Protectionism and the Business Cycle*

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Abstract

We study the consequences of protectionism for macroeconomic fluctuations. First, using high frequency trade-policy data, we present fresh evidence on the dynamic effects of temporary trade barriers. Estimates from country-level and panel VARs show that protectionism acts as a supply shock, causing output to fall and inflation to rise in the short run. Moreover, protectionism has at best a small positive effect on the trade balance. Second, we build a small-open economy model with firm heterogeneity, endogenous tradability, and nominal rigidity to study the channels through which protectionism affects aggregate fluctuations. The model successfully reproduces the VAR evidence and highlights the importance of both macro and micro forces for the contractionary effects of tariffs. We then use the model to study scenarios where temporary trade barriers have been advocated as potentially beneficial, including recessions with binding constraints on monetary policy easing or in the presence of a fixed exchange rate. Our main conclusion is that, in all the scenarios we consider, protectionism is not an effective tool for macroeconomic stimulus and/or to promote rebalancing of external accounts.

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Keywords: Inflation; Liquidity trap; Macroeconomic dynamics; Protectionism; Tariffs.

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1 Introduction

To paraphrase Karl Marx and Friedrich Engels (1848), a specter is haunting the world economy—the specter of protectionism. The outcomes of meetings of G-20 finance ministers and central bank governors have been raising the concern that key powers may be taking steps away from existing alliances that had been forged also to exorcise this specter.[1] Disappointment with the performance of the globalized world economy since the crisis of 2007-08 and a wave of referendum or electoral outcomes have sharply increased the likelihood of aggressive use of trade restrictions as instruments of economic policy. In the United States, President Trump's administration has threatened punitive tariffs against a number of partners, and the corporate tax reform proposals by Congress leadership would introduce a border adjustment in taxation that would amount to a combination of import tariff and export subsidy.[2] Analysts and pundits everywhere have been debating possible costs and benefits of trade policy as a tool to boost aggregate economic performance, rebalance external accounts, or address distributional effects of trade. Influential scholars have argued that tariffs may be beneficial when countries are mired in a liquidity trap, as the inflationary effect of increased import costs may help lift the economy out of the trap (for instance, Eichengreen, 2016).

This paper contributes to this debate by studying the effects of protectionism on macroeconomic fluctuations. First, we take a fresh look at time series evidence by using vector autoregressions (VARs) to investigate the short-run effects of trade policy on macroeconomic outcomes. We perform two variants of this exercise: one that focuses on individual countries using quarterly or monthly data, and the other that uses annual data in a panel VAR for a larger set of countries. In the first exercise, we use Bown's (2016) Global Antidumping Database (GAD) to construct series of initiations of antidumping investigations, which are usually followed by the imposition of antidumping tariffs. We identify exogenous trade policy shocks by exploiting the contemporaneous exogeneity of antidumping investigations with respect to macroeconomic variables. We consider three countries: two emerging economies that are most active in using these trade policy measures (Turkey and India) and the largest user among small-open developed economies (Canada). We combine these time series with series on inflation, GDP, and the trade balance (as a ratio to GDP) to study the consequences of protectionist shocks in structural VAR regressions.

In the second exercise, we use a panel VAR on fifteen small open economies that addresses the

[1] For instance, references to commitment by the members of the group to reject protectionism were not included in the communiqué issued at the end of the March 2017 meeting of G-20 policymakers in Baden-Baden, Germany. This was in striking contrast to past meetings.

[2] See Freund (2017).

fact that the GAD covers only a limited portion of total imports. In this exercise, we consider the import weighted average of applied tariff rates. This restricts our attention to annual data, but we expand sample size by working with a panel of countries. Important for our analysis that follows, none of the countries in our panel found itself at the zero lower bound (ZLB) on monetary policy interest rates in our sample, and all the countries operated under floating exchange rates.

Three robust conclusions emerge from our empirical exercises (and a variety of checks): protectionism is recessionary, inflationary, and it has, at best, a small positive effect on the trade balance/GDP ratio. Essentially, the dynamic effects of protectionism in small open economies are akin to those of negative supply-side shocks that contract output, increase prices, and have a combination of contrasting effects on the trade balance.

In the second part of the paper, we lay down a benchmark small open economy model of international trade and macroeconomic dynamics that allows us to delve deeper into the dynamic effects of protectionism. The model builds on Ghironi and Melitz's (2005—GM below) dynamic stochastic general equilibrium version of Melitz's (2003) trade model by incorporating the endogenous entry of heterogeneous producers into domestic and export markets. Differently from GM, endogenous tradedness in the tradable sector (the fact that only a subset of tradable goods is actually traded in equilibrium) is supplemented by the inclusion of a traditional exogenously non-tradable sector. We also assume that one of the two countries in the model is a small open economy that has no impact on the rest of the world. Nominal rigidity is introduced in the form of sticky nominal wages. We calibrate the model and study the consequences of an increase in protectionism by the small open economy under flexible exchange rates.

The predictions of the model match the robust results of the empirical evidence: Protectionism is inflationary, recessionary, and it can generate a small improvement in the trade balance, but at the cost of a recession. The model highlights the importance of both macro and micro forces for the contractionary effects of tariffs. Higher import prices prevail on a decline in the price of domestic non-tradables (due to lower aggregate demand) in driving CPI inflation upward. Tariffs induce expenditure switching toward domestic tradable goods, but they also reallocate domestic market share toward less efficient domestic producers. Households find themselves having to spend more of their reduced real income to consume any given amount of imports and any given amount of the bundle of less-efficiently produced domestic tradables. The result is a reduction in aggregate demand. At the same time, the increase in the price of consumption reduces the resources available for investment in physical capital and producer entry. The decline of investment in both physical capital and creation of new productive units is key in propagating the recessionary effects of protectionism. In addition to this, the central bank's response to higher inflation imparts an additional contractionary impulse. Lower aggregate demand and monetary policy contraction prevail on expenditure switching in causing recession in the aftermath of an increase in protectionism. Improvement in the trade balance follows from the combination of expenditure switching and the fact that contraction of domestic income reduces the demand for imports. Overall, model and empirical investigation line up closely in terms of qualitative results and implications: In normal times and under a flexible exchange rate, protectionism is not advisable if policymakers want to avoid economic contraction, and, given its recessionary effect, it is at best of dubious value if policymakers want to improve their countries' external accounts.

We then use the model to study counterfactual scenarios where temporary trade barriers have been advocated as potentially beneficial. We first consider the argument that protectionism could be helpful when countries are in a liquidity trap (i.e., when countries are stuck at the zero lower bound—ZLB—on policy interest rates). Both our empirical evidence and theoretical analysis suggest that protectionism is inflationary. Through this channel, protectionism may indeed be temporarily useful to lift economies out of ZLB situations. We therefore perform the following counterfactual exercise: Suppose the model-home economy is hit by an exogenous, recessionary shock that pushes the central bank against the ZLB constraint. Would the imposition of tariffs on imports in the aftermath of this shock help lift the economy out of the liquidity trap? Since the predictions of the model line up nicely with the evidence when tariffs are imposed under "normal economic conditions"—none of the countries in our empirical analysis found itself at the ZLB in our sample—the counterfactual exercise sheds empirically-relevant light on the issue of interest.

The answer is that any beneficial inflationary effects of protectionism are not sufficient to overcome the unfavorable macroeconomic effects of reduced real income. Moreover, larger or more persistent trade shocks have larger recessionary effects along the transition dynamics when the economy is at the ZLB. The reason is that larger or more persistent tariff increases have a more unfavorable effect on aggregate demand, which reduces the extent to which the trade policy is inflationary. Through this channel, a large or persistent trade policy shock ends up becoming deflationary very shortly after its initial inflationary effect, which worsens the liquidity trap instead of ameliorating it.

We then explore the consequences of protectionism for countries that peg the nominal exchange rate. Our interest reflects the widespread diffusion of pegs, crawling pegs, or very narrow bands

(Reinhart and Rogoff, 2004). A recent illustration of the issue is the experience of Ecuador—a dollarized economy that applied a broad range of temporary tariffs between 2015 and 2016 to fight a balance-of-payments crisis. Over this period, the trade balance of Ecuador effectively improved, but the growth of real GDP further declined, together with consumption and investment. In contrast to the typical conclusion of textbook models, we find that protectionism remains contractionary even when the exchange rate is fixed: Higher import prices continue to result in lower aggregate income and investment, pushing the economy into a recession.

In sum, the policy conclusion of our paper is that protectionism remains a bad idea—at least for small open economies—even when it is used temporarily, even when economies are stuck in liquidity traps, and regardless of the flexibility of the exchange rate. Detrimental economic effects arise even abstracting from retaliation from trade partners.

The paper is related to several literatures. There is a massive amount of work that studies virtually every aspect of the consequences of protectionism in the international trade field, both theoretically and empirically. It is impossible to do this work any justice in the limited space of a non-survey paper.[3] Our research is obviously related to work in the trade field by virtue of using data and concepts that are familiar to trade economists—most notably, Bown (2013) and Bown and Crowley (2013, 2014). To the best of our knowledge, this is the first study to use high frequency trade policy data to identify the short-term effects of protectionism.

We also connect to trade research by incorporating rigorous, state-of-the-art trade microfoundations in our macroeconomic model. This allows us to move the frontier set by early analyses of the dynamic effects of protectionism in international macro models closer to the current frontier of the trade field, and to use present-day modeling tools to address the connection between protectionism and macroeconomic dynamics that so many analysts and pundits are spilling ink on.

The macroeconomic effects of trade policy were among the topics of Mundell's (1961) seminal analysis of "Flexible Exchange Rates and Employment Policy." Mundell warned against the potential recessionary effects of restrictive trade policies under flexible exchange rates, but highlighted deflationary effects of terms of trade movements. Krugman (1982) showed that Mundell's conclusion is in fact quite robust to various extensions of the basic IS-LM model. Dornbusch, Fischer, and Samuelson (1977) included changes in tariffs among the scenarios they explored in their Ricardian model of international trade and macro dynamics. Eichengreen (1981, 1983) studied the conse-

[3] See Goldberg and Pavcnik (2016) and references therein for a comprehensive discussion of the effects of trade policy on trade volumes, prices, productivity, and labor market outcomes.

quences of tariffs in a portfolio balance model of exchange rate and macro dynamics. In contrast to previous work, he found that a tariff can have temporary expansionary effects before reducing output and employment in subsequent periods. In more recent literature on trade and macro dynamics, interest shifted toward understanding the dynamic consequences of trade integration (permanently lower trade costs) rather than temporary increases in protectionism. For instance, see Barattieri's (2014) analysis of global imbalances and asymmetric trade integration in goods versus services, or Cacciatore's (2014) study of trade integration and labor market dynamics with heterogeneous firms and labor market frictions. Farhi, Gopinath, and Itskhoki (2014) pioneered a literature that investigates the ability of policymakers to deliver devaluation-consistent dynamics under a flexible exchange rate by using fiscal policy tools, and a budding literature is exploring the macroeconomic consequences of combinations of trade policy instruments (tariffs-cum-subsidies) or of the border adjustment proposal (Barbiero, Farhi, Gopinath, and Itskhoki, 2017; Erceg, Prestipino, and Raffo, 2017; Lindé and Pescatori, 2017). We restrict attention to tariffs (which it would be legal to impose under WTO rules in the context of antidumping procedures) as the benchmark trade policy tool, and—when the exchange rate is fixed—we do not design tariff setting to generate dynamics that mimic any feature of a devaluation. We focus on exogenous increases in tariffs to keep the model-based exercise close to the empirical investigation. Our paper contributes to the literature that reintroduces analysis of protectionism in present-day international macro modeling by using a quantitative trade and macro model with implications in line with the evidence on the issues we focus on.[4]

There is much that this paper does not do: We restrict attention to small open economies, since this is where we find more data to perform empirical investigation of the dynamic effects of protectionism. Given the "America First" stance of President Trump's administration and the debate on trade policy in the United States, it will be important to investigate the interaction of protectionism and macro dynamics when economies are large and their policy actions have non-negligible external effects. The recent papers we mentioned in the previous paragraph make a start at that in models that do not feature the trade microfoundation of our framework. We do not study optimal tariff setting.[5] Finally, we do not address the distributional consequences of

[4] By exploring whether protectionism is expansionary at the ZLB, this paper is also related to the study of the possible expansionary effects of negative supply shocks in Wieland (2016) and to the analysis of non-conventional fiscal policy at the ZLB by Correia, Farhi, Nicolini, and Teles (2011).

[5] Eaton and Grossman (1981) provide an interesting analysis of the interaction of optimal tariff setting and market incompleteness for a small open economy. They find that incomplete markets motivate the optimality of positive tariffs. Optimal tariff arguments are part of the analysis of monetary policy in Bergin and Corsetti (2015). They use a model with endogenous producer entry in the traded sector, but they do not focus on the consequences of trade

protectionism or the dynamic impact it could have on the sectoral structure of the economy. These are all interesting, important topics that we leave for future research.

The rest of the paper is organized as follows. Section 2 presents our empirical exercise. Section 3 lays down the model. Section 4 presents the calibration, Section 5 uses the calibrated model to investigate the effects of imposing tariffs in normal times or at the ZLB. Section 6 studies the effects of protectionism under a fixed exchange rate. Section 7 concludes.

2 Empirical Evidence

In this Section, we study the macroeconomic effects of trade policy shocks by applying structural vector autoregression methods. First, we use quarterly and monthly measures of temporary trade barriers and macroeconomic data for individual countries. Second, we consider annual tariffs and macroeconomic data for a panel of 15 small-open economies. We identify trade policy shocks by exploiting decision lags inherent in trade policy decisions. The main conclusion is that protectionism acts as a supply shock, as it is both inflationary and recessionary. At the same time, protectionism has at best a small positive effect on the trade balance.

Monthly and Quarterly Trade Policy Data

Antidumping duties, global safeguards, and countervailing duties—what Bown (2011) calls temporary trade barriers—are the primary policy exceptions to the trade rules embodied in the GATT/WTO. These are the policies used by both industrial and developing countries to implement new trade restrictions during the last twenty years. As a result, exporters are simultaneously subject to low (on average) applied import tariffs, while facing frequently changing temporary trade barriers. Among the latter, antidumping initiatives account for the vast majority of trade policy actions—across countries, they account for between 80 and 90 percent of all temporary trade barriers.

The Global Antidumping Database (GAD), maintained by Bown (2016), collects and organizes information on product-level antidumping investigations since the late 1980s across country users.[6] The database provides information about the date in which antidumping investigations are initiated, their outcomes (i.e., the amount of antidumping duties), the products involved, and the trading

policy shocks.

[6] As of June 2017, the data are available at http://econ.worldbank.org/ttbd/gad/. The time coverage varies across countries.

partners against which the initiatives apply. Given the structure of the dataset, it is possible to build time series data for antidumping policy actions at any time frequency longer than daily.

Following Bown and Crowley (2013), our baseline measure of trade policy corresponds to the number of HS-6 products for which an antidumping investigation begins in a given quarter or month. We construct time series data by matching the initiation dates of each anti-dumping case recorded in the GAD to the number of HS-6 products interested by each investigation. Notice that while the products subject to investigations are typically recorded with HS-6 codes, in some cases the information is available at a more disaggregated level (8- or 10-digits). As in Bown (2011), we record such observations at the HS-6 level whenever at least one sub-product is subject to the investigation. We focus on two countries in the main text: Turkey and Canada.[7] Turkey is the largest and most active user of temporary trade barriers together with India (Bown, 2011); Canada is the largest and most active user among developed small-open economies.[8] In the Appendix, we also report the results for India.

We identify exogenous trade policy shocks by exploiting the contemporaneous exogeneity of antidumping investigations with respect to macroeconomic variables. The reason why antidumping investigations are predetermined within a quarter or a month is twofold. First, there are decision lags in the opening of investigations stemming from coordination issues among producers and technical aspects of regulation—the opening of an investigation requires filing a petition (supported by a minimum number of producers) that gathers evidence about dumped imports, and a preliminary assessment of compliance.[9] Second, antidumping investigations respond to trade import-injury due to unfair foreign competition, which is less likely to depend on current macroeconomic conditions in the domestic economy.

The identifying assumption is valid as long as trade policy actions are not anticipated by economic agents—from an econometric standpoint, anticipation can lead to a non-fundamental moving average VAR representation. Our focus on the initiations of antidumping investigations rather than on their final outcome (i.e., the imposed antidumping duties) addresses this issue. The reason is

[7] In Turkey, a small fraction of observations are recorded at the 4-digits level. Our baseline measure does not include these observations. In the Appendix, we show that our results are robust to an alternative treatment of 4-digits observations.

[8] For instance, Bown (2011) reports that in 2009, about 5.3 percent of Turkish imported products were subject to temporary trade barriers, amounting to 1 percent of GDP. The figure is very similar in India. In Canada, over the period 1997-2007, 1.7 percent of imported products were subject to temporary trade barriers on average, corresponding to about 0.4 percent of GDP.

[9] For instance, in Turkey the industry application must represent at least 25 percent of the product's total production. Moreover, once producers bring the application before the board, it takes up to 45 days for a final decision about the opening of an official antidumping investigation.

that petitions to open an investigation are not publicly announced, and the supporting evidence is not disclosed to the public until a later date. By contrast, the final outcomes of ongoing investigations are likely to be anticipated. First, the opening of an investigation (as opposed to the initiation of the process by filing a petition) is immediately announced to the public and agents can access the supporting documentation. Second, the application of antidumping duties is in general retroactive (up to the beginning of the investigation). Third, antidumping tariffs are predictable at the time of the investigation, since duties are commensurate to the margins of dumping. Indeed, the share of antidumping investigations that end up with the imposition of tariffs is substantial (more than 85 percent of cases in Turkey and India and approximately 65 percent of cases in Canada). For these reasons, our benchmark specification focuses on the initiation of antidumping investigations.[10] In the Appendix, we discuss the sensitivity of the results to alternative measures that exploit information about the outcomes of the investigations.

We augment trade policy data with macroeconomic series from the OECD statistical database. We consider both quarterly and monthly time series. Quarterly data allow us to use a comprehensive measure of aggregate economic activity (real GDP rather than industrial production). Monthly data feature a larger number of observations, allowing us to include more series in the VAR. Notice that the specific frequency of observations (quarterly versus monthly) is not crucial for the identification of exogenous trade policy shocks, since, as noted above, decision lags realistically exceed a quarter. We now turn to the discussion of the econometric models and results.

Quarterly Data

For each country, we estimate a structural VAR with four observables: the number of antidumping initiatives, real GDP growth, the core CPI inflation rate, and real net exports over GDP.[11] The data cover the period 1994:Q1 to 2015:Q4. The Appendix presents the details about the data.

Figure 1 and Figure 2 report the dynamics of the trade policy measure at quarterly frequency

[10] Whether or not the assumption has first-order effects depends on the time elapsing between the beginning and the end of an investigation. For Canada, the median duration of an investigation is 90 days, suggesting that at quarterly frequencies the distinction is less important. For Turkey, the information about the dates of preliminary decisions is in general not available. Staiger and Wolak (1994) find that the mere opening of an antidumping investigation has effects on imports due both to an exporter pricing mechanism and to an importer reaction to the filing of an investigation.

[11] Core inflation is more appropriate than headline inflation to assess the effects of antidumping investigations, since antidumping policy in practice is never applied to energy and food products. Results remain robust when considering headline CPI inflation. Notice also that Turkish inflation dynamics display a significant decline in the early 2000s, reflecting the adoption of inflation targeting (the new regime was announced in 2002 and implemented in 2006). For this reason, we allow the mean of the inflation rate to differ pre- and post-2004—by 2004, inflation was stabilized, leading to a new regime with lower mean and variance.

together with the growth rate of real GDP. Both figures show substantial variation over time in the number of products subject to new antidumping investigations.

We estimate the VAR including two lags of each variable, ordering the trade policy measure first.[12] This is tantamount to imposing a recursive ordering of the structural shocks such that trade policy does not respond to macroeconomic shocks contemporaneously. Since we are not interested in identifying shocks to macroeconomic variables, their ordering is irrelevant for the purpose of our analysis.

