

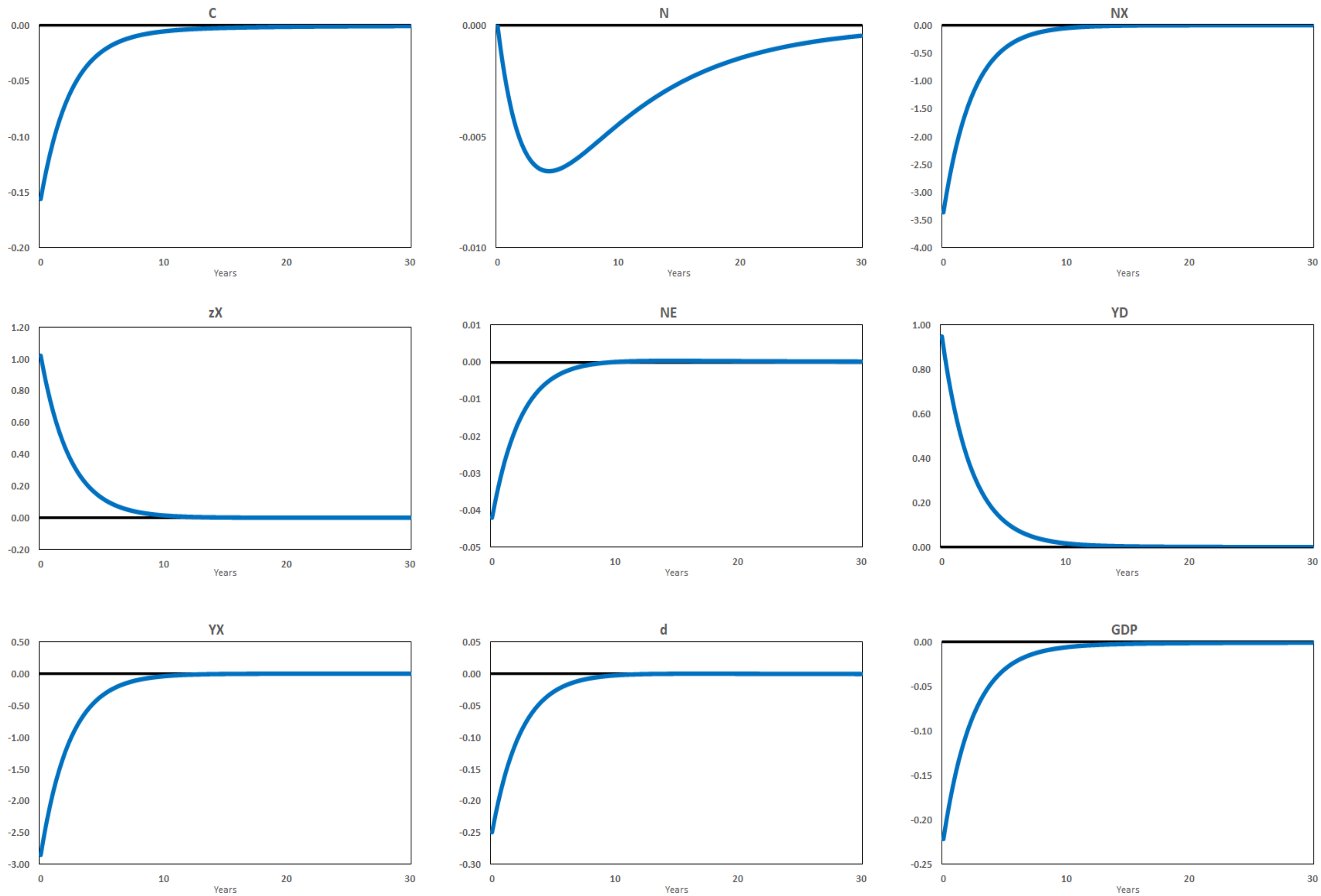
In contrast, since country A is not facing higher tariffs, the adverse effects observed are smaller. Even though the deterioration of B's economy reduces demand for goods produced in A, the income effect described above dominates so that investment in shares and mutual funds in country A rises, leading to an upturn in the number of entrants (N_E).