Figures 3 and 4 report the impulse responses to a one-standard deviation shock to antidumping initiations in Turkey and Canada, respectively.[13] In Turkey, the trade policy shock increases inflation, with a peak three quarters after the shock. At the same time, the shock is recessionary, since the growth rate of GDP declines—the trough is also three quarters after the shock. Real net exports rise. Annualized inflation increases by almost 1.5 percent at its peak, and GDP growth decreases by approximately 0.5 percent. To understand the magnitude of the responses, notice that a one-standard deviation shock is equivalent to doubling the number of HS-6 products that are subject to antidumping investigations in the average quarter. Moreover, once imposed, the antidumping tariffs are high—ad-valorem tariffs are on average 35 percent—and they remain in place for several years (75 months in Turkey and 60 in Canada). Finally, input-output linkages contribute to the propagation of protectionism, since higher tariffs raise the cost of intermediate inputs across sectors.

The results for Canada are qualitatively identical, although the response of macroeconomic variables is quantitatively smaller. Annualized inflation rises by approximately 0.2 percent at the peak, while GDP growth declines by 0.2 percent at the trough. The smaller effect is attributable to the smaller size of the trade policy shock, since in this case a one-standard deviation shock is equivalent to a 50-percent increase in the number of HS-6 products subject to antidumping investigations. The average antidumping tariff imposed by Canada is approximately 48 percent. Finally, we find a modest, albeit significant, increase in the trade balance over GDP.

In the Appendix, we conduct several additional exercises to assess the robustness of our findings. First, we consider alternative trade policy measures. Second, we replace the growth rate of real GDP with log-deviations of real GDP from a deterministic trend. Third, we include the oil price in the VAR, an additional control for supply-side determinants of GDP and inflation.[14] The results

[12] The Akaike information criterion suggests this is a plausible choice for both countries.

[13] The error bands are at 68 percent confidence level and obtained via bootstrapping as in Kilian (1998).

[14] We use the Global Price of WTI Crude provided by the Federal Reserve Bank of St. Louis. To limit the number

remain very similar to those generated by the benchmark specification. Finally, we estimate the VAR on Indian data. Also in this case, the results are similar to those for Canada and Turkey.

Monthly Data

At monthly frequency, we replace real GDP growth with the log-deviations of industrial production from a deterministic trend, and we consider the level of real net exports (measured in 2010 USD billions). We also add the nominal interest rate and the appreciation rate of the effective nominal exchange rate to the list of macroeconomic variables.[15] The increased number of observations also allows us to control for the role of macroeconomic developments that characterize the Turkish economy in the early 2000s—Turkey experienced both financial and monetary policy reforms in the aftermath of the 2001 crisis. In particular, we restrict the sample to the post-2004 period, although the results are not substantially affected by using the full sample. The period of analysis is hence 2004:M1-2015M:12 for Turkey and 1994:M1-2015:M12 for Canada.

Figure 5 reports the results for Turkey. Following the increase in antidumping initiations, inflation increases on impact, and it remains positive for four months. A second positive and significant peak occurs at the seventh month. Industrial production declines for seven months with a decline of about 0.5 percent at the trough. Real net exports display a modest increase. The nominal exchange rate, after an initial depreciation, displays a persistent appreciation, with a significant peak at the seventh month. By contrast, the response of the interest rate is not significant.

Figure 6 reports the results for Canada. The industrial production index declines slowly, and it remains negative and statistically significant for several months. The annualized inflation rate displays a statistically significant increase after four months (by about 0.3 percent). The response of the interest rate is also positive and significant on impact, with a slow decay afterwards. Initially, the response of net exports is positive and statistically significant, followed by a decline, which is however non statistically significant. The nominal exchange rate display an appreciation, which becomes significant at the fifth month.

In the Appendix, we show that the results are robust to considering the same alternative trade

of impulse responses presented in the Appendix, the estimates from the VARs that include the oil price are available upon request.

[15] For the Canadian interest rate, we use the overnight interbank rate provided by the OECD. For Turkey, we follow Kilinc and Tunc (2014) and use the overnight repo interest rate provided by the Bolsa of Istanbul. (In the robustness analysis with quarterly data, we used a different series for the Turkish interest rate, since the repo rate is only available since 2000.)

policy measures as for the quarterly VAR and to the inclusion of the growth rate of industrial production rather than its level. We also report impulse responses for India. The results are similar to those obtained for Canada and Turkey.

Annual Tariff Data: A Panel SVAR of Small Open Economies

The Global Antidumping Database makes it possible to construct monthly and quarterly measures of trade policy. However, antidumping investigations only apply to a subset of imports. For this reason, we now consider a more comprehensive trade policy measure, the import-weighted average of the applied tariff rates.[16]

Since tariff data are only available at annual frequency, we estimate a panel SVAR using harmonized data for a sample of fifteen countries over the period 1996-2014. Data limitations determine the list of countries that we include in the analysis.[17] All the countries in the sample had a floating exchange rate regime and none of them hit the zero lower bound on the policy interest rate over the sample period.[18]

Figure 7 plots the tariff data for the fifteen countries in our sample. Over time, the applied tariff rates show a general decline in all the countries considered.[19] However, there is significant variation around the downward trend in several countries. Given this observation, we measure temporary trade policy interventions by removing a linear trend from the tariff series.

Our benchmark SVAR specification includes three macroeconomic variables: the growth rate of real GDP, CPI inflation, and real net exports over GDP.[20] The data come from the World Development Indicators database (see the Appendix for details). We also include country-fixed effects, accounting for unobserved, time-invariant cross-country heterogeneity, and year fixed effects, accounting for the presence of common shocks across countries. Due to the limited dimension of the dataset, we restrict each equation coefficient to be the same across countries.

[16] We use HS-6 digits tariff rates from WITS. The import-weighted average of applied tariff rates is computed by using fixed weight, with imports fixed at the 1996 level. This addresses the concern that variation in the average may reflect changes in weights rather than in tariffs.

[17] The countries in the sample are Australia, Brazil, Canada, Chile, Colombia, Iceland, South Korea, South Africa, Malaysia, Norway, New Zealand, Philippines, Paraguay, Turkey, and Uruguay.

[18] Malaysia pegged its currency to the US dollar for part of the sample. However, the exclusion of Malaysia from the sample does not affect our results.

[19] Especially at the beginning of the sample, coinciding with the implementation of the Uruguay round of trade negotiations, and the establishment of the WTO.

[20] We remove a linear trend from CPI inflation due to the presence of deterministic trends in inflation for several countries in the sample. The panel-unit-root tests proposed by Levin, Lin, and Chu (2002) reject at the one percent confidence level the presence of unit roots in the three macroeconomic variables we use (against the alternative that each panel variable is trend-stationary).

We continue to identify trade policy shocks by assuming that trade policy responds with a one-period delay to macroeconomic shocks. As before, the assumption reflects decision lags in trade policy changes. For instance, in the context of the WTO, when tariffs increase above their bound rate, countries have to negotiate with the most concerned trading partners (possibly settling a compensation for the loss of trade). Moreover, various countries in our sample are part of custom unions (Brazil, Colombia, Paraguay, Turkey and Uruguay), and common external tariffs are set at the level of the union. We estimate the VAR including one lag of each variable.

Figure 8 reports the impulse responses to a one-standard deviation tariff increase (around 1.2 percentage points).[21] Inflation rises by 0.4 percentage points, while GDP growth decreases by about 0.3 percent on impact. While the point estimate of real next exports over GDP is positive, the effect is not statistically significant.

In the Appendix, we show that the results are robust to the inclusion of a measure of the short term interest rate.[22] Furthermore, we provide additional evidence by considering a measure of the extensive margin of trade policy. In particular, for each year and country, we compute the share of non-zero tariff lines using a 6-digits HS classification code. Also in this case, we find that an increase in the share of non-zero tariff lines is inflationary and recessionary.[23]

Overall, the empirical analysis provides evidence of non-negligible macroeconomic effects of temporary trade barriers at frequencies that are relevant for business cycle analysis. In particular, trade policy tends to be inflationary and recessionary in small open economies that operate under flexible exchange rates. At the same time, protectionism has at best a small positive effect on the trade balance.

3 The Model

In this Section, we develop the small open economy model of trade and macroeconomic dynamics that we will use for the exercises in the remainder of the paper.

As is now standard practice in the literature, we model the small open economy as a limiting case of a two-country dynamic general equilibrium model in which one country (the small open economy, also referred to as Home) is of measure zero relative to the rest of the world (Foreign

[21] As before, the error bands are at 68 percent confidence level and obtained via bootstrapping as in Kilian (1998).

[22] As detailed in the Appendix, data on interest rates come mostly from the OECD. For Paraguay and Uruguay, the data come from the IMF IFS. For Malaysia and Philippines, we used data directly collected from the respective central banks.

[23] However, while the response of inflation is statistically significant, the response of GDP growth is not.

henceforth). As a consequence, the policy decisions and macroeconomic dynamics of the small open economy have no impact on Foreign. We abstract from monetary frictions that would motivate a demand for cash currency, and we resort to a cashless model following Woodford (2003). Next we describe in detail the problems facing households and firms in the small open economy.

Household Preferences

The small open economy is populated by a unit mass of atomistic households. Each household is a monopolistic supplier of one specific labor input. The representative household, indexed by $h \in [0,1]$, maximizes the expected intertemporal utility function

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[u((C_t(h)) - v(L_t(h))\right], \tag{1}$$

where $\beta \in (0,1)$ is the discount factor, $C_t(h)$ is a consumption basket that aggregates traded and non-traded goods as described below, and $L_t(h)$ is the number of hours worked. Period utility from consumption, $u(\cdot)$, and disutility of effort, $v(\cdot)$, satisfy the standard assumptions. In order to simplify the notation, we anticipate symmetry of the equilibrium across households and omit the index h below, unless it is necessary for clarity.

Consumption is a C.E.S. composite of tradable and non-tradable baskets, C_t^T and C_t^N:

$$C_t = \left[(1-\alpha_N)^{\frac{1}{\phi_N}} \left(C_t^T\right)^{\frac{\phi_N - 1}{\phi_N}} + \alpha_N^{\frac{1}{\phi_N}} \left(C_t^N\right)^{\frac{\phi_N - 1}{\phi_N}}\right]^{\frac{\phi_N}{\phi_N - 1}},$$

where $\alpha_N \in (0,1]$ is the share of non-tradables and $\phi_N > 0$ denotes the constant elasticity of substitution. The consumption-based price index is

$$P_t = \left[(1-\alpha_N)\left(P_t^T\right)^{1-\phi_N} + \alpha_N \left(P_t^N\right)^{1-\phi_N}\right]^{\frac{1}{1-\phi_N}},$$

where P_t^T is the price of the tradable basket and P_t^N is the price of the non-tradable basket (all prices are in units of Home currency unless noted). The demand for tradables is $C_t^T = (1 - \alpha_N)\left(P_t^T/P_t\right)^{-\phi_N} C_t$; the demand for non-tradables is $C_t^N = \alpha_N \left(P_t^N/P_t\right)^{-\phi_N} C_t$.

The non-tradable consumption basket C_t^N aggregates consumption varieties $C_t^N(n)$ over a continuum $(0,1)$: $C_t^N = \left[\int_0^1 C_t^N(n)^{(\theta_N - 1)/\theta_N} dn\right]^{\theta_N/(\theta_N - 1)}$, where $\theta_N > 1$ is the symmetric elasticity of substitution across non-tradable goods. The corresponding consumption-based price index is

$P_t^N = \left[\int_0^1 P_t^N(n)^{1-\theta_N} dn\right]^{1/(1-\theta_N)}$, where $P_t^N(n)$ is the price of product n.

We use the subscript D to denote quantities and prices of a country's own tradable goods consumed domestically, and the subscript X to denote quantities and prices of exports. The tradable consumption basket C_t^T aggregates consumption sub-baskets of Home tradables and Foreign exports in Armington form with elasticity of substitution $\phi_T > 0$:

$$C_t^T = \left[(1-\alpha_X)^{\frac{1}{\phi_T}} \left(C_{D,t}^T\right)^{\frac{\phi_T - 1}{\phi_T}} + \alpha_X^{\frac{1}{\phi_T}} \left(C_{X,t}^{T*}\right)^{\frac{\phi_T-1}{\phi_T}}\right]^{\frac{\phi_T}{\phi_T - 1}}, \quad 0 < \alpha_X < 1,$$

where $1-\alpha_X$ is the weight attached to the country's own good. Preferences for tradables are biased in favor of domestic goods whenever $\alpha_X < 1/2$. The price index that corresponds to the basket C_t^T is given by

$$P_t^T = \left[(1-\alpha_X)\left(P_{D,t}^T\right)^{1-\phi_T} + \alpha_X P_{X,t}^{T*1-\phi_T}\right]^{\frac{1}{1-\phi_T}}.$$

Home demand for domestic tradable consumption is $C_{D,t}^T = (1-\alpha_X)\left(P_{D,t}^T / P_t^T\right)^{-\phi_T} C_t^T$, while the demand for the imported bundle is $C_{X,t}^{T*} = \alpha_X \left(P_{X,t}^{T*}/P_t^T\right)^{-\phi T} C_t^T$.

Domestic tradable consumption, $C_{D,t}^T$, aggregates consumption varieties $C_{D,t}^T(\omega)$ over a continuum Ω: $C_{D,t}^T = \left[\int_{\omega \in \Omega} C_{D,t}^T(\omega)^{(\theta_T - 1)/\theta_T} d\omega\right]^{\theta_T/(\theta_T-1)}$, where $\theta_T > 1$ is the symmetric elasticity of substitution across goods. Following Ghironi and Melitz (2005), at any given point in time, only a subset of goods $\Omega_t \in \Omega$ is available. A similar basket describes the imported consumption bundle: $C_{X,t}^{T*} = \left[\int_{\omega \in \Omega^*} C_{X,t}^{T*}(\omega)^{(\theta_T-1)/\theta_T} d\omega\right]^{\theta_T/(\theta_T-1)}$. The price index for the domestic tradable bundle is $P_{D,t}^T = \left[\int_{\omega\in\Omega_t} P_{D,t}^T(\omega)^{1-\theta_T} d\omega\right]^{1/(1-\theta_T)}$, where $P_{D,t}^T(\omega)$ is the nominal price of good $\omega \in \Omega_t$. The price index for the imported bundle is $P_{X,t}^{T*} = \left\{\int_{\omega\in\Omega_t}\left[\left(1+\tau_t^{IM}\right) P_{X,t}^{T*}(\omega)\right]^{1-\theta_T} d\omega\right\}^{1/(1-\theta_T)}$, where $\tau_t^{IM} \geqslant 0$ is an ad-valorem import tariff and $P_{X,t}^{T*}(\omega)$ is the dock price of the imported variety (denominated in Home currency). We assume that the government rebates the tariff revenue to the households in lump-sum fashion. Home demand for a domestic tradable variety is $C_{D,t}^T(\omega) = \left(P_{D,t}^T(\omega)/P_{D,t}^T\right)^{-\phi_T} C_{D,t}^T$, while the demand for a Foreign tradable product is $C_{X,t}^{T*}(\omega) = \alpha_X \left[\left(1+\tau_t^{IM}\right) P_{X,t}^{T*}(\omega)/P_{X,t}^{T*}\right]^{-\phi T} C_{X,t}^{T*}$. Intuitively, higher tariffs increase the relative price of Foreign exports and shift demand away from Foreign products.

Production

In each country, there are two vertically integrated production stages. At the upstream level, perfectly competitive firms use capital and labor to produce a non-tradable intermediate input. At the downstream level, two sectors use the intermediate input to produce tradable and non-tradable final consumption goods. In the benchmark version of the model, we consider flexible prices in both tradable and non-tradable sectors. We consider the role of price-setting frictions in the Appendix.

Homogeneous Intermediate Input Production

There is a unit mass of perfectly competitive intermediate producers. The representative intermediate firm produces output $Y_t^I = Z_t K_t^{\alpha} L_t^{1-\alpha}$, where Z_t is aggregate productivity, K_t is physical capital, and L_t is a bundle of the labor inputs supplied by individual households. We assume there is a competitive rental market for capital. Home productivity follows an exogenous autoregressive process: $\log Z_t = \rho_Z \log Z_{t-1} + \epsilon_{Z,t}$, where $\rho_Z \in (0;1)$ and $\epsilon_{Z,t} \overset{i.i.d.}{\sim} N\left(0, \sigma_Z^2\right)$.

Let φ_t be the real price (in units of final consumption) of the intermediate input. The Home intermediate sector firm chooses L_t and K_t to maximize the value of per-period profit: $d_t^I \equiv \varphi_t Y_t^I - \left(w_t^n / P_t\right) L_t - r_{K,t} K_t$, where w_t^n is the nominal cost of labor, and $r_{K,t}$ is the rental rate of capital. The first-order conditions for L_t and K_t imply $(1-\alpha)\varphi_t Y_t^I / L_t = w_t^n / P_t$ and $\alpha \varphi_t Y_t^I / K_t = r_{K,t}$, respectively.

The composite labor input aggregates in Dixit-Stiglitz form the differentiated labor inputs provided by domestic households: $L_t \equiv \left[\int_0^1 \left(L_t\left(h\right)\right)^{(\eta-1)/\eta} dh\right]^{\eta/(\eta-1)}$ where $\eta > 0$ is the elasticity of substitution between the different labor inputs, and $L_t\left(h\right)$ denotes the labor hired from household h. The total wage bill is $w_t^n \equiv \left[\int_0^1 \left(w_t^n\left(h\right)\right)^{1-\eta} dh\right]^{1/(1-\eta)}$, where $w_t^n\left(h\right)$ is the nominal wage rate paid to household h. Labor demand for the labor input h is thus:

$$L_t\left(h\right) = \left(\frac{w_t^n\left(h\right)}{w_t^n}\right)^{-\eta} L_t. \tag{2}$$

Each household sets the nominal wage $w_t^n\left(h\right)$ acting as a monopolistic supplier of its differentiated labor input. We discuss wage determination when presenting the household's optimal decisions.

Non-Tradable Sector

Our model will feature Melitz-type selection of tradable producers into exporting. However, the Melitz model is best thought of as a model of the *tradable* sector, part of which turns out to be *non-traded* in equilibrium (thus, the model is naturally suited to capture the evidence that many manufacturing producers do not export—see Bernard, Eaton, Jensen, and Kortum, 2003). We address the fact that economies include sectors that produce truly non-tradable output by augmenting the framework with an exogenously non-tradable sector.

This sector is populated by a continuum of monopolistically competitive firms, each producing a different non-traded variety n.[24] Production requires intermediate inputs. Consumption demand for variety n is $Y_t^N(n) = \left(P_t^N(n)/P_t^N\right)^{-\theta_N} Y_t^N$, where Y_t^N denotes aggregate demand of the composite non-tradable bundle by domestic households. Per-period (real) profits are given by $d_t^N(n) \equiv \left[P_t^N(n)/P_t - \varphi_t\right] Y_t^N(n)$. All profits are returned to households as dividends. Optimal price setting implies that the real price of product n is equal to a markup over marginal cost: $\rho_t^N(n) \equiv P_t^N(n)/P_t = [\theta_N/(\theta_N - 1)]\,\varphi_t$.

Tradable Sector

There is a continuum of monopolistically competitive firms, each producing a different tradable consumption good variety ω that can be sold domestically and abroad. Firms are heterogeneous since they produce with different technologies indexed by relative productivity z. Since in equilibrium all firms with the same productivity behave symmetrically, we index firms by z from now on, omitting the variety index ω. The number of firms serving the domestic and export market is endogenous. Prior to entry, firms face a sunk entry cost $f_{E.t}$ (in units of intermediate input), representing the real costs of regulation and the technological investment associated with market entry. Upon entry, Home and Foreign firms draw their productivity level z from a common distribution $G(z)$ with support on $[z_{\min}, \infty)$. This relative productivity level remains fixed thereafter. There are no fixed costs of production. Hence, all firms that enter the tradable sector produce in every period until they are hit by a "death" shock, which occurs with probability $\delta \in (0,1)$ in every period. Exporting is costly and it involves both a per-unit iceberg trade cost $\tau_t > 0$ and a per-period fixed cost $f_{X,t}$ in units of the intermediate input.[25]

Let $P_{D,t}^T(z)$ and $P_{X,t}^T(z)$ denote, respectively, the nominal domestic price (in Home currency) and the export price (in Foreign currency) set by Home producer z. Notice that $P_{X,t}^T(z)$ is the

[24] We abstract from producer heterogeneity and endogenous producer entry in the non-tradable sector, since these mechanisms are not central to understanding the short-run effects of protectionism. See Cacciatore, Duval, Fiori, and Ghironi (2016) for a model with endogenous producer entry in the non-tradable sector.

[25] Although a substantial portion of fixed export costs are sunk upon market entry, we follow Ghironi and Melitz (2005) and do not model the sunk nature of these costs explicitly. The presence of sunk export costs would introduce an option value to exporting, complicating the solution method considerably. As Ghironi and Melitz (2005), we conjecture that the presence of sunk export costs would enhance the persistence properties of the model.

dock export price, i.e., $P^T_{X,t}(z)$ does not include Foreign import tariffs (if any). Domestic demand is $Y^T_{D,t}(z) = \left(P^T_{D,t}(z)/P^T_{D,t}\right)^{-\theta_T} Y^T_{D,t}$, while export demand is $Y^T_{X,t}(z) = \left[\left(1+\tau^{IM*}_t\right) P^T_{X,t}(z)/P^T_{X,t}\right]^{-\theta_T} Y^{T*}_{X,t}$, where $\tau^{IM*}_t \geqslant 0$ is an ad-valorem import tariff imposed by Foreign. The terms $Y^T_{D,t}$ and $Y^{T*}_{X,t}$ denote, respectively, Home and Foreign aggregate demand of the basket of Home tradable goods. All firms set flexible prices that reflect the same proportional markup $\theta_T/(\theta_T-1)$ over marginal cost. Let $\rho^T_{D,t}(z) \equiv P^T_{D,t}(z)/P_t$ and $\rho^T_{X,t}(z) \equiv P^T_{X,t}(z)/P^*_t$ denote real prices relative to the consumer price index in the destination market. The optimal prices are then given by: $\rho^T_{D,t}(z) = [\theta_T/(\theta_T-1)]\,\varphi_t/z$ and $\rho^T_{X,t}(z) = (1+\tau_t)\,\rho^T_{D,t}(z)/Q_t$, where $Q_t \equiv \varepsilon_t P^*_t/P_t$ is the consumption-based real exchange rate (units of Home consumption per unit of Foreign) and ε_t is the nominal exchange rate (units of Home currency per unit of Foreign).

Due to the fixed export cost, firms with low productivity levels z may decide not to export in any given period. When making this decision, a firm decomposes its total real profit $d^T_t(z)$ into portions earned from domestic sales, $d^T_{D,t}(z)$, and from potential export sales, $d^T_{X,t}(z)$. These profit levels, expressed in units of Home consumption, are given by the following expressions:

$$d^T_{D,t}(z) \equiv \left(\rho^T_{D,t}(z) - \frac{\varphi_t}{z}\right) Y^T_{D,t}(z),$$

and

$$d^T_{X,t}(z) \equiv \left[Q_t \rho^T_{X,t}(z) - (1+\tau_t)\frac{\varphi_t}{z}\right] Y^T_{X,t}(z) - \varphi_t f_{X,t}.$$

A firm will export if and only if the expected profit from exporting is non-negative. This will be the case as long as productivity z is above a cutoff level $z_{X,t}$ such that: $z_{X,t} = \inf\{z : d^T_{X,t}(z) > 0\}$. We assume that the lower-bound productivity $z_{\min}$ is low enough relative to the export costs that $z_{X,t}$ is above $z_{\min}$. Firms with productivity levels between $z_{\min}$ and the export cutoff level $z_{X,t}$ produce only for their domestic market in period t. The set of exporting firms fluctuates over time with changes in the profitability of export.

Firm Averages In every period, a mass $N_{D,t}$ of tradable-sector firms produces in the Home country. Among these firms, there are $N_{X,t} = [1 - G(z_{X,t})]\,N_{D,t}$ exporters. As in Melitz (2003) and Ghironi and Melitz (2005), all the information on the distribution of productivity levels $G(z)$ that is relevant for aggregate outcomes can be summarized by appropriately defined average productivity levels. Define an average productivity level $\tilde{z}_D$ for all producing firms that serve the domestic market and an average $\tilde{z}_{X,t}$ for all Home exporters:

$$\tilde{z}_D \equiv \left[\int_{z_{\min}}^{\infty} z^{\theta_T-1} dG(z)\right]^{1/(\theta_T-1)}, \qquad \tilde{z}_{X,t} \equiv \left[\frac{1}{1-G(z_{X,t})}\int_{z_{X,t}}^{\infty} z^{\theta_T-1} dG(z)\right]^{1/(\theta_T-1)},$$

where $\tilde{z}_D$ and $\tilde{z}_{X,t}$ are based on weights proportional to relative firm output shares. The model can be restated in terms of average (representative) firms. The average price of Home firms in their domestic market is $\tilde{\rho}^T_{D,t} \equiv \rho^T_{D,t}(\tilde{z}_D)$, while the average price of Home exports is $\tilde{\rho}^T_{X,t} \equiv \rho^T_{X,t}(\tilde{z}_{X,t})$. Average domestic tradable output is $\tilde{Y}^T_{D,t} = \left(\tilde{\rho}^T_{D,t}/\rho^T_{D,t}\right)^{-\theta_T} Y^T_{D,t}$, while average export is $\tilde{Y}^T_{X,t} = \left(\tilde{\rho}^T_{X,t}/\rho^T_{X,t}\right)^{-\theta_T} Y^T_{X,t}$. The average profit from domestic sales is $\tilde{d}^T_{D,t} \equiv d^T_{D,t}(\tilde{z}_D)$, while the average export profit is $\tilde{d}^T_{X,t} \equiv d^T_{X,t}(\tilde{z}_{X,t})$. Thus, the average total profit of Home firms is given by $\tilde{d}^T_t = \tilde{d}^T_{D,t} + (N_{X,t}/N_{D,t})\,\tilde{d}^T_{X,t}$. Finally, we can also define the average productivity of Home firms in the tradable sector as:

$$\tilde{z}_t = \left[\tilde{z}_D^{\theta_T-1} + \left(\frac{\tilde{z}_{X,t}}{1+\tau_t}\right)^{\theta_T-1}\left(\frac{N_{X,t}}{N_{D,t}}\right)\right]^{\frac{1}{\theta_T-1}}.$$

Following Melitz (2003) and Ghironi and Melitz (2005), we assume that z is drawn from a Pareto distribution with lower bound $z_{\min}$ and shape parameter $\kappa > \theta_T - 1$. The share of exporting firms is then given by $N_{X,t}/N_{D,t} = (z_{\min}/\tilde{z}_{X,t})^{\kappa}\left[\kappa/\left(\kappa-\theta_T+1\right)\right]^{\kappa/(\theta_T-1)}$, while the zero-profit condition that determines the productivity cutoff $z_{X,t}$ is such that $\tilde{d}_{X,t} = \left(\theta_T-1\right)/\left[\kappa-\theta_T+1\right)]\,\varphi_t f_{X,t}$.

Firm Entry and Exit In every period there is an unbounded mass of prospective entrants in both countries. As in Ghironi and Melitz (2005), entrants at time t start producing only at $t+1$, a plausible assumption given the quarterly calibration we will pursue. Potential entrants are forward looking and form rational expectations about their expected post-entry value $\tilde{e}_t$. The latter is defined by the expected present discounted value of the stream of per-period average profits: $\tilde{e}_t \equiv E_t\left[\sum_{s=t+1}^{\infty}\beta_{t,s}(1-\delta)^{s-t}\tilde{d}^T_s\right]$. We assume that firms are owned by domestic households, which implies that future profits are discounted with their stochastic discount factor, adjusted by the probability of firm survival. The discount factor is defined by $\beta_{t,t+s} \equiv \beta^s u_{C,t+s}/u_{C,t}$, where $u_{C,t}$ denotes the marginal utility of consumption in period t. Entry occurs until average firm value equals the entry cost, leading to the free-entry condition $\tilde{e}_t = \varphi_t f_{E.t}$. Finally, time-to-build and the assumption that the exit shock happens at the end of each period imply that the law of motion for the number of producing firms is $N_{D,t} = (1-\delta)(N_{D,t-1} + N_{E,t-1})$.

Household Budget Constraint and Intertemporal Decisions

International asset markets are incomplete, as non-contingent nominal bonds denominated in Foreign currency are the only internationally traded asset. The representative household can also invest in non-contingent nominal bonds denominated in Home currency, which are traded only domestically. Let $A_{t+1}(h)$ and $A_{*,t+1}(h)$ denote, respectively, nominal holdings of Home and Foreign bonds for the representative Home household h. To ensure a determinate steady-state equilibrium and stationary responses to temporary shocks in the model, we follow Turnovsky (1985), and, more recently, Benigno (2009), and assume a quadratic cost of adjusting Foreign bond holdings $\psi \left[A_{*,t+1}(h)/P_t\right]^2/2$.[26] These costs are paid to financial intermediaries whose only function is to collect these transaction fees and rebate the revenue to households in lump-sum fashion in equilibrium.

In addition to bonds, the representative household can invest also in shares in a mutual fund of the domestic firms producing in the tradable sector. As in Ghironi and Melitz (2005), we assume extreme home bias in equity holdings and rule out international trade in firm shares. Investment in the mutual fund of firms in the stock market is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. Let $x_t(h)$ be the share in the mutual fund held by the representative household entering period t. The mutual fund pays a total dividend in each period (in units of consumption) that is equal to the average total profit of all home firms in the tradable sector that produce in that period, $N_{D,t}\tilde{d}_t^T$. During period t, the representative household buys $x_{t+1}(h)$ shares in a mutual fund of $N_{D,t} + N_{E,t}$ firms. Even though only $1-\delta$ of these firms will produce and pay dividends in $t+1$, the household does not know which firms will be hit by the death shock. Hence, it finances operations by all incumbents and new entrants, with exit risk affecting the equilibrium price of equity as shown below. The date-t price of a claim to the future profit stream of the mutual fund is equal to the average price of claims to future profits of Home firms, $\tilde{e}_t$.

The household also accumulates physical capital and rents it to intermediate input producers in a competitive capital market. Investment in the physical capital stock, $I_{K,t}$, requires use of the same composite of all available varieties as the basket C_t. Physical capital obeys a standard law of motion:

$$K_{t+1}(h) = (1-\delta_K) K_t(h) + I_{K,t}(h), \tag{3}$$

[26] Since only Foreign bonds are traded across borders, defining an adjustment cost for Foreign bond holdings is sufficient to pin down a unique steady state and ensure stationarity of the model.

where $\delta_K \in (0,1)$ denotes the depreciation rate of capital.

Households set the nominal wage $w_t^n(h)$ taking into account firms' demand (2) in the utility maximization problem. Households face a quadratic cost of adjusting the hourly nominal wage rate $w_t^n(h)$ between period $t-1$ and t:

$$\frac{\nu_w}{2}\left(\frac{w_t^n(h)}{w_{t-1}^n(h)}-1\right)^2 w_t^n(h)\,L_t(h),$$

where $\nu_w \geq 0$ determines the size of the adjustment cost (wages are flexible if $\nu_w = 0$). In real terms, the adjustment cost can be interpreted as units of final consumption that the household needs to purchase when implementing a wage change. The size of this cost is assumed to be larger when the household's labor income increases.

The representative Home household's period budget constraint is:

$$\begin{aligned} A_{t+1}(h)+\varepsilon_t A_{*,t+1}(h)+\frac{\psi}{2}\varepsilon_t P_t^*\left(\frac{A_{*,t+1}(h)}{P_t^*}\right)^2+P_tC_t(h)+P_tI_{K,t}(h)+\tilde{e}_t(N_{D,t}+N_{E,t})x_{t+1}(h)= \\ (1+i_t)A_t(h)+(1+i_t^*)A_{*,t}(h)\,\varepsilon_t+\left[1-\frac{\nu_w}{2}\left(\frac{w_t^n(h)}{w_{t-1}^n(h)}-1\right)^2\right]w_t^n(h)\,L_t(h)+ \\ +P_t r_{K,t}K_t(h)+(\tilde{d}_t^T+\tilde{e}_t)N_{D,t}x_t(h)+T_t(h), \end{aligned} \tag{4}$$

where i_{t+1} and i_{t+1}^* are, respectively, the nominal interest rates on Home and Foreign bond holdings between t and $t+1$, known with certainty as of t. Moreover, $T_t(h)$ aggregates lump-sum rebates of the cost of adjusting bond holdings, the profits from non-tradables producers, and the revenue that the government receives from tariffs.

The household maximizes its expected intertemporal utility subject to (2), (3), and (4). The first-order condition for $w_t^n(h)$ implies that the real wage is a time-varying markup, $\mu_t^w(h)$, over the marginal rate of substitution between hours and consumption, $v_{L,t}(h)/u_{C,t}(h)$:

$$w_t(h) \equiv \frac{w_t^n(h)}{P_t} = \mu_t^w(h)\,\frac{v_{L,t}(h)}{u_{C,t}(h)},$$

where $v_{L,t}(h)$ denotes the marginal disutility of hours. The endogenous wage markup is given by:

$$\mu_t^w(h) \equiv \frac{\eta}{(\eta-1)\left(1-\frac{\nu_w}{2}\pi_{w,t}^2(h)\right)+\nu_w\left\{\begin{array}{c}\pi_{w,t}(h)\,(1+\pi_{w,t}(h)) \\ -E_t\left[\beta_{t,t+1}\pi_{w,t+1}(h)\,\frac{(1+\pi_{w,t+1}(h))^2}{1+\pi_{C,t+1}}\frac{L_{t+1}}{L_t}\right]\end{array}\right\}},$$

where $\pi_{w,t}(h) = w_t^n(h)/w_{t-1}^n(h) - 1$ denotes nominal wage inflation. Intuitively, the cost of adjusting wages gives households an incentive to change their markups over time in order to smooth wage changes across periods.

The Euler equation for capital accumulation requires $1 = E_t[\beta_{t,t+1}(r_{K,t+1} + 1 - \delta_K)]$, while the Euler equation for share holdings implies $\tilde{e}_t = (1-\delta) E_t \left[\beta_{t,t+1}\left(\tilde{d}_{t+1}^T + \tilde{e}_{t+1}\right)\right]$. Iterating this equation forward and imposing transversality returns the solution for average firm value that appears in the free-entry condition for tradable producers, which shows the general equilibrium link between household saving and investment decisions and the entry decisions of producers.

Finally, the Euler equations for bond holdings are:

$$1 + \Lambda_{at} = (1 + i_{t+1}) E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}}\right),$$

$$1 + \psi a_{*,t+1} + \Lambda_{at} = \left(1 + i_{t+1}^*\right) E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}^*} \frac{Q_{t+1}}{Q_t}\right),$$

where $a_{*,t+1} \equiv A_{*,t+1}(h)/P_t$. The term Λ_{at} captures a risk-premium shock that we append to the Euler equations for bond holdings and that affects the household's demand for risk-free assets. We assume that Λ_{at} follows a zero-mean autoregressive process: $\Lambda_{at} = \rho_{\varepsilon_a}\Lambda_{at-1} + \epsilon_{at}$, where $\epsilon_{at} \overset{i.i.d.}{\sim} N\left(0, \sigma_{\epsilon_a}^2\right)$. We follow Smets and Wouters (2007) and subsequent literature in specifying this shock as an exogenous term appended to the Euler equations for bonds. Nevertheless, as shown by Fisher (2015), the shock Λ_{at} can be interpreted as a structural shock to the demand for safe and liquid assets, i.e., Λ_{at} captures, in reduced form, stochastic fluctuations in household preferences for holding one-period nominally risk-free assets.[27] We describe below the most important features of the equilibrium of the model and present the law of motion for net foreign assets that follows from imposing equilibrium conditions in the household's budget constraint.

Equilibrium

In equilibrium, households and non-tradable firms are symmetric. Labor market clearing requires:

$$Z_t K_t^\alpha L_t^{1-\alpha} = Y_t^N + N_{D,t}\tilde{Y}_{D,t}^T/\tilde{z}_D + (1+\tau_t) N_{X,t}\tilde{Y}_{X,t}^T/\tilde{z}_{X,t} + N_{E,t}f_{E,t} + N_{X,t}f_{X,t}.$$

[27] Notice that the risk-premium shock is isomorphic to a discount factor shock (a "beta shock") only up to a first-order approximation.

The lump-sum transfer is:

$$T_t = \left(\frac{\psi}{2}\right) \varepsilon_t P_t^* \left(\frac{A_{*,t+1}}{P_t^*}\right)^2 + d_t^N + \tau_t^{IM} \rho_{X,t}^* \tilde{Y}_{X,t}^{T*}.$$

Aggregate demand of the final consumption basket must be equal to the sum of market consumption, investment in physical capital, and the cost of adjusting nominal wages:

$$Y_t = C_t + I_{K,t} + \left[1 - \frac{\nu_w}{2} (\pi_{w,t})^2\right] w_t L_t.$$

Finally, Home bonds are in zero net supply and shares in the mutual fund of tradable producers are fully held domestically, which implies the equilibrium conditions $a_{t+1} = a_t = 0$ and $x_{t+1} = x_t = 1$ in all periods. Home net foreign assets are determined by:

$$Q_t a_{*,t+1} = Q_t \frac{1 + i_t^*}{1 + \pi_{C,t}^*} a_{*,t} + TB_t,$$

where $TB_t \equiv N_{X,t} Q_t \tilde{\rho}_{X,t}^T \tilde{Y}_{X,t}^T - N_{X,t}^* \tilde{\rho}_{X,t}^* \tilde{Y}_{X,t}^{T*}$ is the trade balance. The change in net foreign assets between t and $t+1$ is determined by the current account: $Q_t (a_{*,t+1} - a_{*,t}) = CA_t \equiv Q_t r_t^* a_{*,t} + TB_t$, where the foreign real interest rate r_t^* is defined by $1+r_t^* = (1+i_t^*)/(1+\pi_{C,t}^*)$ and $\pi_{C,t}^* \equiv P_t^*/P_{t-1}^* - 1$.

Monetary Policy

To close the model, we specify a rule for monetary policy. In the presence of endogenous producer entry and preferences that exhibit "love for variety," an issue concerns the empirically relevant variables that enter the theoretical representation of monetary policy. As highlighted by Ghironi and Melitz (2005), when the economy experiences entry of Home and Foreign firms, the welfare-consistent tradable price indexes $P_{D,t}^T$ and $P_{X,t}^{T*}$ can fluctuate even if product prices remain constant. In the data, however, aggregate price indexes do not take these variety effects into account.[28] To resolve this issue, we follow Ghironi and Melitz (2005) and obtain a data-consistent price index, $\tilde{P}_t$, by removing the pure product variety effect from the welfare-consistent index P_t as explained in the Appendix. In turn, given any variable X_t in units of consumption, we then construct its data-consistent counterpart as $X_{Rt} \equiv P_t X_t / \tilde{P}_t$.

[28] There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010). Furthermore, the adjustment for variety neither happens at the frequency represented by periods in the model, nor using the specific functional form for preferences that the model assumes.

Our benchmark policy specification considers a flexible exchange rate.[29] The monetary authority sets the nominal interest rate following a feedback rule of the form

$$1+i_{t+1}=\max\left\{1+i^{zlb},(1+i_t)^{\varrho_i}\left[(1+i)\left(1+\tilde{\pi}_{Ct}\right)^{\varrho_\pi}\left(\tilde{Y}_{gt}\right)^{\varrho_Y}\right]^{1-\varrho_i}\right\} \tag{5}$$

where i is the steady state nominal interest rate. The interest rate responds to movements in data-consistent CPI inflation, $\tilde{\pi}_{Ct}$, and the data-consistent GDP gap, $\tilde{Y}_{gt}$, relative to the flexible-wage outcome. GDP is defined as $Y_t \equiv C_t + I_{Kt} + TB_t$. We explicitly take into account the possibility that the nominal interest rate cannot fall below some lower bound i^{zlb}, so that, in each period, the interest rate is constrained to be such that $i_{t+1} \geqslant i^{zlb}$. We set i^{zlb} equal to zero in our simulations.