Therefore, from the point of view of country A, being the first to raise tariffs could bring about some economic gains (defined as higher GDP) due to expenditure switching towards domestically produced goods. This result is consistent with the empirical findings of Fajgelbaum et al. (2019) who show that if there is no retaliation, the U.S. can profit from imposing higher tariffs. However, in the model, country A's gain comes from assuming that the proceeds from tariffs are fully distributed to the households. If no rebate were available, there would not be any gain.[11]

Note that the lump-sum transfer from tariffs revenue implies a significant difference in the dynamics of consumption and GDP. On the one hand, the extra income distributed to the households in country A allows them to finance the entry of new firms. Later on, the transfer also contributes to a sustained recovery of aggregate consumption. On the other hand, the transfer also supports country A's GDP via higher household income.

[11] We also consider the case where consumers can acquire shares from foreign firms. The results remain practically similar since the negative effect in the number of exporting firms and export profits dominates any possible increase in household income coming from shares ownership.

Figure 2: Response to a Temporary Rise in Tariffs in Countries A and B



In percent deviations from the steady-state

3.2 Retaliation

Figure 2 shows that if country B retaliates with a similar increase in tariffs, both economies will experience a negative impact on firm dynamics, consumption, and GDP (only country A variables are shown in Figure 2, those for B are identical due to the symmetry of the model). When both countries raise tariffs, it drives more firms to abandon the export market and sell their products domestically. This causes an increase in domestic supply, which pushes domestic prices and wages down. Also, the cut-off export productivity rises even more since there are fewer exporting firms.

Besides, since firms can no longer export, they now sell their products domestically, driving domestic prices down. Lower prices also reduce wages while domestic prices increase. Nevertheless, the fall in the number of exporting firms together with lower export prices dominates, and total profits in both countries drop. Finally, consumption and GDP fall in both countries leading to a fall in the number of new entrants.

In contrast to the no-retaliation case, there are no differences in aggregate consumption and GDP dynamics. Such a result occurs because the lump-sum transfer of tariffs is not enough to compensate for the significant negative effects of both countries imposing tariffs.

4 Conclusion

In recent years, the U.S. enacted several measures favoring protectionism, particularly in the form of higher import tariffs. Hence, it is necessary to assess the impact of a possible return of protectionism on the world economy. The objective of this work is to study the macroeconomic effects of tariffs using Ghironi and Melitz (2005) two-country model with heterogeneous firms and endogenous trade but augmented with revenue tariffs and assuming that the proceeds from tariffs are distributed to the households via a lump-sum transfer.

This work shows that in a no retaliation scenario, the model provides results in line with those of Fajgelbaum et al. (2019) in the sense that the country that increases tariffs obtains a small gain (increase in GDP) while the other country suffers an economic contraction. This occurs because the country that did not raise tariffs experiences a more significant number of firms abandoning the export market. Also, the increase in the price of its exports reduces its demand abroad, which deteriorates household income. As a result, consumption and output fall in that country. In contrast, household income in the country that rose tariffs is higher due to the lump-sum transfer from tariffs. This higher income raises the demand for domestically produced goods and, by the same token, domestic production and profits. As a result, GDP increases in this country.

However, when both countries raise tariffs, the fall in the number of exporting firms and the increase in the cut-off export productivity is significantly higher than in the previous scenario in both countries. Despite that expenditure switches towards domestically produced goods driving profits up, the drop in export profits overcomes this effect pushing total profits down within each country. This translates into lower household income so that consumption and output plunge in both economies.[12]

Finally, it is essential to note that since the model is calibrated for the U.S. economy and an identical trade partner, the results may be sensitive to a different calibration. In particular, the magnitude and persistency of firms' dynamics and consumption could change if the model is calibrated for countries with different sizes (asymmetric equilibrium). In addition, the model does not consider other factors that may affect the results. For example, an increase in trade policy uncertainty reduces investment, particularly of exporting firms and output (see Caldara et al. (2020)), labor market frictions, price rigidities, etc.

References

Barattieri, A., Cacciatore, M., and Ghironi, F. (2018). Protectionism and the business cycle. Working Paper 24353, National Bureau of Economic Research.

Bergin, P. R. and Corsetti, G. (2020). The Macroeconomic Stabilization of Tariff Shocks: What is the Optimal Monetary Response? NBER Working Papers 26995, National Bureau of Economic Research, Inc.