Table 1 summarizes the equilibrium conditions of the model. Eight Foreign variables directly affect macroeconomic dynamics in the small open economy: Y_t^*, i_{t+1}^*, $\pi_t^{C^*}$, $\rho_t^{T^*}$, $\rho_{X,t}^{T^*}$, $\tilde{\rho}_{X,t}^{T^*}$, $\tilde{Y}_{X,t}^{T^*}$, and $N_{X,t}^*$. Aggregate demand, Y_t^*, the nominal interest rate, i_{t+1}^*, and inflation, $\pi_t^{C^*}$, are determined by treating the rest of the world (Foreign) as a closed economy that features the same production structure, technology, and frictions that characterize the small open economy. To determine price and quantities related to Foreign exports and imports, we assume that Foreign producers solve a profit maximization problem that is equivalent to that faced by Home producers. See the Appendix for details.

4 Calibration

We interpret periods as quarters. Below, variables without a time subscript denote steady-state values. We use standard values for all the parameters that are conventional in the business cycle literature. We parametrize the utility function by assuming $u(C_t)=C_t^{1-\gamma_C}/\left(1+\gamma_C\right)$ and $v\left(L_t\right)=L_t^{1+\gamma_L}/\left(1+\gamma_L\right)$. We set the discount factor β equal to 0.99, the share of capital in the Cobb-Douglas production function of the upstream intermediate sector, α, equal to 0.33, the capital depreciation rate δ_K equal to 0.025, and risk aversion, γ_C, equal to 2. We calibrate the elasticity of substitution between tradable and non-tradable goods, ϕ_N, equal to 0.5, consistent with the estimates for industrialized countries in Mendoza (1991). We set the elasticity of substitution between tradable goods produced in Home and Foreign, ϕ_T, equal to 1.5, the standard value in the international business cycle literature. We set the elasticity of substitution of non-tradable varieties such that $\theta_N = 6$ to generate a 20 percent markup in steady state. Following Ghironi and

[29] We consider the case of a fixed exchange rate in Section 6.

Melitz (2005), we set the elasticity of substitution of tradable varieties θ_T equal to 3.8, the shape parameter κ of the Pareto distribution of firm productivity draws equal to 3.4, and we normalize $z_{\min}$ and f_E to one. We choose the fixed export cost f_X such that, in steady state, 21 percent of tradable-sector firms export output abroad.[30] Using the results in Born and Pfeifer (2016), we map the Rotemberg wage adjustment cost, ν_w, into an average duration of nominal wage contracts. Consistent with Christiano, Eichenbaum, and Evans (2005), we assume that nominal wages are fixed for approximately 3 quarters on average, which implies $\nu_w = 116$. We set the elasticity of substitution of differentiated labor inputs $\eta = 11$, which implies a wage markup equal to 10 percent under flexible wages. We set the Frisch elasticity of labor supply, $1/\gamma_L$, equal to 4, a conventional value in the literature. Finally, to ensure steady-state determinacy and model stationarity, we set the adjustment cost parameter for foreign bond holdings, ψ, to 0.0025.

We calibrate the parameters that directly affect trade volumes and monetary policy to match Canadian data, a benchmark small open economy. We calibrate the degree of home bias, α_N, and the size of the tradable sector, α_T, to match a steady-state trade-to-GDP ratio of 50 percent and a steady-state output share of 30 percent in manufacturing (the tradable sector). We set iceberg trade costs, τ and τ^*, equal to 0.3, and we set average import tariffs, τ^{IM} and τ^{IM^*}, equal to 2 percent, in line with Canadian and U.S. tariffs. Finally, we parametrize the interest rate rule consistent with the estimates in Kichian (2015): $\varrho_i = 0.5$, $\varrho_\pi = 2.80$, $\varrho_Y = 0$. The model calibration is summarized in Table 2.

5 Protectionism and Business Cycle Dynamics under a Flexible Exchange Rate

The theoretical literature on the macroeconomic effects of tariffs has long been dominated by Mundell's (1961) conclusion that, under flexible exchange rates, a tariff is contractionary. In Mundell's static model, the imposition of a tariff improves the terms of trade, which increases saving via the Laursen-Metzler effect. This rise in saving reduces aggregate demand, and aggregate supply falls to clear the goods market. Chan (1978) and Krugman (1982) showed that Mundell's result is indeed robust with respect to various extensions of the basic IS-LM model. In addition, Krugman (1982) argued that the imposition of tariffs can lead to a deterioration of the current account balance. In contrast with these results, the first analysis of tariffs in a dynamic setting

[30] Bernard, Eaton, Jensen, and Kortum (2003) documented that, on average, 21 percent of U.S. manufacturing plants sell output abroad.

by Eichengreen (1981) showed that the short-run output contraction depends upon the extent to which the domestic currency appreciates in the short run, emphasizing the intertemporal tradeoffs involved in a tariff.

In this Section, we re-assess the classic question about the consequences of import tariffs under a flexible exchange rate. We first investigate the consequences of protectionism by assuming that the economy is at the deterministic steady state. This exercise allows us to evaluate the prediction of the model against the data. Next, we study the short-run effects of protectionism when the economy faces major slack (induced by a risk-premium shock) and binding constraints on monetary policy easing (the ZLB). Notice that in our analysis, we abstract from export subsidies, since those are forbidden under WTO rules.

We study macroeconomic dynamics following a temporary increase in Home import tariffs, τ_t^{IM}. We consider a perfect foresight environment: The policy shock comes as an initial surprise to agents, who then have perfect foresight from that moment on. We assume that τ_t^{IM} follows the same stochastic process estimated in the panel VAR. This implies that τ_t^{IM} is back to its initial level after approximately 2 years and half. For illustrative purposes, we assume that τ_t^{IM} increases by 5 percent. We solve the model as a nonlinear, forward-looking, deterministic system using a Newton-Raphson method, as described in Laffargue (1990). This method solves simultaneously all equations for each period, without relying on low-order, local approximations.

Protectionism in Normal Times

Figure 9 (continuous lines) shows the effects of a temporary increase in τ_t^{IM} when the economy is at the deterministic steady state. Consistent with the VAR evidence, output falls and inflation increases in the aftermath of the tariff shock. Moreover, net exports increase.

The inflationary effect of the trade policy shock is easily understood. The (welfare-consistent) CPI index, P_t, can be written as:

$$P_t = \left\{ (1-\alpha_N) \left[\varpi_{D,t}^T \left(\tilde{P}_{D,t}^T \right)^{1-\phi_T} + \varpi_{X,t}^{T*} \left(\varepsilon_t \frac{\tilde{P}_D^{T*}}{\tilde{z}_{X,t}^*} \left(1+\tau_t^{IM}\right) \right)^{1-\phi_T} \right]^{\frac{1-\phi_N}{1-\phi_T}} + \alpha_N \left(P_t^N \right)^{1-\phi_N} \right\}^{\frac{1}{1-\phi_N}}, \tag{6}$$

where $\varpi_{D,t}^T = (1-\alpha_X) N_{D,t}^{(1-\phi_T)/(1-\theta_T)}$ and $\varpi_{X,t}^{T*} = \left[(1+\tau)\, \tilde{z}_D^* \right]^{1-\phi_T} N_{X,t}^{*(1-\phi_T)/(1-\theta_T)}$ are time-varying weights on prices of Home and Foreign tradable goods that depend on producer dynamics.[31] Higher

[31] Equation (6) combines the definition of the Home price index, with the equilibrium conditions $P_{D,t}^T =$

tariffs increase import prices faced by Home consumers, raising, other things equal, this price index. In addition, Home market share is reallocated from relatively more productive Foreign exporters to relatively less productive domestic producers, which implies an increase in $\varpi^T_{D,t}$ relative to $\varpi^{T^*}_{X,t}$. The reallocation of market share lowers the average productivity content of goods sold to Home consumers, raising the price index other things equal.[32] Higher import prices and lower efficiency of production prevail on a decline in the price of domestic non-tradables (due to lower aggregate demand, as explained below) in pushing inflation upward.

The output response depends on the relative importance of three margins of adjustment: (i) expenditure-switching toward domestic goods (an expansionary force); (ii) a reduction in real income; and (iii) a contractionary monetary policy response. Expenditure-switching towards Home goods—which, other things equal, boosts domestic demand and output—stems from the increase in the average price of imported varieties, $\left(1+\tau_t^{IM^*}\right)\tilde{P}^T_{X,t}$. However, expenditure switching is mitigated by the endogenous appreciation of the nominal exchange rate, which, other things equal, lowers $\tilde{P}^T_{X,t}$.[33]

At the same time, higher tariffs reduce households' real income.[34] The reason is again a combination of macroeconomic and microeconomic forces. At the macro level, the increase in the price of consumption implies that investment in physical capital and product creation are more costly. As a result both $I_{K,t}$ and $N_{E,t}$ fall, reducing output over time. Moreover, since households consume a mix of both domestic and foreign goods, households find themselves having to spend more of their reduced real income to consume any given amount of imports and any given amount of the bundle of less-efficiently-produced domestic tradables. Finally, appreciation of the domestic currency lowers Home exports (both the number of exporting firms, $N_{X,t}$, and their average output, $\tilde{Y}^T_{X,t}$, decline), reducing the average productivity of domestic firms—a decline in $N_{X,t}/N_{D,t}$ in the definition of $\tilde{z}_t$, reflecting the shift of market share towards relatively less productive non-exporting firms.[35] Expenditure switching and lower real income cause imports to decline, so net exports increase, and Home experiences a current account surplus.

Finally, since the trade shock acts as a supply shock, the central bank faces a trade-off between

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$N_{D,t}^{1/(1-\theta_T)}\tilde{P}^T_{D,t}$, $P^T_{X,t} = N^{*\,1/(1-\theta_T)}_{DX,t}\tilde{P}^{T^*}_{X,t}$ and $\tilde{P}^{T^*}_{X,t} = (1+\tau_t)\,\varepsilon_t\tilde{P}^{T^*}_{D,t}\tilde{z}^*_D/\tilde{z}^*_{X,t}$. Notice that $\tilde{P}^{T^*}_{D,t} = \tilde{P}^{T^*}_D$ because Home protectionism has no effect on the rest of the world. Moreover, $\tau_t = \tau$.

[32] Notice that, in absolute terms, even $\varpi^T_{D,t}$ declines initially, since the number of domestic producers, $N_{D,t}$, falls.

[33] Notice that the Foreign domestic price $\rho^{T^*}_{D,t}$ and the iceberg trade cost τ^*_t are not affected by Home protectionism.

[34] The effects we describe are only partially mitigated by the increase in the tariff revenue that the government rebates to households.

[35] Notice that $\tilde{z}_t$ declines even if the average productivity of exporters increases (due to the increase in the export-productivity cutoff $z_{X,t}$).

stabilizing output and inflation. When the response to inflation is sufficiently aggressive (as implied by our calibration), the policy rate increases, further depressing current demand. Both nominal and real exchange rates appreciate.[36]

In equilibrium, lower real income and the contractionary response of monetary policy push the small open economy into a recession: consumption, investment, employment, and GDP decline. Overall, these findings represent a combination of the results in Mundell (1961), Krugman (1982), and Eichengreen (1981). The contractionary effect of the tariff is as in Mundell and Krugman, but is contrary to the short-run expansionary effect discussed by Eichengreen. On the other hand, the initial current account surplus is consistent with Eichengreen but in contrast to Krugman.

Figure 10 assesses the sensitivity of the results to tariff shocks of different size (we consider positive tariff shocks of size equal to 5, 10, and 15 percent). The negative short-run response of output is essentially monotonic in the size of the shock, implying that the contractionary effects are the higher the tariff increase. In the Appendix, we show that increasing the persistence of the tariff shock (keeping the size of the shock unchanged) leads to a similar conclusion.

To understand the relative importance of macro and micro forces in accounting for the recessionary effects of protectionism, Figure 11 presents impulse responses for three simplified versions of the model. The first version assumes financial autarky (i.e., no international trade in bonds); the second version abstracts from firm-level dynamics (by assuming a constant number of symmetric producers in the tradable sector); the third version abstracts from both firm dynamics and physical capital.[37] Figure 10 shows that each margin of adjustment plays an important role in propagating the initial recession. Under financial autarky, the appreciation of the real exchange rate is stronger, since relative prices adjust more to preserve external balance. In turn, the stronger appreciation reduces the impact of the trade policy shock. The absence of firm-level dynamics removes the hump-shaped response of output, making the recession less persistent. This happens because with a constant number of symmetric producers there are no micro-level reallocations in the tradable sector.[38] Finally, the absence of both endogenous producer entry and physical capital accumulation results in a much smaller initial decline of economic activity, since the reduction in real income no longer translates in a reduction of investment in both physical capital and firm creation.

[36] Notice that the real exchange rate appreciation holds true both when considering the welfare-consistent exchange rate, Q_t, and its data consistent counterpart, $\tilde{Q}_t = \varepsilon_t \tilde{P}_t^* / \tilde{P}_t$.

[37] The details of each model are presented in the Appendix.

[38] Notice that the initial decline in output is lower in the presence of endogenous producer entry and firm heterogeneity. This stems from the fact that the number of producers is predetermined, implying that production declines more slowly.

Overall, the model accounts for the inflationary and recessionary effects of protectionism under a flexible exchange rate. The analysis shows that the macroeconomic impact of tariffs is larger with a closed capital account. Furthermore, firm and investment dynamics are key ingredients in the negative macroeconomic effects of protectionism.

The Role of Price Stickiness

In the Appendix, we extend the model to include nominal price rigidities. We consider both producer currency pricing (PCP) and local currency pricing (LCP) in the tradable sector as well as price stickiness in the non tradable sector. Qualitatively, the results are not affected by the introduction of price-setting frictions. Both under PCP and LCP, the recessionary effects are initially stronger relative to the flexible price scenario, since price stickiness increases the tariff pass through on final consumers. Not surprisingly, the contractionary effects of tariffs are larger under LCP. This happens because the appreciation of the exchange rate does not pass-through on import prices under LCP, implying that the higher tariff results in higher import prices. While this effect increases expenditure switching toward Home goods, it also reduces real income (and thus investment) by more. As a result, the recession is stronger.

Protectionism in a Liquidity Trap

We now turn to the short-run transmission of protectionism when the economy is in a recession that pushed the central bank against the ZLB constraint. Our interest reflects the observation that macroeconomic applications of restrictive trade policy typically come to the forefront of public debate when domestic production is buffeted by shocks. In our crisis scenarios, we follow the recent literature and assume that a risk-premium shock $\Lambda_{a,t}$ hits the small open economy, depressing output and generating deflation. We assume that at quarter 0 the Home economy is hit by the risk-premium shock.[39] Next, we assume that at quarter 1 the small open economy increases trade barriers. As before, we treat this policy shock as unanticipated.[40]

From a theoretical standpoint, there are two key differences relative to protectionism in normal times. First, the increase in tariffs occurs when aggregate income and demand are already low

[39] We calibrate the size of the shock so that responses reproduce a peak-to-trough decline of output of about 4 percent, a value consistent with the experience of several small open economies following the collapse of Lehman Brothers in September 2008. We set the persistence of the shock such that it takes about 3 years for the Home economy to exit the ZLB in the absence of protectionism.

[40] This amounts to considering an unanticipated trade policy shock assuming that all the state variables of the model take the value implied by the impact response to the risk-premiumy shock.

(because of the recession). Second, the monetary policy response is constrained by the zero lower bound on the nominal interest rate. In such a circumstance, an inflationary shock (such as protectionism) lowers the real interest rate, boosting aggregate demand and output other things equal. Ultimately, whether temporary protectionism can be expansionary at the ZLB is a quantitative issue.

Figure 9 (dashed lines) shows the net effects of a temporary increase in τ_t^{IM}, where the net effect corresponds to the difference between the dynamics implied by the risk premium shock followed by the increase in tariffs and the dynamics of the risk premium shock alone.[41] The figure shows that the imposition of the tariff is more inflationary at the ZLB on impact. The reason is that the central bank cannot offset the inflationary effects of the trade shock, since the deflationary pressure imposed by the risk premium shock dominates. However, the increase in trade barriers remains recessionary, i.e., the inflationary pressure is not sufficient to boost consumption and output. Once again, the result depends on the interdependence between capital accumulation and producer entry. In particular, higher tariffs continue to reduce real income (even more so when protectionism is implemented at times of low aggregate demand), reducing investment and product creation other things equal. In turn, the reduction in aggregate demand mitigates the inflationary pressure, and in equilibrium the policy shock is contractionary. The inflationary boost from the imposition of tariffs is extremely short lived, and the extra contraction imposed by protectionism on an already weak economy quickly prevails and turns the net inflation effect of the tariff into negative. This worsens the ZLB problem instead of ameliorating it.

As before, the presence of price stickiness does not affect the conclusions. Figure 10 investigates the sensitivity of the results to the size of the trade shock—the nonlinearities implied by the zero lower bound imply that the relative strength of the economic channels described above may be sensitive to shock size. As in normal times, the recessionary effects of protectionism are larger the larger the trade policy shock. However, in relative terms, short-run output losses increase more in normal times relative to a recession only initially, i.e., larger trade shocks become more recessionary at the zero lower bound along the transition dynamics.

[41] The responses to protectionism at the ZLB and protectionism in normal times are aligned so the impact response to protectionism at the ZLB (which happens in period 1) is aligned with the impact response to protectionism in normal times (which happens in period 0). To show transparently the differences in responses in the same diagram, we are shifting the impulse responses to protectionism at the ZLB to the left by one period.

6 Protectionism with a Fixed Exchange Rate

A long-standing argument in the literature is that, when the exchange rate is fixed, temporary tariffs are expansionary (at least in the absence of retaliation from trading partners). The textbook argument relies on two channels: First, the lack of appreciation of the nominal exchange rate results in stronger expenditure switching toward Home goods. Second, the response of the domestic central bank is expansionary to maintain exchange-rate parity, sustaining aggregate demand in the short run. We now re-evaluate these conclusions in the context of our model.

Our interest stems from the observation that pegs, crawling pegs, or very narrow bands feature prominently in the international monetary system (Reinhart and Rogoff, 2004). A recent illustration of the issue is the experience of Ecuador. Following the halving of oil prices in the second half of 2014, Ecuador—a dollarized economy—slipped into recession, accumulating a large trade deficit. In March 2015, the Ecuadorian government started to apply tariffs on roughly a third of its imports, ranging from 5 percent (capital goods) to 45 percent (final goods). The tariff increase was explicitly temporary (lasting 15 months). During the following quarters, in 2015 and early 2016, the trade balance of Ecuador effectively improved, but real GDP dropped even more, with a significant decline in consumption and investment.[42]

Figure 12 presents the dynamic adjustment to the same temporary increase in tariffs discussed in the previous section when the Home economy pegs the nominal exchange rate to Foreign. It also presents the results for the three alternative versions of the model already discussed in the previous section—financial autarky, no firm dynamics, and no firm dynamics and physical capital accumulation. The key message is that protectionism remains contractionary in the benchmark model. In particular, GDP declines, inflation increases, and the trade balance improves. By contrast, Figure 12 shows that the standard argument about the expansionary effects of tariffs under a peg holds true when the model abstracts from endogenous producer entry and capital accumulation, or when the capital account is closed.

What can explain these findings? In the benchmark model, the lack of exchange-rate appreciation is not sufficient to ensure an expansionary response of the economy because higher import prices continue to result in lower investment and producer entry, pushing the economy into recession. Moreover, with an open current account, the Home policy rate is tied to the (constant) Foreign interest rate—under our perfect foresight scenario, it is straightforward to verify that

[42] The protectionist measures were implemented under the provisions of Article XVII of the WTO, which allows exceptional measures to respond to balance of payment crises in developing countries.