Bernard, A. B., Eaton, J., Jensen, J. B., and Kortum., S. (2003). Plants and productivity in international trade. *American Economic Review*, 93(4):1268–1290.

Caldara, D., Iacoviello, M., Molligo, P., Prestipino, A., and Raffo, A. (2020). The economic effects of trade policy uncertainty. *Journal of Monetary Economics*, 109:38–59.

Caliendo, L., Feenstra, R. C., Romalis, J., and Taylor, A. M. (2015). Tariff Reductions, Entry, and Welfare: Theory and Evidence for the Last Two Decades. NBER Working Papers 21768, National Bureau of Economic Research, Inc.

Costinot, A., Rodríguez-Clare, A., and Werning, I. (2016). Micro to macro: Optimal trade policy with firm heterogeneity. Working Paper 21989, National Bureau of Economic Research.

Costinot, A. and Rodríguez-Clare, A. (2014). *Trade Theory with Numbers: Quantifying the Consequences of Globalization*, volume 4 of *Handbook of International Economics*, chapter 0, pages 197–261. Elsevier.

[12] A welfare analysis in a dynamic setting goes beyond the scope of the paper. However, in a static framework Haaland and Venables (2016), Costinot et al. (2016), and of course, Caliendo et al. (2015) do analyze the welfare implications of rising tariffs.

Demidova, S. (2008). Productivity improvements and falling trade costs: Boon or bane? *International Economic Review*, 49(4):1437–1462.

Erceg, C., Prestipino, A., and Raffo, A. (2018). The Macroeconomic Effect of Trade Policy. 2018 Meeting Papers 221, Society for Economic Dynamics.

Fajgelbaum, P. D., Goldberg, P. K., Kennedy, P. J., and Khandelwal, A. K. (2019). The return to protectionism. Working Paper 25638, National Bureau of Economic Research.

Furceri, D., Hannan, S., Ostry, J., and Rose, A. (2018). Macroeconomic consequences of tariffs. Technical report, NBER.

Ghironi, F. and Melitz, M. J. (2005). International trade and macroeconomic dynamics with heterogeneous firms. *The Quarterly Journal of Economics*, 120(3):865–915.

Grossman, G. M. and Helpman, E. (1994). Protection for Sale. *American Economic Review*, 84(4):833–850.

Haaland, J. I. and Venables, A. J. (2016). Optimal trade policy with monopolistic competition and heterogeneous firms. *Journal of International Economics*, 102:85 – 95.

Jacquinot, P., Lozej, M., and Pisani, M. (2020). Macroeconomic effects of tariffs shocks: the role of the effective lower bound and the labour market. Working Paper Series 2434, European Central Bank.

Maggi, G. and Goldberg, P. (1999). Protection for sale: An empirical investigation. *American Economic Review*, 89(5):1135–1155.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6):1695–1725.

A Model Description

We show the model for the country A noting that by symmetry there are analogous solutions for country B.

A.1 Intratemporal Solution

Define θ as the intratemporal elasticity of substitution across varieties in country A. Then, as is typical in the business cycle literature country A representative household first solve:

$$\min \int_{\omega\in\Omega_t} p_t(\omega)c_t(\omega)\,d\omega$$
$$s.t. \quad C_t = \left[\int_{\omega\in\Omega_t} c_t^{\frac{\theta-1}{\theta}}\,d\omega\right]^{\frac{\theta}{\theta-1}}$$

Then the demand for variety ω is:

$$c_t(\omega) = \left(\frac{p_t(\omega)}{P_t}\right)^{-\theta} C_t \tag{A.1}$$

CES aggregation over varieties implies that the price index at country A can be expressed as:

$$P_t = \left[\int_{\omega\in\Omega_t} p_t(\omega)^{1-\theta}\,d\omega\right]^{\frac{1}{1-\theta}} \tag{A.2}$$

All firms behave monopolistically, each producing one variety ω with the linear technology $y(\omega)_t = zZ_tL_t$, where z is the relative productivity level, Z_t indexes aggregate labor productivity, and L_t is firm's labor demand.

Country A firms selling in the domestic market solve:

$$\max d_t = \left[\rho_{X,t} - \frac{W_t}{zZ_t}\right]\frac{p_t}{P_t}^{-\theta} C_t$$

where we use the fact that $y(\omega)_t = c_t(\omega) = \left(\frac{p_t(\omega)}{P_t}\right)^{-\theta} C_t$.

The solutions to profit maximization implies that the price set by each firm would be a function of its relative productivity level z. Let $w_t = W_t/P_t$ be the real wage, then, optimal real price is:

$$\hat{p}_t(z) = \frac{\theta}{\theta-1}\frac{w_t}{zZ_t} \tag{A.3}$$

This implies that the real profits of firms in country A selling domestically are:

$$\hat{d}_{D,t}(z) = \frac{1}{\theta} p_t(z)^{1-\theta} C_t \tag{A.4}$$

Firms desiring to enter the export market must face both a fixed cost $w_t f_{X,t}/Z_t$ expressed in units of effective labor, an iceberg-melting cost τ_t and an *ad valorem* revenue tariff ψ_t. To cover the exporting real fixed cost, firms hire labor from their own domestic country. Once a firm has entered the export market it exhibits a pricing to market behavior. Then, a country A exporting firm solves:

$$\max d_{X,t} = Q_t \left[\rho_{X,t} - Q_t^{-1} \tau_t \frac{w_t}{zZ_t} \right] \frac{p_{X,t}}{P_t^*}^{-\theta} C_t^* - \frac{w_t f_{X,t}}{Z_t}$$

where $Q_t = S_t \frac{P_t^*}{P_t}$ is the real exchange rate and S_t is the nominal exchange rate. As seen in section 2, $\rho_{X,t} = \frac{p_{X,t}}{1+\Psi_t}$ is the net-of-tariff export price and ψ_t is the *ad valorem* revenue tariff.

Then, the optimal prices set by the exporting firms in real terms is:

$$\hat{\rho}_{X,t}(z) = Q_t^{-1} \frac{\theta}{\theta - 1} \frac{\tau_t w_t}{zZ_t} \tag{A.5}$$

A.2 Firm Dynamics, Average Prices and Average Profits

The solution to the firm´s problem implies that prices and profits depend on each firm specific productivity level z. The model assumes that before production starts firms in country A and B must draw their productivity level z and z^* from a standard distribution $G(z)$.[13] Once this productivity level is drawn it will remain fixed. This implies that firms will be heterogeneous in the sense that they will have different productivity levels.[14]

Producing implies that firms must face a sunk entry cost measured in effective units of labor equal to $w_t f_{E,t}/Z_t$. These costs are paid period by period by the firms and hence are excluded from the profit computation. Then, a productivity level z_{min} exists such that $d_{D,t}(z_{min}) = 0$. Therefore, any firm with productivity level below z_{min} will never produce. Also, since exporting firms must pay a fixed cost then this will define a cut-off productivity level $z_{X,t}$ such that $D_{X,t}(z_{X,t}) = 0$. This $z_{X,t}$ represents the minimum productivity level needed to enter the export market. Note that $z_{min} < z_{X,t}$ so that exporting firms can sell in both domestic and export markets.[15]

Once a firm has decided to start producing it will require one period to build up. Then, a firm initiating activities at time t will start producing at $t+1$. At every t there exists and exogenous

[13] Ghironi and Melitz (2005) provide an excellent description of such distribution. Here I follow all their assumptions.

[14] These differences also imply differences in the technology used by the firms.

[15] One important assumption is that G(z) has support in the interval (z_{min}, ∞).

exit shock that occurs with fixed probability δ, and an unlimited number of firms are expecting to enter, we denote these firms by $N_{E,t}$. These possible entrants are forward looking and correctly estimate the present discounted value of all their future profits.