$1 + i_{t+1} = (1 + i^*) / (1 + \psi a_{*,t+1})$, where ψ is the (very small) bond adjustment cost. As a result, the response of the Home central bank to protectionism is muted. Not surprisingly, the tariff shock becomes expansionary under financial autarky. In this case, the monetary authority lowers the policy rate to keep the exchange rate fixed, providing additional stimulus to the economy.

We show in the Appendix that the presence of price stickiness does not affect these results. The dynamics are only marginally stronger relative to the flexible price scenario.[43]

7 Conclusions

We studied the consequences of protectionism for macroeconomic fluctuations. Using trade-policy data at different frequency, we estimated country-level and panel structural VARs finding that temporary trade barriers act as a supply shock, causing output to fall and inflation to rise in the short run. Protectionism has at best a small positive effect on the trade balance. Next, we built a small-open economy model with firm heterogeneity, endogenous tradability, and nominal rigidity to study the channels through which protectionism affects aggregate fluctuations. The model successfully reproduces the VAR evidence and highlights the importance of both macro and micro forces for the contractionary effects of tariffs. We then used the model to study scenarios where temporary trade barriers have been advocated as potentially beneficial, including recessions with binding constraints on monetary policy easing or in the presence of a fixed exchange rate. The main policy conclusion of our paper is that protectionism remains a bad idea—at least for small open economies—even when it is used temporarily, even when economies are stuck in liquidity traps, and regardless of exchange rate arrangements.

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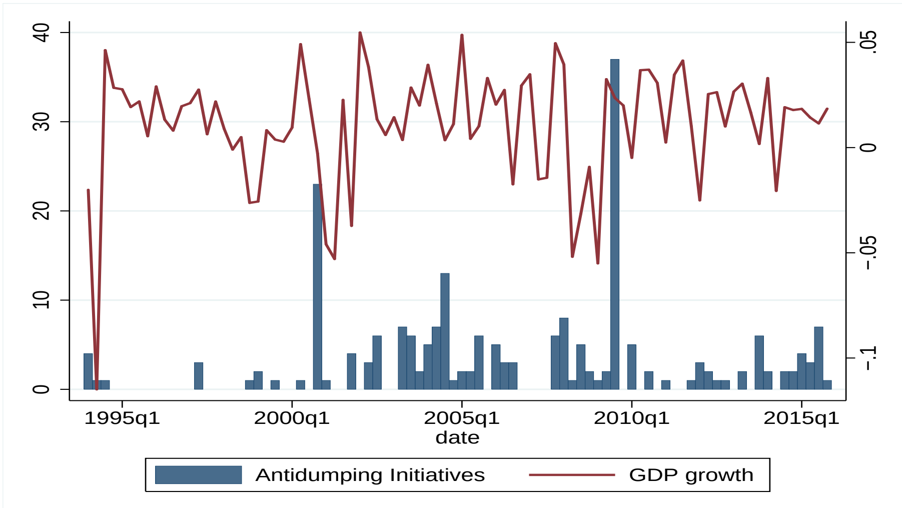

Figure 1: Anti-Dumping Initiatives and Real GDP growth, Turkey

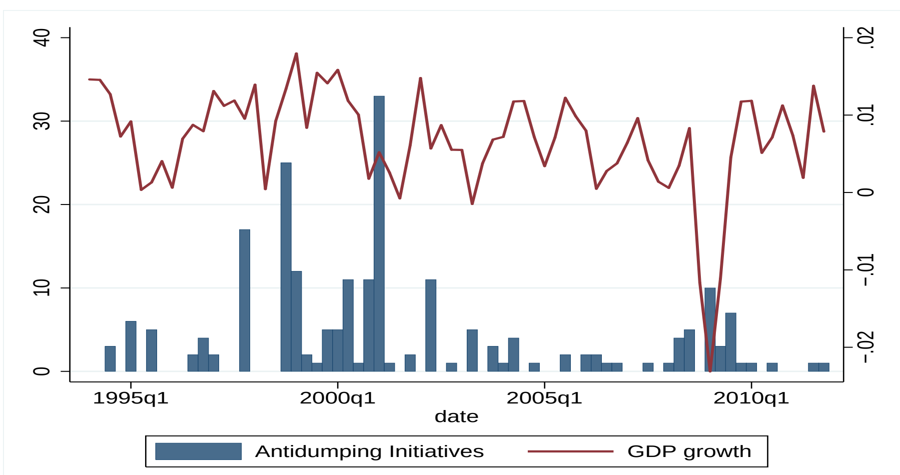

Figure 2: Anti-Dumping Initiatives and Real GDP growth, Canada

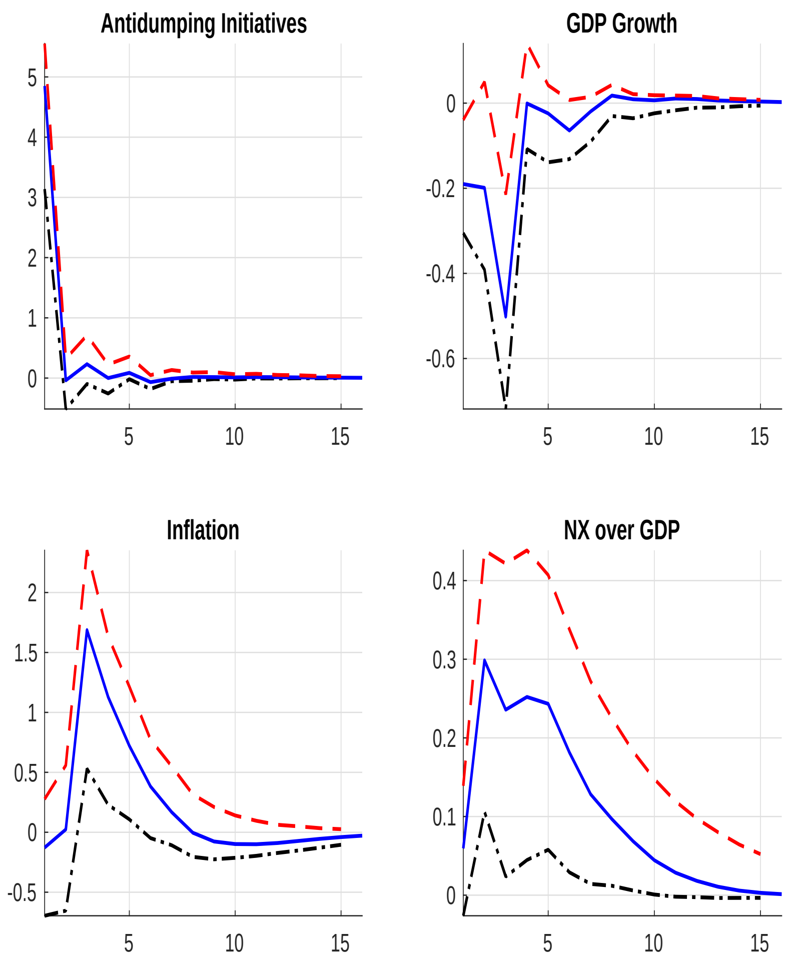

Figure 3: Quarterly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

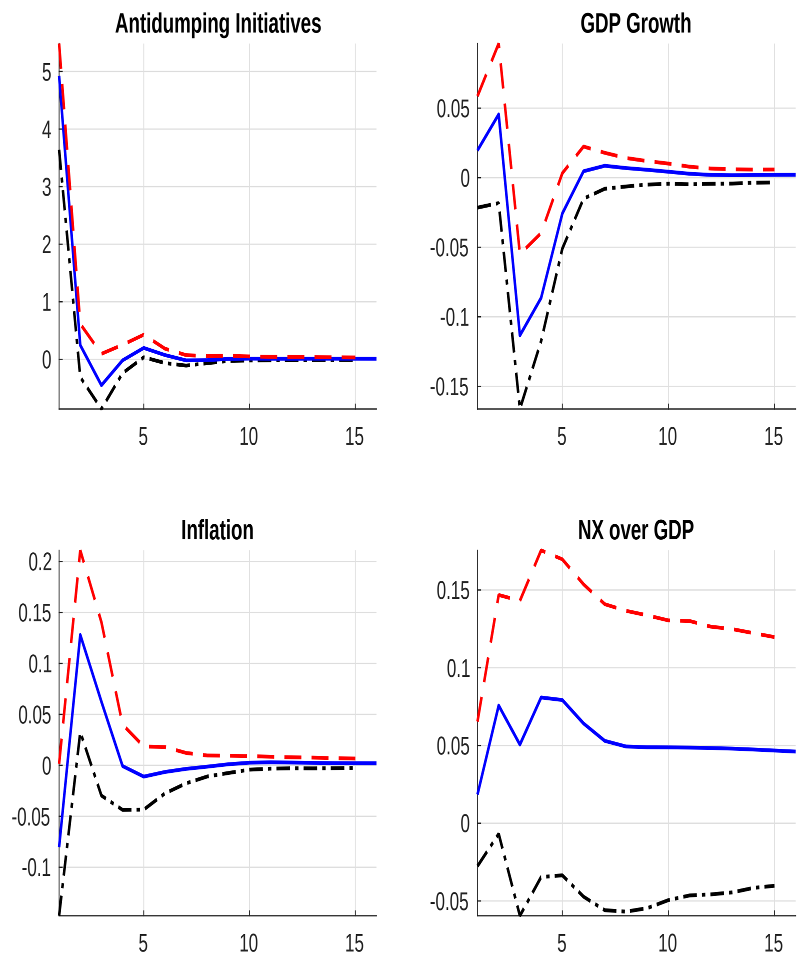

Figure 4: Quarterly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

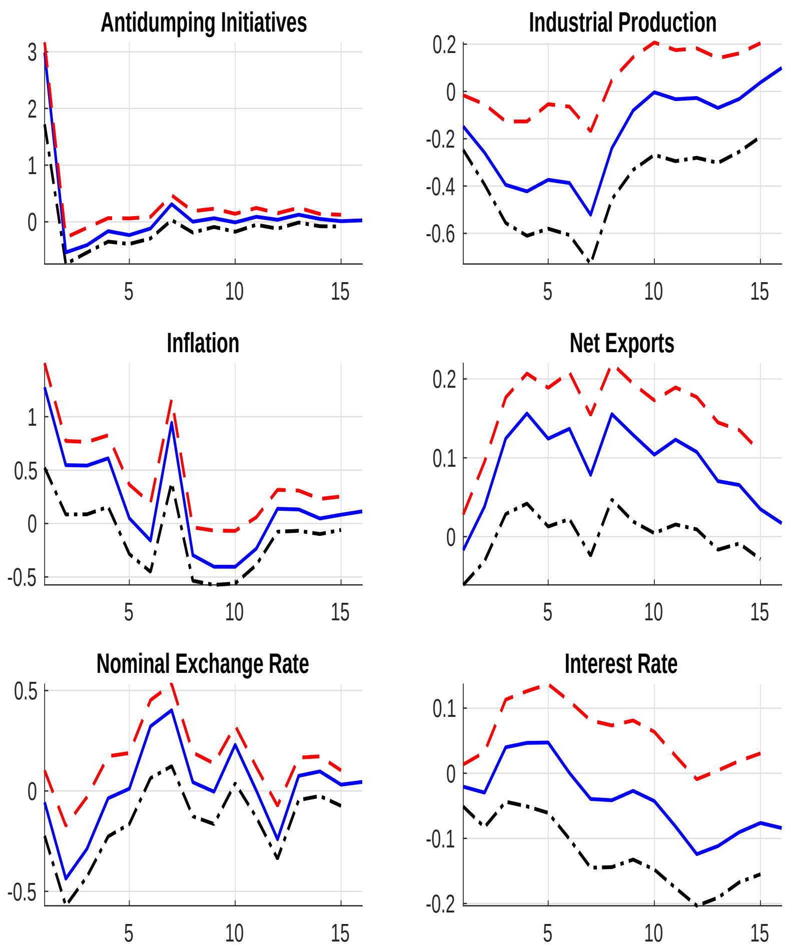

Figure 5: Monthly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Turkey. Industrial production, net exports, and nominal exchange rate are in percentage points. The inflation rate and the interest rate are annualized.

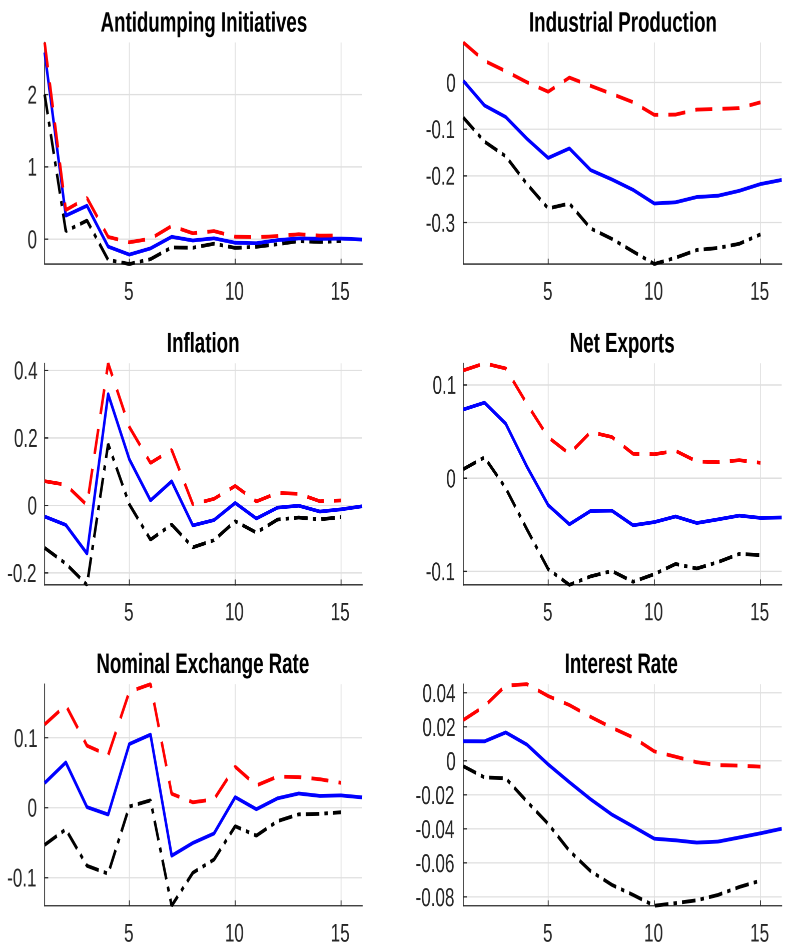

Figure 6: Monthly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Canada. Industrial production, net exports, and nominal exchange rate are in percentage points. The inflation rate and the interest rate are annualized.

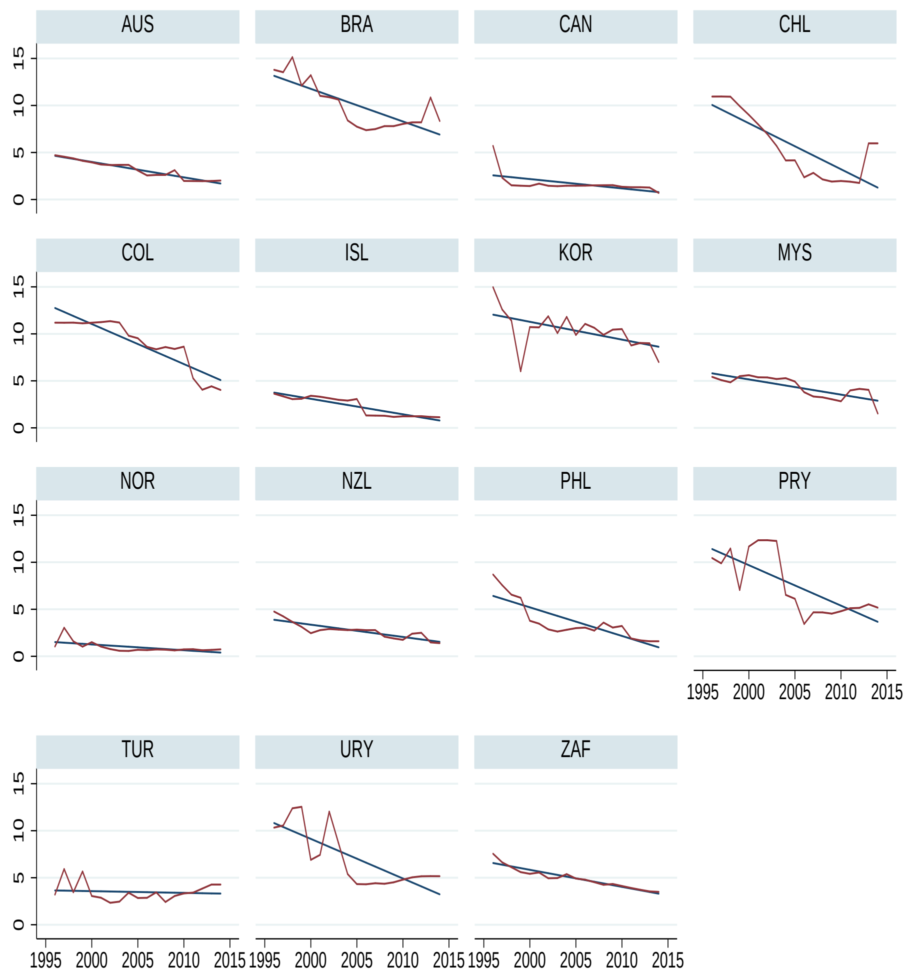

Figure 7: Weighted average of applied tariffs, 1996-2014.

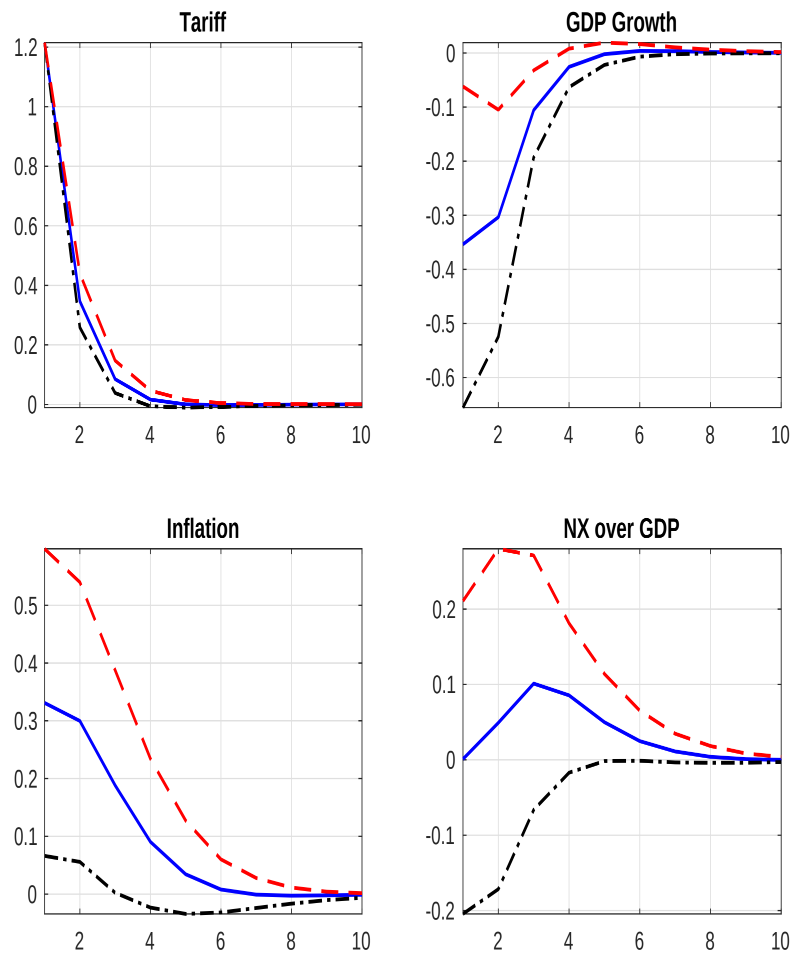

Figure 8: Panel-VAR, impulse responses to a one-standard deviation increase in detrended tariffs. Tariffs, GDP growth, and net exports over GDP are in percentage points.