There is a number of producing firms N_t in every period. Then, the total number of firms in each country at time t is given by the number of firms that survive the previous period exit shock[16] and the firms that entered in $t-1$. This implies that:

$$N_t = (1-\delta)[N_{t-1} + N_{E,t-1}] \tag{A.6}$$

Now, as noted in Ghironi and Melitz (2005) G(z) can also be thought of as the productivity distribution of all country A producing firms. If the productivity level needed to enter the exporting market is known, it is possible to determine the number of exporting firms in each country; i.e., given $z_{X,t}$ the number of exporting firms is $N_{X,t} = [1-G(z_{X,t})]N_t$. Following these authors, two special average productivity levels are defined:

$$\tilde{z}_D \equiv \left[\int_{z_{min}}^{\infty} z^{\theta-1}\, dG(z)\right]^{\frac{1}{\theta-1}} \tag{A.7}$$

$$\tilde{z}_{X,t} \equiv \left[\frac{1}{1-G(z_{X,t})}\int_{z_{X,t}}^{\infty} z^{\theta-1}\, dG(z)\right]^{\frac{1}{\theta-1}} \tag{A.8}$$

where $\tilde{z}_D$ is the average productivity level of all firms in country A, and $\tilde{z}_{X,t}$ is the average productivity level of all firms in country A exporting to B.

Define $\hat{p}_{D,t} \equiv p_{D,t}(\tilde{z}_D)$ as the real average price of country A goods sold domestically and $\hat{p}_{X,t} \equiv p_{X,t}(\tilde{z}_{X,t})$ as the real average price that households in country B pay for goods produced in A. Then, the price index must express the price of all domestic firms selling domestically plus the price of goods bought from abroad. In real terms the price index is:

$$1 = N_t(\hat{p}_{D,t})^{1-\theta} + N^*_{X,t}(\hat{p}^*_{X,t})^{1-\theta} \tag{A.9}$$

In the same way, we define $\hat{d}_{D,t}$ as the average real domestic profits, and $\hat{d}_{X,t}$ as average real export profits. Thus, total profits of all firms producing in country A are:

$$\hat{d}_t = \hat{d}_{D,t} + \frac{N_{X,t}}{N_t}\hat{d}_{X,t} \tag{A.10}$$

where $N_{X,t}/N_t = 1-G(z_{X,t})$ is the fraction of exporting firms in A and B respectively.

[16]The probability of survival is given by $1-\delta$.

Firms will continue entering the domestic market up to the point where the average value of the firm, $\tilde{v}_t$, equals the entry cost:[17] providing us with the "free entry" condition

$$\hat{v}_t = \frac{w_t f_{E,t}}{Z_t} \tag{A.11}$$

Productivity levels z are parameterized as in Ghironi and Melitz (2005): $G(z)$ is a Pareto distribution with lower bound z_{min} and shape parameter $k > \theta - 1$. Total average productivity $\tilde{z}_D = [k/(k-\theta+1)^{\frac{1}{\theta-1}}]z_{min}$. Average productivity of exporters is $\tilde{z}_{X,t} = [k/(k-\theta+1)^{\frac{1}{\theta-1}}]z_{X,t}$, and the share of exporting firms is $N_{X,t}/N_t = \{[k/(k-\theta+1)^{\frac{1}{\theta-1}}]z_{min}/\tilde{z}_{X,t}\}^k$.

Then, the zero export profits condition becomes:

$$\hat{d}_{X,t} = \frac{\theta-1}{k}\frac{u^{\theta-1}}{(1+\psi_t^*)^{\theta}}\frac{w_t f_{X,t}}{Z_t} \tag{A.12}$$

A.3 Intertemporal Solution

The representative household solves:

$$\begin{aligned} \max \quad & E_t\left[\sum_{s=t}^{\infty}\beta^{s-t}\frac{C_s^{1-\gamma}}{(1-\gamma)}\right] \\ s.t. \quad & B_{t+1} + \hat{v}_t N_{H,t} x_{t+1} + C_t = (1+r_t)B_t + (\hat{d}_t + \hat{v}_t)N_t x_t + T_t + w_t L \end{aligned}$$

where B are risk-free domestic bonds, x denotes shares in a mutual fund of firms in A, r_t is the real interest rate, $\hat{d}_t$ represents average firm profits, and $\hat{v}_t$ is the amount of shares hold by the representative household, and $N_{H,t} = N_t + N_{E,t}$ is total number domestic firms. Note that consumers have no information about which firm will be affected by the exit inducing shock forcing them to invest in all the surviving firms at the end of $t-1$ and all the new entrants at the beginning of time t. T_t is the rebate of tariffs equal to $\psi_t N_{X,t}^*(\hat{p}_{X,t}^*)^{1-\theta}Y_{X,t}^*$.