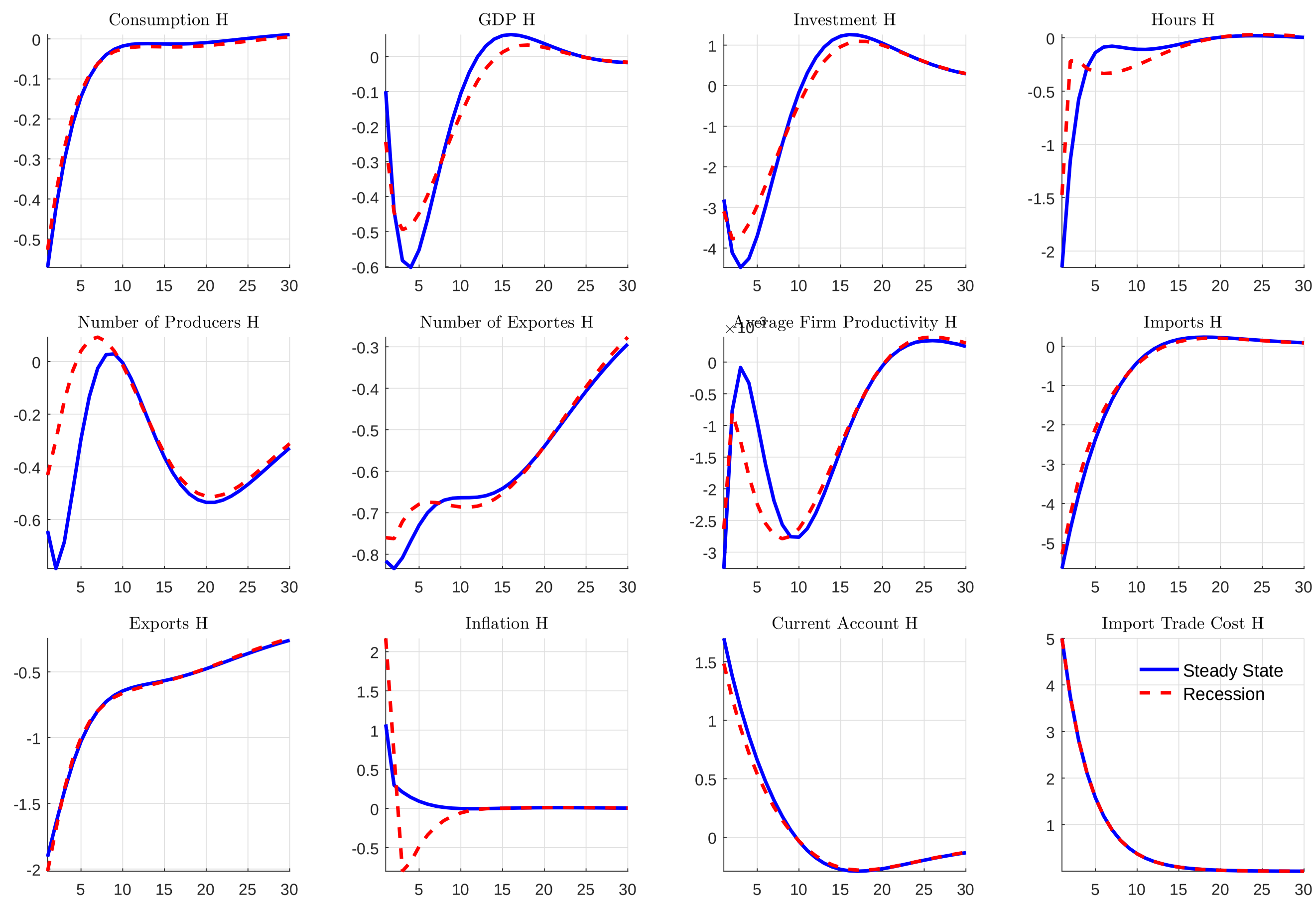

Figure 9: Responses to a temporary increase in Home trade barriers in normal times (continuos lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the steady state. The inflation rate is annualized.

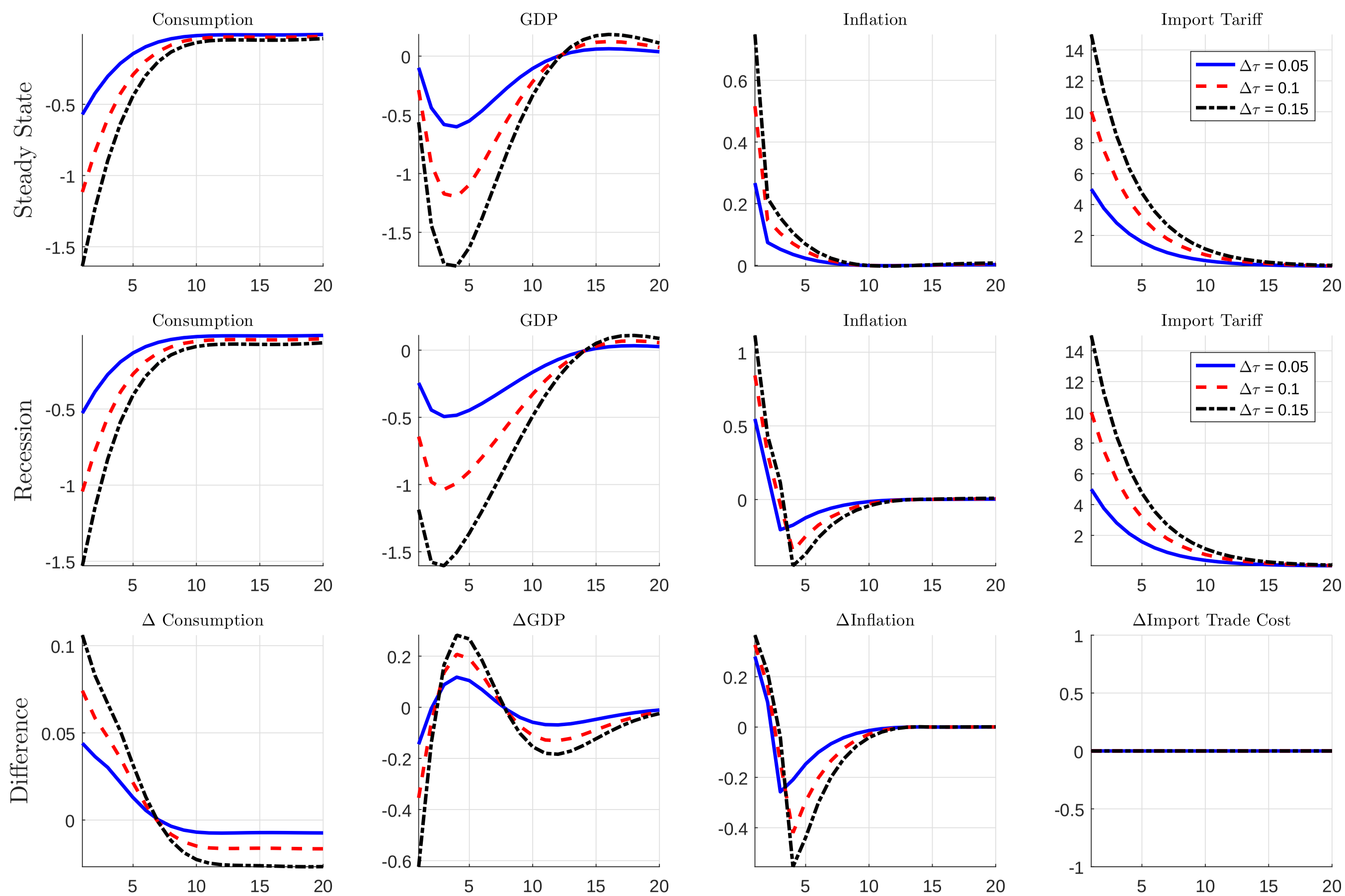

Figure 10: Responses to a temporary increase in Home tariffs, shocks of different size, normal times (continuos lines) vs. recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. The in‡ation rate is annualized.

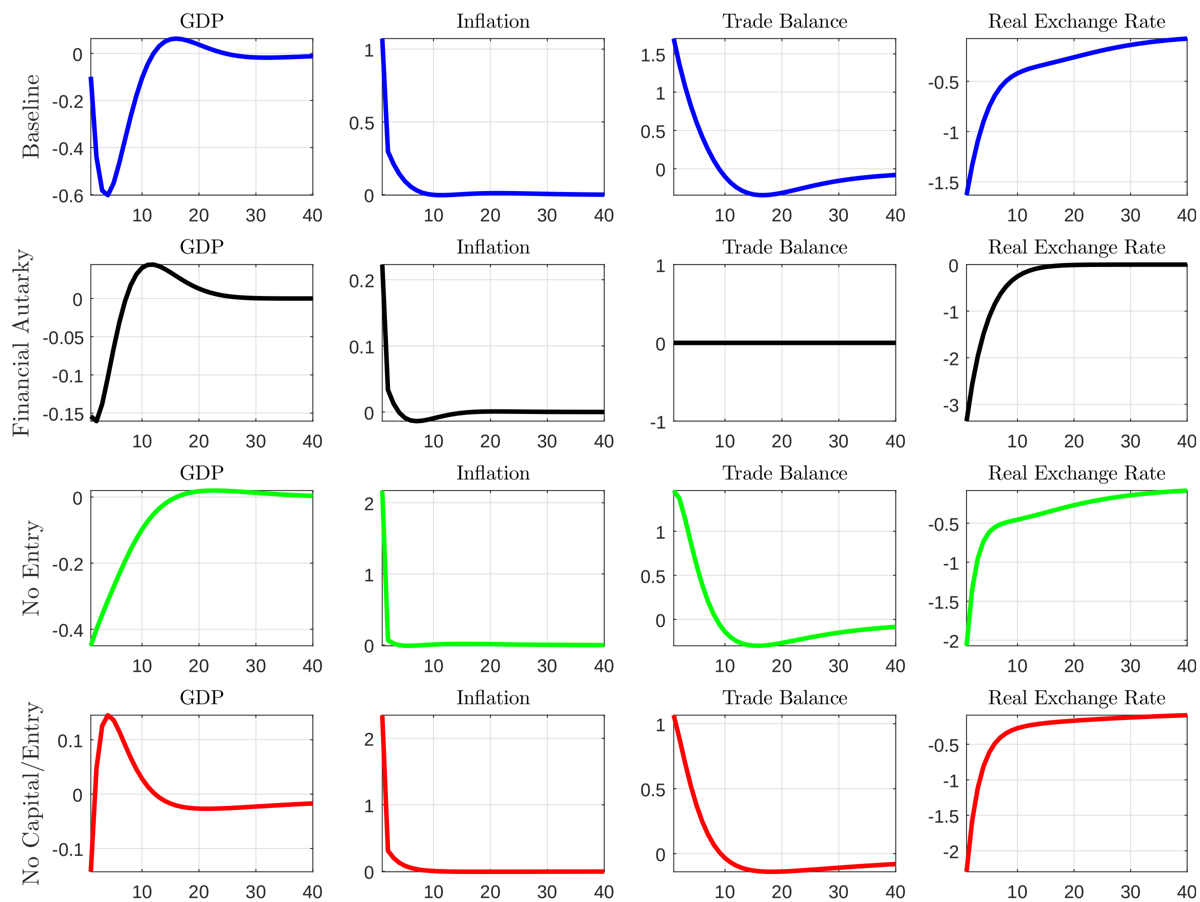

Figure 11: Responses to a temporary increase in Home tariffs in normal times, flexible exchange rate. The top raw: baseline model; second raw: baseline model under financial autarky; third raw: baseline model without firm dynamics; fourth raw: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

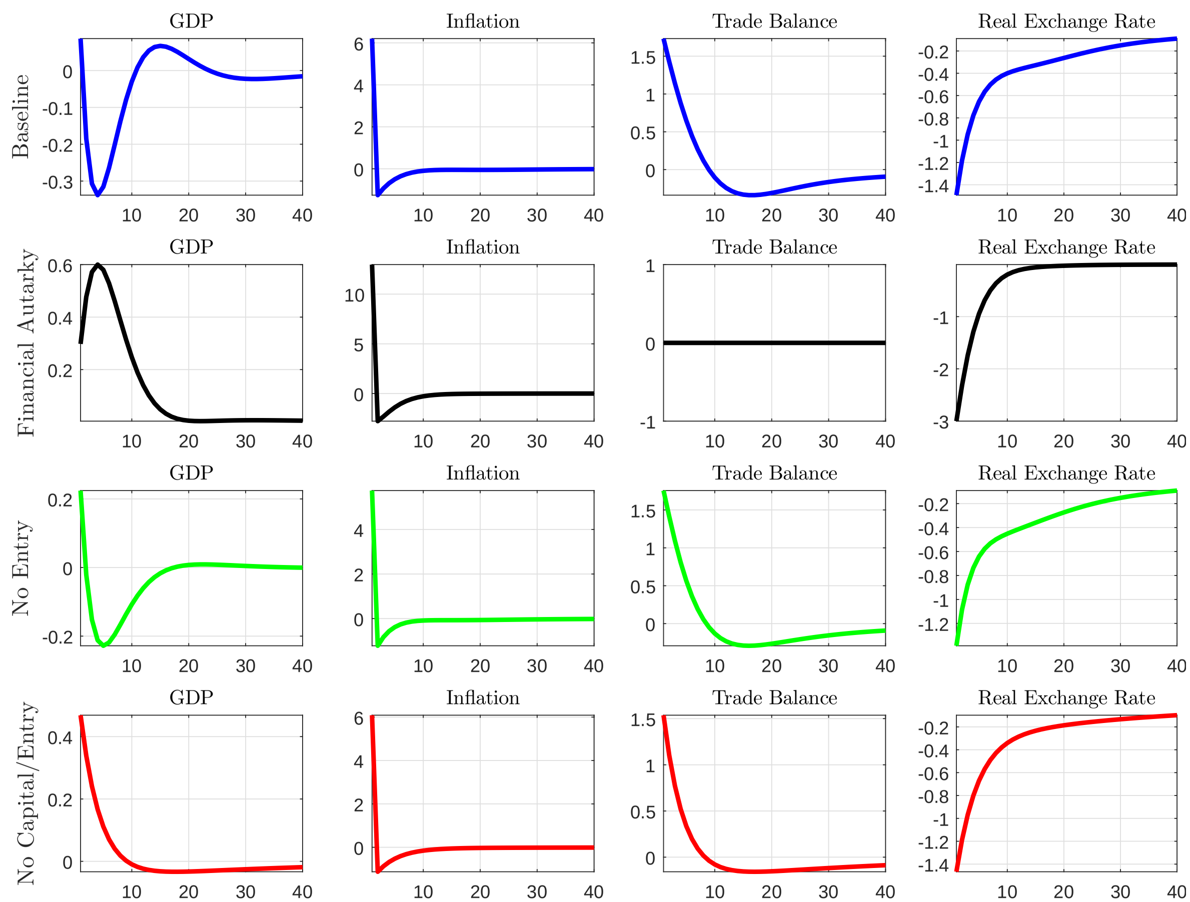

Figure 12: Responses to a temporary increase in Home tariffs in normal times, fixed exchange rate. The top raw: baseline model; second raw: baseline model under financial autarky; third raw: baseline model without firm dynamics; fourth raw: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

Technical Appendix to "Protectionism and the Business Cycle"

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Abstract

This Appendix gathers supplementary material to Barattieri, Cacciatore, and Ghironi (2017).

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A Data Description

We use a variety of data sources in Section 2. Here we describe the variables used, as well as how we treated them.

Antidumping Initiatives Our baseline measure of Antidumping initiatives for the quarterly and monthly VAR is the number of HS-6 products on which new antidumping investigations are launched in a give quarter (or month). The information is taken from the Global Antidumping Database maintained by Bown (2016). We construct time series data by matching the initiation dates of each initiation of anti-dumping investigations recorded in the GAD to the number of HS-6 products interested by each investigation.

Tariffs In the panel VAR, we use information coming from the UN-WITS Database on tariffs. We aggregate HS-6 product level applied tariff building import-weighted averages of tariffs for each country and each year. In our baseline specification, we take weights to be constant (using imports data for 1996). Given the presence of trends in the evolution of applied tariffs, we use a detrended measure of tariffs in the panel VAR. We then compute a measure of extensive margin of trade policy corresponding to the share of tariff lines (at HS-6 products level) that in each country and each year is non-zero.

Real GDP For the quarterly VAR for Turkey, Canada, and India, we use information on Real GDP coming from the OECD quarterly national account database. We use the measure coded VPVOBARSA (US dollars, volume estimates, fixed PPPs, OECD reference year [2010], annual levels, seasonally adjusted). In the main text, we report the results obtained using the growth rate of real GDP. Below, we report the results using detrended real GDP. In the panel VAR, we use instead the series coming from the World Bank World Developing Indicators. Annual GDP is measured in 2010 USD. We use growth rate of the real GDP in our baseline specification.

Inflation For the quarterly and monthly VAR for Turkey and Canada, we use the series for Core CPI inflation ("all items, less food and energy") provided by the OECD prices database. For India, only the series for "all items" is available. Since these series are not seasonally adjusted, and yet they display clear seasonal patterns, we use a standard additive Census-X-11 filter to deseasonalize them. In the case of Turkey, we observe the presence of a clear regime shift in the pre and post 2004 period (an inflation targeting regime was announced in 2002 and it was implemented in 2006). We therefore use a regime-specific demeaned series for core CPI inflation. In the panel VAR, we use annual CPI inflation data coming from the World Bank World Development Indicators. Given the presence of trends in the series for inflation for several countries, we used a detrended measure of inflation in the panel VAR.

Real Net Exports In the quarterly VAR, we use a measure of real net export over real GDP. Exports and imports of good and services coming from the OECD quarterly national account database. We use the measure coded VPVOBARSA (US dollars, volume estimates, fixed PPPs, OECD reference year [2010], annual levels, seasonally adjusted). For the monthly VAR we use data on exports and imports of goods coming from the OECD Main indicator database. These data are seasonally adjusted and reported in USD Billions. We deflate these figures using country specific CPI indexes. In the case of India, the dynamics of net exports featured clear trends. We therefore used detrended series in the quarterly and monthly VAR for India. In the panel VAR, we use net exports over GDP. Data for real exports and imports comes from the World Bank Development Indicators.

Industrial Production In the monthly VAR we use data for Industrial Production coming from the Main Economic indicators of the OECD. The index is seasonally adjusted. We use a detrended series in the monthly SVAR for the results presented in the main paper for Turkey and Canada. We report below the results for Turkey and Canada using the growth rates of industrial production.

Interest Rates For the quarterly VAR, we check the robustness of our results to the inclusion of a measure of short term interest rate using the series for the interbank overnight interest rate provided by the OECD main economic indicators for Turkey, India, Canada. As for the monthly VAR, we use the overnight interest rate series provided by the OECD main economic indictors for India and Canada. For Turkey, we instead use the average daily interest rate on interbank REPO provided to us from the Bolsa Istanbul. We find these series characterized by clear (decreasing) trends. We therefore use detrended series in the quarterly and monthly SVARs. In the panel VAR, we also check the robustness of our results to the inclusion of a measure of short term interest rate. The information on overnight interbank interest rates comes from the OECD for Australia, Brazil, Canada, Chile, Colombia, Iceland, South Korea, South Africa, Norway, New Zealand, and Turkey. In the case of Paraguay and Uruguay, data come from discount rate available through the IMF IFS statistics. Finally, for Malaysia and Philippines we used short term interest rate data directly collected from the respective central banks website. We use detrended series.

Oil Price The Oil price series is the Global Price of WTI Crude provided by the Federal Reserve Bank of St. Louis.

Nominal Exchange Rate Data for the Nominal Effective Exchange Rates come from the Bank of International Settlement for Turkey, Canada and India. In the monthly SVAR, we use the rate of growth of the nominal effective exchange rate (due to the BIS convention, an increase in the rate signals an appreciation).