The first order conditions are:

$$C_t^{-\gamma} = \beta(1+r_{t+1})E_t\left[C_{t+1}^{-\gamma}\right] \tag{A.13}$$

$$\hat{v}_t = \beta(1-\delta)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}(\hat{d}_{t+1}+\hat{v}_{t+1})\right] \tag{A.14}$$

Note that solving forward the equation for shares we obtain an expression for the average value

[17] $\hat{v}_t$ is equivalent to the present discounted value of all future profits.

of firms (expected discounted value of all future profits). This implies that the average value of the firm is:

$$\hat{v}_t = E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^{s-t} \left(\frac{C_{t+1}}{C_t}\right)^{-\gamma} \hat{d}_s$$

As in Ghironi and Melitz (2005) baseline model, we assume financial autarky which implies the following expression for aggregate accounting:

$$C_t = w_t L + N_t \tilde{d}_t - N_{E,t} \tilde{v}_t + \psi_t N^*_{X,t} (\hat{p}^*_{X,t})^{1-\theta} Y^*_{X,t} \tag{A.15}$$

Also, financial autarky implies balance trade so that exports from A to B must be equal to exports from B to A when expressed in the same units of consumption, i.e.

$$Q_t N_{X,t} (\hat{p}_{X,t})^{1-\theta} Y^*_{X,t} = N^*_{X,t} (\hat{p}^*_{X,t})^{1-\theta} Y_{X,t} \tag{A.16}$$

Lastly, note that Q_t is the welfare based real exchange rate; i.e., it measures households' welfare change when consuming goods produced in A and B. Then, as shown by Ghironi and Melitz (2005) Q_t could respond differently to shocks than the CPI based real exchange rate which measures the cost of the basket in country B in terms of the basket of country A. To analyze the impact of tariffs in the CPI based real exchange rate (Qav hereafter) such authors proposed to decompose the price indices into components representing average prices and varieties:

$$Qav = \left(\frac{N_{D,t} + N^*_{X,t}}{N^*_{D,t} + N_{X,t}}\right)^{\frac{1}{\theta-1}} Q_t \tag{A.17}$$

B Equilibrium Conditions

Real Domestic Profits:

$$d_{D,t} = \frac{1}{\theta} p_{D,t} (\tilde{z}_D)^{1-\theta} C_t \tag{B.1}$$

$$d^*_{D,t} = \frac{1}{\theta} p^*_{D,t} (\tilde{z}^*_D)^{1-\theta} C^*_t \tag{B.2}$$

$$\tag{B.3}$$

Real Export Profits:

$$d_{X,t} = \frac{1}{\theta} Q_t \frac{p_{X,t}(\tilde{z}_{X,t})^{1-\theta}}{(1+\psi^*_t)^\theta} Y_{X,t} - \frac{w_t f_{X,t}}{Z_t} \tag{B.4}$$

$$d^*_{X,t} = \frac{1}{Q_t \theta} \frac{p^*_{X,t}(\tilde{z}^*_{X,t})^{1-\theta}}{(1+\psi_t)^\theta} Y^*_{X,t} - \frac{w^*_t f^*_{X,t}}{Z^*_t} \tag{B.5}$$

Total Real Profits

$$d_t = d_{D,t} + \frac{N_{X,t}}{N_t} d_{X,t} \tag{B.6}$$

$$d^*_t = d^*_{D,t} + \frac{N^*_{X,t}}{N^*_t} d^*_{X,t} \tag{B.7}$$

Price Indices:

$$1 = \left[N_t p_{D,t} (\tilde{z}_D)^{1-\theta} + N^*_{X,t} p^*_{X,t} (\tilde{z}^*_{X,t})^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{B.8}$$

$$1 = \left[N^*_t p^*_{D,t} (\tilde{z}^*_D)^{1-\theta} + N_{X,t} p_{X,t} (\tilde{z}_{X,t})^{1-\theta} \right]^{\frac{1}{1-\theta}} \tag{B.9}$$

Free Entry Condition:

$$v_t = \frac{w_t f_{E,t}}{Z_t} \tag{B.10}$$

$$v^*_t = \frac{w^*_t f^*_{E,t}}{Z^*_t} \tag{B.11}$$

Number of Producing Firms:

$$N_{D,t} = (1-\delta)[N_{t-1} + N_{E,t-1}] \tag{B.12}$$
$$N^*_{D,t} = (1-\delta)[N^*_{t-1} + N^*_{E,t-1}] \tag{B.13}$$