B Alternative Measures of Antidumping Initiatives

As explained in the main text, we check the robustness of our results to the use of alternative measures of antidumping initiatives. Our baseline measure does not include the products recorded at 4-digits level of disaggregation. An hypothetical approach could be imputing investigations recorded at 4-digits to all 6-digit subproducts contained in a given 4-digits sector. However, this would risk overstating the importance of such investigations—not all 6-digit products that are part of the 4-digit aggregate are necessarily subject to the investigation. As a reasonable alternative, we computed a measure where each time a product is recorded at 4-digits we count it as a one. This allows us to take into account that our baseline measure might miss some products effectively subject to an antidumping investigation. At the same time, this alternative measure prevents from the risk of overstating the number of products subject to a new investigation.

Moreover, both for our baseline measure and for the alternative measure just described, we computed a measure including only the subset of products covered by initiatives that effectively ended up in an antidumping tariff.

The results obtained for the quarterly and monthly data for Turkey and Canada using these four different measures are reported by Figures A.1 to A.4. In each figure, the first panel reproduces the result obtained with our baseline measure. The second panel report the results obtained with the measure counting as one each HS-4 product. The third panel report the measure obtained by excluding from our baseline measure those initiatives not ending up in an antidumping tariff. Finally, the fourth panel report the results for restricting our alternative measure to those initiatives ending up in an antidumping tariff. For ease of comparison, we report only the responses for GDP and Core Inflation when using quarterly data and for Industrial Production and Core Inflation when using monthly data.

Looking at the Figures it's clear how in Turkey, both using quarterly and monthly data, the evidence of a recessionary and inflationary response of the economy to trade policy shock is very robust to the alternative measures used. As for Canada, while the responses are all looking remarkably similar, the level of significance of the responses of real activity seems to be less strong when using only the initiatives that effectively end up in the imposition of a tariff. This is probably due to the fact that in Canada, the success rate of these initiatives is smaller than in Turkey (roughly 65%, against the 85% registered in Turkey).

C Alternative Treatment of the Measure of Real Activity

In the main text, we use the growth rate of real GDP for the quarterly VAR and detrended industrial production for the monthly VAR. Here we consider the level of detrended real GDP (in the quarterly VAR) and the growth rate of industrial production (in the monthly VAR for Turkey and Canada).

Figure A.5 reports the responses of GDP, inflation and net exports over GDP for Turkey (top panel) and Canada (bottom panel). We omit the responses of the trade policy measure to improve the readability of the figures (and because they are almost identical to the ones reported in Figures 3 and 4 in the main text). As for the case presented in the main text, a shock to the number of products subject to new antidumping investigation increases inflation and reduces output, with a modest positive effect on the trade balance over GDP. The bottom panel of Figure A.5, report the results obtained for Canada. Again, the evidence shows an increase in inflation and a decrease in GDP.

Figure A.6 reports instead the responses we obtained using the growth rates of industrial production in the monthly VAR for Turkey (top panel) and for Canada (bottom panel). Again, we omit the response of the trade policy measure since it's very similar to the one we showed in Figures 5 and 6. The overall picture is still consistent with the results presented in the main text. The results obtained for industrial production growth are however less statistically significant than those obtained when using the levels.

D Additional Empirical Evidence

Monthly and Quarterly VARs: India

We corroborate the evidence provided in the main text for Turkey and Canada by using data from India, which is the other main user of antidumping initiatives among developing countries. Figure A.7 reports the results what we obtained for India using quarterly data from 1996q2 to 2015q4.[1] Following a trade policy shock, we observe a decrease in the of GDP (of about 0.2%), significant after two quarters. Net exports over GDP increase, while we do not find a significant inflationary effect. It is important to stress, however, that we have to use headline inflation (as opposed to core inflation) for the case of India. Moreover, the dynamics of urban and rural inflation are likely to be differentially impacted by changes in trade policy, and this might have an impact of the estimates of the effect of trade policy on the overall inflation rate.

In Figure A.8 we report the results obtained for India using monthly data.[2] Also in this case, the results are similar to those obtained for Canada and Turkey, where following an antidumping initiative shock, we see a fall in industrial production, and increase in net exports over GDP. Inflation, as for the case of quarterly data, at first decreases (thought the fall is not significant) and then slowly rises to a positive and significant peak that is reached after 6 months.

[1] The choice of the sample period is due to data availability. We report here the responses using detrended GDP and industrial production. We also tried using the growth rates of these real activity variables, with similar qualitative conclusions.

[2] The period covered is from 1995m5 to 2015m2, due to the limited availability of the series for industrial production from the OECD.

Panel VAR: Extensive Margin of Tariffs and Additional Controls

In the context of the panel VAR, we experimented also with a different measure of protection, namely the share of non-zero tariff lines. For each country and year, we compute the share of non-zero tariff lines in the universe of HS-6 products imported. Therefore, we consider this to be a measure of the *extensive margin* of protection (rather than the *intensive margin*, as represented by the average tariff applied). Given the presence of trends also in this measure, we use a detrended version of this measure in our panel VAR.

Figure A.9 reports the results that we obtained for a one standard deviation increase of the share of tariff lines which are non zero. As in the case of the average applied tariff, inflation increases following a tariff shock. Real GDP declines, but the decline is not statistically significant. Net exports over GDP at first decline, then increases, but as in the case of the intensive measure of protectionism, this increase is not statistically significant.

In results available upon requests, we show how both the results provided in Figure A.8 in the main paper and the results presented in Figure A.9 are not changed if we include a measure of the short term interest rate in the panel VAR. Following a tariff shock, the response of the interest rate is positive and statistically significant in both cases.

E Data-Consistent Variables

First, decompose the price of domestic and imported tradable goods as $P_{D,t}^{T} = \Delta_{D,t}^{T}\tilde{P}_{D,t}^{T}$ and $P_{X,t}^{T^*} = \Delta_{X,t}^{T^*}\tilde{P}_{X,t}^{T^*}$, where

$$\Delta_{D,t}^{T} \equiv N_{D,t}^{\frac{1}{1-\theta_T}} \text{ and } \Delta_{X,t}^{T} \equiv N_{D,t}^{\frac{1}{1-\theta_T}}.$$

As in Ghironi and Melitz (2005), $\tilde{P}_{D,t}^{T}$ and $\tilde{P}_{X,t}^{T^*}$ represents average prices that are not affected by changes in the number of goods available to consumers. Now recall that

$$P_t^T = \left[(1-\alpha_X)\left(P_{D,t}^T\right)^{1-\phi_T} + \alpha_X\left(P_{X,t}^{T^*}\right)^{1-\phi_T}\right]^{\frac{1}{1-\phi_T}},$$

and consider the decomposition: $P_t^T \equiv \Delta_t^T \tilde{P}_t^T$, where

$$\Delta_t^T \equiv \left[(1-\alpha_X)\left(\Delta_{D,t}^T\right)^{1-\phi_T} + \alpha_X\left(\Delta_{X,t}^{T^*}\right)^{1-\phi_T}\right]^{\frac{1}{1-\phi_T}}$$

captures fluctuations in P_t^T due to variety effects, i.e., fluctuations that would occur even in the absence of changes in the average prices $\tilde{P}_{D,t}^{T}$ and $\tilde{P}_{X,t}^{T^*}$. As a result:

$$P_t^T \equiv \Delta_t^T \tilde{P}_t^T = \left[(1-\alpha_X)\left(\Delta_{D,t}^T\tilde{P}_{D,t}^T\right)^{1-\phi_T} + \alpha_X\left(\Delta_{X,t}^{T^*}\tilde{P}_{X,t}^{T^*}\right)^{1-\phi_T}\right]^{\frac{1}{1-\phi_T}}.$$

By combining the above results, we can decompose the CPI index P_t as follows:

$$P_t \equiv \Delta_t \tilde{P}_t = \left[(1-\alpha_N) \left(\Delta_t^T \tilde{P}_t^T \right)^{1-\phi_N} + \alpha_N \left(P_t^N \right)^{1-\phi_N} \right]^{\frac{1}{1-\phi_N}},$$

where the overall CPI deflator Δ_t is defined by:

$$\Delta_t \equiv \left[(1-\alpha_N) \left(\Delta_t^T \right)^{1-\phi_N} + \alpha_N \right]^{\frac{1}{1-\phi_N}}.$$

In turn, given any variable X_t in units of consumption, its data-consistent counterpart is:

$$X_{R,t} \equiv \frac{P_t X_t}{\tilde{P}_t} = X_t \Delta_t.$$

F Foreign Aggregates

As summarized in Table 1, eight Foreign variables directly affect macroeconomic dynamics in the small open economy: Y_t^*, i_{t+1}^*, $\pi_t^{C^*}$, $\rho_t^{T^*}$, $\rho_{X,t}^{T^*}$, $\tilde{\rho}_{X,t}^{T^*}$, $\tilde{Y}_{X,t}^{T^*}$, and $N_{X,t}^*$. Aggregate demand, Y_t^*, the nominal interest rate, i_{t+1}^*, and inflation, $\pi_t^{C^*}$, are determined by treating the rest of the world (Foreign) as a closed economy that features the same production structure, technology and frictions that characterize the small open economy. Here we focus on the determination of the real price of the basket of tradable goods, $\rho_t^{T^*}$, the real price of the exported consumption bundle, $\rho_{X,t}^{T^*}$, the real average price of an exported variety, $\tilde{\rho}_{X,t}^{T^*}$, the average export demand, $\tilde{Y}_{X,t}^{T^*}$, and the number of Foreign exporters, $N_{X,t}$. Since the small open economy is infinitesimally small relative to the rest of the world, these variables affect macroeconomic dynamics in the small open economy without having any effect on the rest of the world.

To determine price and quantities related to exports and imports, we assume that Foreign producers solve a profit maximization problem that is equivalent to that faced by Home producers. Therefore:

$$\tilde{Y}_{X,t}^{*T} = \alpha_X (1-\alpha_N) \left[\left(1+\tau_t^{it}\right) \tilde{\rho}_{X,t}^{*T} \right]^{-\phi_T} \left(N_{X,t}^* \right)^{\frac{\theta_T - \phi_T}{1-\theta_T}} \left(\rho_t^T \right)^{\phi_T - \phi_N} Y_t,$$

where $\tilde{\rho}_{X,t}^* = Q_t \left(1+\tau_t^*\right) \rho_{D,t}^{*^T}$ and $N_{X,t}^* = \left(z_{\min} / \tilde{z}_{X,t}^* \right)^{-k} \kappa^{\frac{k}{\theta_T - 1}} N_{D,t}^*$. In turn, the Foreign average export productivity, $\tilde{z}_{X,t}^*$, is determined by the zero-profit condition:

$$\frac{k-(\theta_T-1)}{(\theta_T-1)k} \frac{\varphi_t^*}{\tilde{z}_{X,t}^*} \frac{Y_{X,t}^*}{N_{X,t}^*} \left(1+\tau_t^*\right) = f_{X,t}^* \varphi_t^*,$$

where $\tau_t^* \geqslant 0$ denotes iceberg trade costs faced by Foreign exporters. Finally, $\rho_t^{T^*} = \rho_{D,t}^{T^*} = \left[\theta_T / \left(\theta_T - 1 \right) \right] \varphi_t^* / \tilde{z}_D$ and $\rho_{X,t}^{T^*} = N_{X,t}^{*^{1/(1-\theta_T)}} \tilde{\rho}_{X,t}^{*^T}$. The variables $\rho_{D,t}^{*^T}$, $N_{D,t}^*$, and φ_t^* that appear above are determined also by treating the rest of the world (Foreign) as a closed economy.

G Sensitivity Analysis

Flexible Prices and Wages

Figure A.10 plots the impulse responses following a 5 percent increase in the Home tariff assuming that both prices and wages are flexible. The figure shows that contractionary monetary policy has a rather limited impact in normal times, since aggregate dynamics are similar to the baseline model.

Persistence of Tariff Shocks

Figure A.11 plots the impulse responses following a 5 percent increase in the Home tariff for three different levels of persistence ($\rho_{\tau^{it}}$). We consider $\rho_{\tau^{it}} = 0.75$, $\rho_{\tau^{it}} = 0.8$, and $\rho_{\tau^{it}} = 0.85$. As for Figure A.12, the top row assumes that the tariff increase occurs in normal times, while the bottom row refers to a recession. The figure shows that protectionism remains recessionary, regardless of the persistence of the tariff shock. However, there is a difference between normal times and ZLB. In normal times, the recession is stronger when the tariff shock is more persistent. At the ZLB, the opposite is true—a more persistent shock induces a milder contraction. The reason for these different results is that the ZLB the higher persistence induces a longer lasting increase in inflation, which other things reduces the real interest rate by more. Notice however, that the same argument does not hold true when considering shocks of larger size (see the main text of the paper). The reason is twofold. First, the short-run income loss is significantly larger when the size the tariff shock increases. Second, larger shocks can trigger a contractionary monetary policy response if their impact on inflation is sufficiently big.

H The Role of Price Stickiness

Non-Tradable Sector

We introduce price stickiness by following Rotemberg (1982) and assuming that final producers must pay a quadratic price adjustment cost:

$$\frac{\nu_N}{2}\left(\frac{P_t^N(i)}{P_{t-1}^N(i)}-1\right)^2 P_t^N(i)\, Y_t^N(i),$$

where $\nu_N \geq 0$ determines the size of the adjustment cost.[3] Per-period (real) profits are given by

$$d_t^N(i) = \left\{\left[1-\frac{\nu_N}{2}\left(\frac{P_t^N(i)}{P_{t-1}^N(i)}\right)^2\right]\frac{P_t^N(i)}{P_t} - \varphi_t\right\} Y_t^{C_N}(i).$$

[3] The total real adjustment cost implies a loss of revenue when implementing a price change. The size of this loss is assumed to be larger when revenue increases.

Firms maximize the expected present discounted value of the stream of current and future real profits: $E_t\left[\sum_{s=t}^{\infty}\beta_{t,t+s}d_s^N(i)\right]$, where, as in the main text, $\beta_{t,t+s}\equiv\beta^s u_{C,t+s}/u_{C,t}$. Optimal price setting implies that the real output price is equal to a markup, $\mu_t^N(i)$, over marginal cost, φ_t:

$$\rho_t^N(i)\equiv\frac{P_t^N(i)}{P_t}=\mu_t^N(i)\varphi_t,$$

where the endogenous, time-varying markup $\mu_t^N(i)$ is given by

$$\mu_t^N(i)\equiv\frac{\theta_N}{(\theta_N-1)\left[1-\frac{\nu_N}{2}(\pi_{N,t}(i))^2\right]+\nu_N\left\{\begin{array}{c}(1+\pi_{N,t}(i))\pi_{N,t}(i)\\ -E_t\left[\beta_{t,t+1}\pi_{N,t+1}(i)\frac{(1+\pi_{N,t+1}(i))^2}{1+\pi_{C,t+1}}\frac{Y_{t+1}^N(i)}{Y_{t+1}^N(i)}\right]\end{array}\right\}},$$

where $\pi_{N,t}(i)\equiv\left(P_t^N(i)/P_{t-1}^N(i)\right)-1$. Price stickiness introduces endogenous markup variation as the cost of adjusting prices gives firms an incentive to change their markups over time in order to smooth price changes across periods.

Notice that in equilibrium, $Y_t^N=\left[1-(\nu/2)(\pi_{N,t})^2\right]^{-1}C_t^N$, where $C_t^N=\alpha_N\left(\rho_t^N\right)^{-\phi_N}Y_t$.

Tradable Sector

We introduce costly price adjustment in the tradable sector by following Cacciatore and Ghironi (2014). To preserve model tractability in the presence of producer heterogeneity, Cacciatore and Ghironi assume that tradable consumption goods are produced by symmetric monopolistically competitive multi-product firms. Each firm purchases intermediate input and produces differentiated varieties of its sectoral output. In equilibrium, some of these varieties are exported while the others are sold only domestically. With flexible prices, the tradable sector is isomorphic to the benchmark model (i.e., to Ghironi and Melitz, 2005).[4] We now present the details of this alternative model, considering both the case of producer currency pricing (PCP) and local currency pricing (LCP).

As in the benchmark model, the tradable consumption basket C_t^T aggregates Home and Foreign tradable consumption sub-baskets in Armington form:

$$C_t^T=\left[(1-\alpha_X)^{\frac{1}{\phi_T}}\left(C_{D,t}^T\right)^{\frac{\phi_T-1}{\phi_T}}+\alpha_X^{\frac{1}{\phi_T}}\left(C_{X,t}^{T^*}\right)^{\frac{\phi_T-1}{\phi_T}}\right]^{\frac{\phi_T}{\phi_T-1}}.$$

The price index that corresponds to the basket C_t^T is given by

$$P_t^T=\left\{(1-\alpha_X)\left(P_{D,t}^T\right)^{1-\phi_T}+\alpha_X\left[\left(1+\tau_t^{it}\right)P_{X,t}^{T^*}\right]^{1-\phi_T}\right\}^{\frac{1}{1-\phi_T}}.$$

[4] This is true as long as the elasticity of substitution across differentiated varieties (denoted with θ_ω below) is equal to the elasticity of substitution of tradable consumption goods (θ_T) in the benchmark model.

In contrast to the benchmark model, there is a continuum $(0,1)$ of symmetric tradable sectors. The domestic tradable consumption $C^T_{D,t}$ aggregates sectoral consumption goods $C^T_{D,t}(i)$:

$$C^T_{D,t} = \left[\int_0^1 C^T_{D,t}(i)^{(\theta_T-1)/\theta_T} di\right]^{\theta_T/(\theta_T-1)}.$$

A similar basket describes Foreign tradable consumption: $C^{T^*}_{X,t} = \left[\int_0^1 C^{T^*}_{X,t}(i)^{(\theta_T-1)/\theta_T} di\right]^{\theta_T/(\theta_T-1)}$. The corresponding price indexes are $P^T_{D,t} = \left[\int_0^1 P^T_{D,t}(i)^{1-\theta_T} di\right]^{1/(1-\theta_T)}$ and $P^{T^*}_{X,t} = \left[\int_0^1 P^{T^*}_{X,t}(i)^{1-\theta_T} di\right]^{1/(1-\theta_T)}$, both expressed in Home currency.

In each tradable consumption sector i, there is a representative, monopolistically competitive firms that produces the sectoral output bundle $Y^T_t(i)$, sold to consumers in Home and Foreign. Producer i is a multi-product firm that produces a set of differentiated product varieties, indexed by ω and defined over a continuum Ω: $Y^T_t(i) = \left(\int_{\omega\in\Omega}^{\infty} Y^T_t(\omega,i)^{(\theta_\omega-1)/\theta_\omega} d\omega\right)^{\theta_\omega/(\theta_\omega-1)}$, where $\theta_\omega > 1$ denotes the symmetric elasticity of substitution across product varieties.[5] We assume that $\theta_\omega = \theta^T$.

Each product variety $Y^T(\omega,i)$ is created and developed by the representative producer i. The number of products (or features) created and commercialized by each producer is endogenous. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. To create a new product, the producer needs to undertake a sunk investment, $f_{E,t}$, in units of intermediate input. Product creation requires each producer to create a new plant that will be producing the new variety.[6] Plants produce with different technologies indexed by relative productivity z. To save notation, we identify a variety with the corresponding plant productivity z, omitting ω. Upon product creation, the productivity level of the new plant z is drawn from a common distribution $G(z)$ with support on $[z_{\min},\infty)$. This relative productivity level remains fixed thereafter. Each plant uses the intermediate input to produce its differentiated product variety, with real marginal cost:

$$\varphi^T_t(z) = \frac{\varphi_t}{z}. \tag{A-1}$$

At time t, the tradable Home produce i commercializes $N_{D,t}(i)$ varieties and creates $N_{E,t}(i)$ new products that will be available for sale at time $t+1$. New and incumbent plants can be hit by a "death" shock with probability $\delta \in (0,1)$ at the end of each period. The law of motion for the stock of producing plants is $N_{D,t+1}(i) = (1-\delta)([N_{D,t}(i) + N_{E,t}(i)]$.