Free Entry Condition Export Market:

$$\hat{d}_{X,t} = \frac{\theta-1}{k}\frac{u^{\theta-1}}{(1+\psi^*_t)^{\theta}}\frac{w_t f_{X,t}}{Z_t} \tag{B.14}$$
$$\hat{d}^*_{X,t} = \frac{\theta-1}{k}\frac{u^{\theta-1}}{(1+\psi_t)^{\theta}}\frac{w^*_t f^*_{X,t}}{Z^*_t} \tag{B.15}$$

Share of exporting firms:

$$\frac{N_{X,t}}{N_t} = \left(\frac{\tilde{z}_d}{\tilde{z}_{X,t}}\right)^k \tag{B.16}$$
$$\frac{N^*_{X,t}}{N^*_t} = \left(\frac{\tilde{z}^*_d}{\tilde{z}^*_{X,t}}\right)^k \tag{B.17}$$

Euler condition for bonds:

$$(C^*_t)^{\gamma} = \beta(1+r_{t+1})E_t(C^*_{t+1})^{-\gamma} \tag{B.18}$$
$$(C^*_t)^{\gamma} = \beta(1+r_{t+1})E_t(C^*_{t+1})^{-\gamma} \tag{B.19}$$

Euler condition for shares:

$$v_t = \beta(1-\delta)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}(d_{t+1}+v_{t+1})\right] \tag{B.20}$$
$$v^*_t = \beta(1-\delta)E_t\left[\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\gamma}(d^*_{t+1}+v^*_{t+1})\right] \tag{B.21}$$

Aggregate accounting:

$$C_t = w_t L_t + d_t N_t - v_t N_{E,t} + \psi_t N^*_{X,t}(\hat{p}^*_{X,t})^{1-\theta} Y^*_{X,t} \tag{B.22}$$
$$C^*_t = w^*_t L^*_t + d^*_t N^*_t - v^*_t N^*_{E,t} + \psi^*_t N_{X,t}(\hat{p}_{X,t})^{1-\theta} Y_{X,t} \tag{B.23}$$

Balance trade:

$$Q_t N_{X,t} (\hat{p}_{X,t})^{1-\theta} Y^*_{X,t} = N^*_{X,t} (\hat{p}^*_{X,t})^{1-\theta} Y_{X,t} \tag{B.24}$$

B.1 Market Clearing

Following Ghironi and Melitz (2005) we know that the total amount of labor hired to produce goods for the domestic market is given by:

$$l_{D,t}(z) = \frac{\theta - 1}{w_t} N_t d_{D,t}(z) \tag{B.25}$$

Similarly, let $l_{X,t}$ represent the amount of labor hired to produce goods for the export market in country A. Then, real profits earned from selling abroad by a firm with productivity z are:

$$d_{X,t} = Q_t \hat{p}_{X,t}(z) \frac{z Z_t l_{X,t}}{\tau_t}(1+\psi_t) - w_t l_{X,t} - w_t \frac{f_{X,t}}{Z_t} \tag{B.26}$$

Keep in mind that the amount produced is $zZ_t l_{X,t}$ but due to iceberg-cost and revenue tariffs the amount sold is $\frac{zZ_t l_{X,t}}{\tau_t}(1+\psi_t)$. Using optimal pricing as well as the zero export profit condition, and after some algebra we get that the total amount hired by the average exporting firm to sell in the export market is:

$$l_{X,t} = \frac{\theta - 1}{1+\theta\psi} \left[\frac{d_{X,t}}{w_t} + \frac{f_{X,t}}{Z_t} \right] \tag{B.27}$$

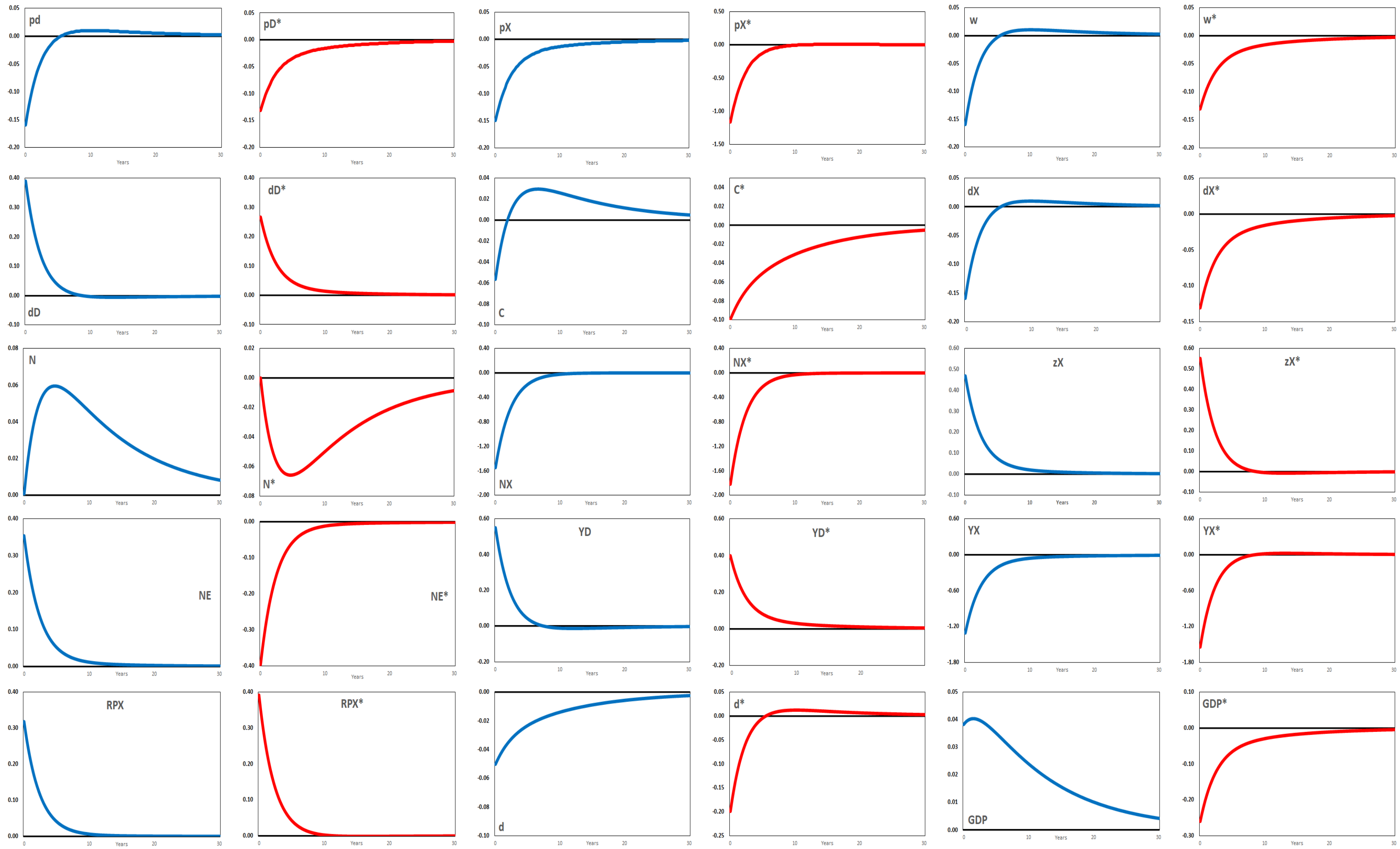
Multiplying this equation by $N_{X,t}$ we get the total amount hired to sell in the export market. Then, the sum of the total labor hired to sell in the domestic market, plus the one hired to sell in the export market, plus the amount of labor hired by the total number of entrants at time t we obtain aggregate labor demand in county A:

$$L_t = \frac{\theta - 1}{w_t} N_t d_{D,t}(z) + \frac{\theta - 1}{1+\theta\psi} \left[\frac{d_{X,t}}{w_t} + \frac{f_{X,t}}{Z_t} \right] + N_{E,t} \frac{f_{E,t}}{Z_t} \tag{B.28}$$

As in Ghironi and Melitz (2005), equalizing L_t to labor supply (L) we obtain country A's labor market equilibrium condition.

C The No Retaliation Scenario

Figure C.1: Response to a Temporary Rise in Tariffs to Exports from Country B



In percent deviations from the steady-state