When serving the Foreign market, each producer faces per-unit iceberg trade costs, $\tau_t > 0$, and fixed export costs, $f_{X,t}$. Fixed export costs are denominated in units of intermediate input and paid for each exported product. Thus, the total fixed cost is $N_{X,t}(i)f_{X,t}(i)$, where $N_{X,t}(i)$ denotes the number of product varieties (or features) exported to Foreign. Absent fixed export costs, each producer would find it optimal

[5] Sectors (and sector-representative firms) are of measure zero relative to the aggregate size of the economy. Notice that $Y^T_t(i)$ can also be interpreted as a bundle of product features that characterize the final product i.

[6] Alternatively, we could decentralize product creation by assuming that monopolistically competitive firms produce product varieties (or features) that are sold to final producers, in this case interpreted as retailers. The two models are isomorphic. Details are available upon request.

to sell all its product varieties in Home and Foreign. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above the cutoff level $z_{X,t}$, determined below) are exported.[7]

Define two special "average" productivity levels (weighted by relative output shares): an average $\tilde{z}_D$ for all producing plants and an average $\tilde{z}_{X,t}$ for all plants that export:

$$\tilde{z}_D = \left[\int_{z_{\min}}^{\infty} z^{\theta_\omega - 1} dG(z)\right]^{\frac{1}{\theta_\omega - 1}}, \qquad \tilde{z}_{X,t}(i) = \left[\frac{1}{1 - G(z_{X,t}(i))}\right]\left[\int_{z_{X,t}(i)}^{\infty} z^{\theta_\omega - 1} dG(z)\right]^{\frac{1}{\theta_\omega - 1}}.$$

Assume that $G(\cdot)$ is Pareto with shape parameter $k_p > \theta_\omega - 1$. As a result, $\tilde{z}_D = \alpha^{1/(\theta_\omega - 1)} z_{\min}$ and $\tilde{z}_{X,t} = \alpha^{1/(\theta_\omega - 1)} z_{X,t}$, where $\alpha \equiv k_p / (k_p - \theta_\omega + 1)$. The share of exporting plants is given by:

$$N_{X,t}(i) \equiv [1 - G(z_{X,t}(i))]\, N_{D,t}(i) = \left(\frac{z_{\min}}{\tilde{z}_{X,t}(i)}\right)^{-k_p} \alpha^{\frac{k_p}{\theta_\omega - 1}} N_{D,t}(i). \tag{A-2}$$

The output bundles for domestic and export sale, and the corresponding unit costs, are defined as follows:

$$Y_{D,t}^T(i) = \left[\int_{z_{\min}}^{\infty} Y_{D,t}^T(z,i)^{\frac{\theta_\omega - 1}{\theta_\omega}} dG(z)\right]^{\frac{\theta_\omega}{\theta_\omega - 1}}, \qquad Y_{X,t}^T(i) = \left[\int_{z_{X,t}(i)}^{\infty} Y_{X,t}^T(z,i)^{\frac{\theta_\omega - 1}{\theta_\omega}} dG(z)\right]^{\frac{\theta_\omega}{\theta_\omega - 1}}, \tag{A-3}$$

$$\varphi_{D,t}^T(i) = \left[\int_{z_{\min}}^{\infty} \left(\varphi_t^T(z)\right)^{1-\theta_\omega} dG(z)\right]^{\frac{1}{1-\theta_\omega}}, \qquad \varphi_{X,t}^T(i) = \left[\int_{z_{X,t}(i)}^{\infty} \left(\varphi_t^T(z)\right)^{1-\theta_\omega} dG(z)\right]^{\frac{1}{1-\theta_\omega}}. \tag{A-4}$$

Notice that using equations (A-1) and (A-4), the real costs of producing the bundles $Y_{D,t}(i)$ and $Y_{X,t}(i)$ can be expressed as:

$$\varphi_{D,t}^T(i) = [N_{D,t}(i)]^{\frac{1}{1-\theta_\omega}} \frac{\varphi_t}{\tilde{z}_D}, \qquad \varphi_{X,t}^T(i) = [N_{X,t}(i)]^{\frac{1}{1-\theta_\omega}} \frac{\varphi_t}{\tilde{z}_{X,t}(i)}. \tag{A-5}$$

Denote with $P_{D,t}^T(i)$ the price (in Home currency) of the product bundle $Y_{D,t}^T(i)$ and let $P_{X,t}^T(i)$ be the price (in Foreign currency) of the exported bundle $Y_{X,t}^T(i)$. Each producer i faces the following domestic and foreign demand:

$$Y_{D,t}^T(i) = \left(\frac{P_{D,t}^T(i)}{P_{D,t}^T}\right)^{-\theta_T} Y_{D,t}^T,$$

$$Y_{X,t}^T(i) = \left[\frac{\left(1 + \tau_t^{it^*}\right) P_{X,t}^T(i)}{P_{X,t}^T}\right]^{-\theta_T} Y_{X,t}^{T^*},$$

where $Y_{D,t}^T$ and $Y_{X,t}^{T^*}$ are aggregate demands of the Home tradable consumption basket in Home and Foreign, respectively.

Prices in the tradable sector are sticky: Tradable producers must pay quadratic price adjustment costs when changing domestic and export prices. We consider to alternative assumptions about the currency

[7] Notice that $z_{X,t}$ is the lowest level of plant productivity such that the profit from exporting is positive.

denomination of export prices: producer currency pricing (PCP) and local currency pricing (LCP).

Producer Currency Pricing

Each producer sets $P_{D,t}^{T}(i)$ and the domestic currency price of the export bundle, $P_{X,t}^{T,h}(i)$, letting the price in the foreign market be $P_{X,t}^{T}(i) = P_{X,t}^{T,h}(i)/\varepsilon_t$, where ε_t is the nominal exchange rate. Absent fixed export costs, the producer would set a single price $P_{D,t}(i)$ and the law of one price (adjusted for the presence of trade costs) would determine the export price as $P_{X,t}^{T}(i) = (1+\tau_t) P_{D,t}(i)/\varepsilon_t$. With fixed export costs, however, the composition of domestic and export bundles is different, and the marginal costs of producing these bundles are not equal. Therefore, producers choose two different prices for the Home and Foreign markets even under PCP.

The nominal costs of adjusting domestic and export price are, respectively

$$\frac{\nu_T}{2}\left(\frac{P_{D,t}^{T}(i)}{P_{D,t-1}^{T}(i)}-1\right)^2 P_{D,t}^{T}(i)\, Y_{D,t}^{T}(i),$$

and

$$\frac{\nu_T}{2}\left(\frac{P_{X,t}^{T,h}(i)}{P_{X,t-1}^{T,h}(i)}-1\right)^2 P_{X,t}^{T,h}(i)\, Y_{X,t}^{T}(i),$$

where $\nu_T \geq 0$ determines the size of the adjustment costs (domestic and export prices are flexible if $\nu_T = 0$). Per-period (real) profits are given by:

$$d_t^T(i) = \left\{ \begin{array}{c} \left\{\left[1-\frac{\nu_T}{2}\left(\frac{P_{D,t}^{T}(i)}{P_{D,t-1}^{T}(i)}-1\right)^2\right]\frac{P_{D,t}^{T}(i)}{P_t} - \varphi_{D,t}^{T}(i)\right\}\left(\frac{P_{D,t}^{T}(i)}{P_{D,t}^{T}}\right)^{-\theta_T} Y_{D,t}^{T} \\ +\left\{\left[1-\frac{\nu_T}{2}\left(\frac{P_{X,t}^{T,h}(i)}{P_{X,t-1}^{T,h}(i)}-1\right)^2\right]\frac{P_{X,t}^{T,h}(i)}{P_t} - (1+\tau_t)\,\varphi_{X,t}^{T}(i)\right\}\left[\frac{\left(1+\tau_t^{it^*}\right)P_{X,t}^{T,h}(i)}{\varepsilon_t P_{X,t}^{T}}\right]^{-\theta_T} Y_{X,t}^{T^*} \\ -\varphi_t\left[N_{E,t}(i)\, f_{E,t} + N_{X,t} f_{X,t}(i)\right] \end{array} \right\}.$$

The representative producer chooses $P_{D,t}^{T}(i)$, $P_{X,t}^{T,h}(i)$, $N_{E,t}(i)$, and $z_{X,t}(i)$ in order to maximize the expected present discounted value of the stream of real profits, $E_t\left[\sum_{s=t}^{\infty}\beta_{s,t} d_s^T(i)\right]$, subject to the constraints (A-2), (A-5), and $\tilde{z}_{X,t}(i) = \alpha^{1/(\theta_\omega-1)} z_{X,t}(i)$.[8]

Since tradable consumption-producing sectors are symmetric in the economy, from now on we omit the index i to simplify notation when presenting the first-order conditions. The first-order condition with respect to $z_{X,t}$ yields:

$$\frac{k_p-(\theta_\omega-1)}{(\theta_\omega-1)k_p}\varphi_{X,t}^{T}\frac{Y_{X,t}^{T}}{N_{X,t}}(1+\tau_t) = f_{X,t}\varphi_t.$$

The above conditions states that, at the optimum, marginal revenue from adding a variety with productivity $z_{X,t}$ to the export bundle has to be equal to the fixed cost. Thus, varieties produced by plants with productivity below $z_{X,t}$ are distributed only in the domestic market. The composition of the traded bundle is endogenous and the set of exported products fluctuates over time with changes in the profitability of

[8] Equation (A-2) implies that by choosing $z_{X,t}$ the producer also determines $N_{X,t}$.

export.

The first-order condition with respect to $N_{D,t+1}$ determines product creation:

$$\varphi_t f_{E,t} = E_t \left\{ (1-\delta)\,\beta_{t,t+1} \left[\begin{array}{c} \varphi_{t+1}\left(f_{E,t+1} - \frac{N_{X,t+1}}{N_{D,t+1}} f_{X,t+1}\right) \\ +\frac{1}{\theta_\omega - 1}\left(\varphi^T_{D,t+1}\frac{Y^T_{D,t+1}}{N_{D,t+1}} + \varphi^T_{X,t+1}\frac{Y^T_{X,t+1}}{N_{X,t+1}}\frac{N_{X,t+1}}{N_{D,t+1}}\tau_{t+1}\right) \end{array} \right] \right\}.$$

In equilibrium, the cost of producing an additional variety, $\varphi_t f_{E,t}$, must be equal to its expected benefit (which includes expected savings on future sunk investment costs augmented by the marginal revenue from commercializing the variety, net of fixed export costs, if it is exported).

The (real) price of Home output for domestic sales is a time-varying markup $\mu^T_{D,t}$ over the domestic marginal cost, $\varphi^T_{D,t}$:

$$\rho^T_{D,t} \equiv \frac{P_{D,t}}{P_t} = \mu^T_{D,t}\varphi^T_{D,t}.$$

The time-varying domestic markup, $\mu^T_{D,t}$, is given by:

$$\mu^T_{D,t} \equiv \frac{\theta_T}{(\theta_T - 1)\left[1 - \frac{\nu_T}{2}\left(\pi^T_{D,t}\right)^2\right] + \nu_T \left\{ \begin{array}{c} \left(1+\pi^T_{D,t}\right)\pi^T_{D,t} \\ -E_t\left[\beta_{t,t+1}\frac{\left(1+\pi^T_{D,t+1}\right)^2}{1+\pi_{C,t+1}}\pi^T_{D,t+1}\frac{Y^T_{D,t+1}}{Y^T_{D,t}}\right] \end{array} \right\}},$$

where $1+\pi^T_{D,t} \equiv P^T_{D,t}/P^T_{D,t-1}$. The (real) price of Home output for export sales (in units of Home consumption) is a time-varying markup $\mu^T_{X,t}$ over the marginal cost of the export bundle, $\varphi^T_{X,t}$:

$$\rho^T_{X,t} \equiv \frac{P^T_{X,t}}{P^*_t} = \mu^T_{X,t}\frac{(1+\tau_t)\,\varphi^T_{X,t}}{Q_t}.$$

The time-varying export markup, $\mu^T_{X,t}$, is given by:

$$\mu^T_{X,t} = \frac{\theta_T}{(\theta_T - 1)\left[1 - \frac{\nu_T}{2}\left(\pi^{T,h}_{X,t}\right)^2\right] + \nu_T \left\{ \begin{array}{c} \left(1+\pi^{T,h}_{X,t}\right)\pi^{T,h}_{X,t} \\ -E_t\left[\beta_{t,t+1}\frac{\left(1+\pi^{T,h}_{X,t+1}\right)^2}{1+\pi_{C,t+1}}\pi^{T,h}_{X,t+1}\frac{Y^T_{X,t+1}}{Y^T_{X,t}}\right] \end{array} \right\}}, \tag{A-6}$$

where

$$1+\pi^{T,h}_{X,t} = \frac{P^{T,h}_{X,t}}{P^{T,h}_{X,t-1}} = \frac{Q_t}{Q_{t-1}}\frac{\rho^T_{X,t}}{\rho^T_{X,t-1}}\left(1+\pi_{C,t}\right).$$

As expected, price stickiness introduces endogenous markup variations both in the domestic and export markets. In equilibrium,

$$Y^T_{D,t} = \left[1 - (\nu/2)\left(\pi^T_{D,t}\right)^2\right]^{-1} C^T_{D,t}$$

and

$$Y^T_{X,t} = \left[1 - (\nu/2)\left(\pi^{T,h}_{X,t}\right)^2\right]^{-1} C^T_{X,t}.$$

Local Currency Pricing

Under LCP, the export price is set in Foreign currency. The nominal costs of adjusting the export price is now given by:

$$\frac{\nu_T}{2}\left(\frac{P^T_{X,t}(i)}{P^T_{X,t-1}(i)}-1\right)^2 \varepsilon_t P^T_{X,t}(i)\, Y^T_{X,t}(i).$$

Therefore, each producer chooses $P^T_{X,t}(i)$ to maximize:

$$d^T_t(i)=\left\{\begin{array}{c} \left\{\left[1-\frac{\nu_T}{2}\left(\frac{P^T_{D,t}(i)}{P^T_{D,t-1}(i)}-1\right)^2\right]\frac{P^T_{D,t}(i)}{P_t}-\varphi^T_{D,t}(i)\right\}\left(\frac{P^T_{D,t}(i)}{P^T_{D,t}}\right)^{-\theta_T} Y^T_{D,t} \\ +\left\{\left[1-\frac{\nu_T}{2}\left(\frac{P^T_{X,t}(i)}{P^T_{X,t}(i)}-1\right)^2\right]\frac{\varepsilon_t P^T_{X,t}(i)}{P_t}-(1+\tau_t)\,\varphi^T_{X,t}(i)\right\}\left[\frac{P^T_{X,t}(i)}{P^{T*}_{X,t}}\right]^{-\theta_T} Y^{T^*}_{X,t} \\ -\varphi_t\left[N_{E,t}(i)\, f_{E,t}+N_{X,t} f_{X,t}(i)\right]. \end{array}\right\}.$$

In the symmetric equilibrium, the time-varying markup, $\mu^T_{X,t}$, is now given by:

$$\mu^T_{X,t}\equiv\frac{\theta_T}{(\theta_T-1)\left[1-\frac{\nu_T}{2}\left(\pi^T_{X,t}\right)^2\right]+\nu_T\left\{\begin{array}{c}\left(1+\pi^T_{X,t}\right)\pi^T_{X,t} \\ -E_t\left[\beta_{t,t+1}\frac{Q_{t+1}}{Q_t}\frac{\left(1+\pi^T_{X,t}\right)^2}{1+\pi_{C,t+1}}\pi^T_{X,t}\frac{Y^T_{X,t+1}}{Y^T_{X,t}}\right]\end{array}\right\}},$$

where $1+\pi^T_{X,t}=P^T_{X,t}/P^T_{X,t-1}$.

Notice that with a fixed exchange rate, there would be no difference in the equilibrium allocation between PCP and LCP. To see this, recall that under PCP $P^T_{X,t}(i)=P^{T,h}_{X,t}(i)/\varepsilon_t$. Therefor the adjustment cost under PCP can be written as

$$\frac{\nu_T}{2}\left(\frac{P^T_{X,t}(i)\,\varepsilon_t}{P^T_{X,t-1}(i)\,\varepsilon_{t-1}}-1\right)^2 P^T_{X,t}(i)\,\varepsilon_t Y^T_{X,t}(i).$$

With a fixed exchange, $\varepsilon_t/\varepsilon_{t-1}=1$. Therefore, the adjustment cost under PCP becomes:

$$\frac{\nu_T}{2}\left(\frac{P^T_{X,t}(i)}{P^T_{X,t-1}(i)}-1\right)^2 P^T_{X,t}(i)\,\varepsilon_t Y^T_{X,t}(i),$$

which is identical to the cost under LCP. Furthermore, $P^T_{X,t}(i)=P^{T,h}_{X,t}(i)$ in deviations from steady state, since $\varepsilon_t=\varepsilon$ (constant).[9]

Impulse Responses

Figure A.12 presents the impulse responses following a temporary increase in tariffs under PCP, while Figure 13 considers LCP. In both scenarios, we assume that the exchange rate is flexible. As in the main text, we consider four model specifications: the baseline model (first row), the baseline model under financial autarky

[9] Absent firm heterogeneity, the exact equivalence between LCP and PCP would no longer hold, since there would be a single Rotemberg adjustment cost for total sales under PCP. Nevertheless, the equilibrium allocations remain very similar.

(second row), the baseline model without endogenous firm dynamics (third row), and the baseline model without firm dynamics and endogenous physical capital accumulation.

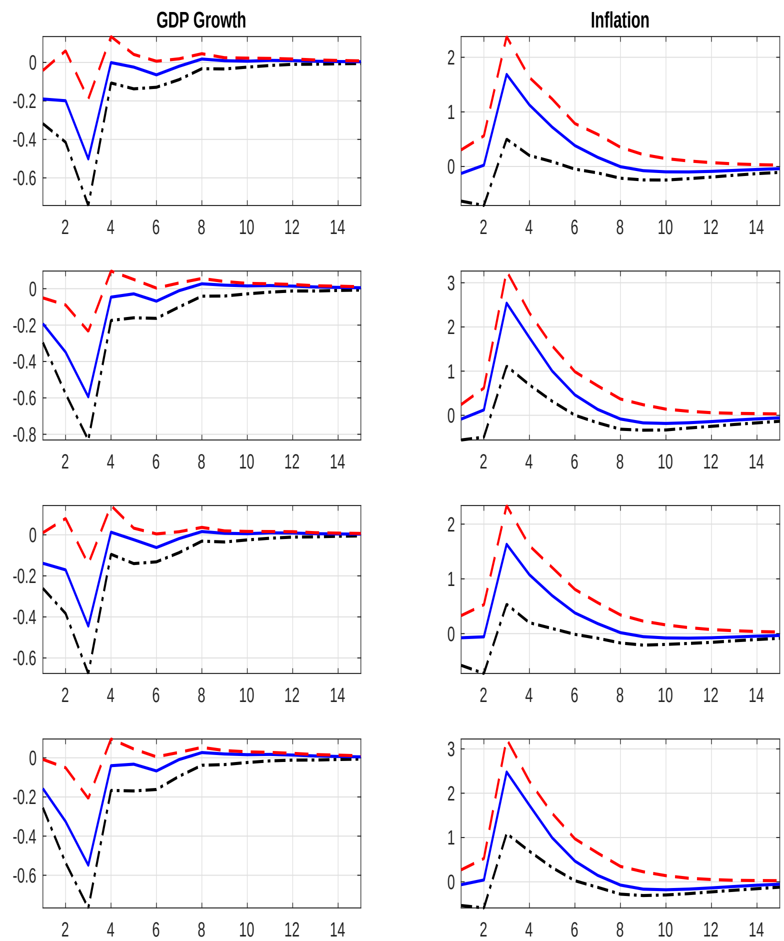

Figure A1: Quarterly VAR, alternative trade policy measures for Turkey. First panel: baseline measure. Second panel: measure counting products reported at 4-digits as ones. Third panel: baseline measure, less initiatives not ending in imposition of antidumping tariff. Fourth panel: measure counting products reported at 4-digits as ones less initiatives not ending in imposition of antidumping tariff. Impulse responses to a one-standard deviation increase in the trade policy measure. GDP growth is in percentage points. The inflation rate is annualized.

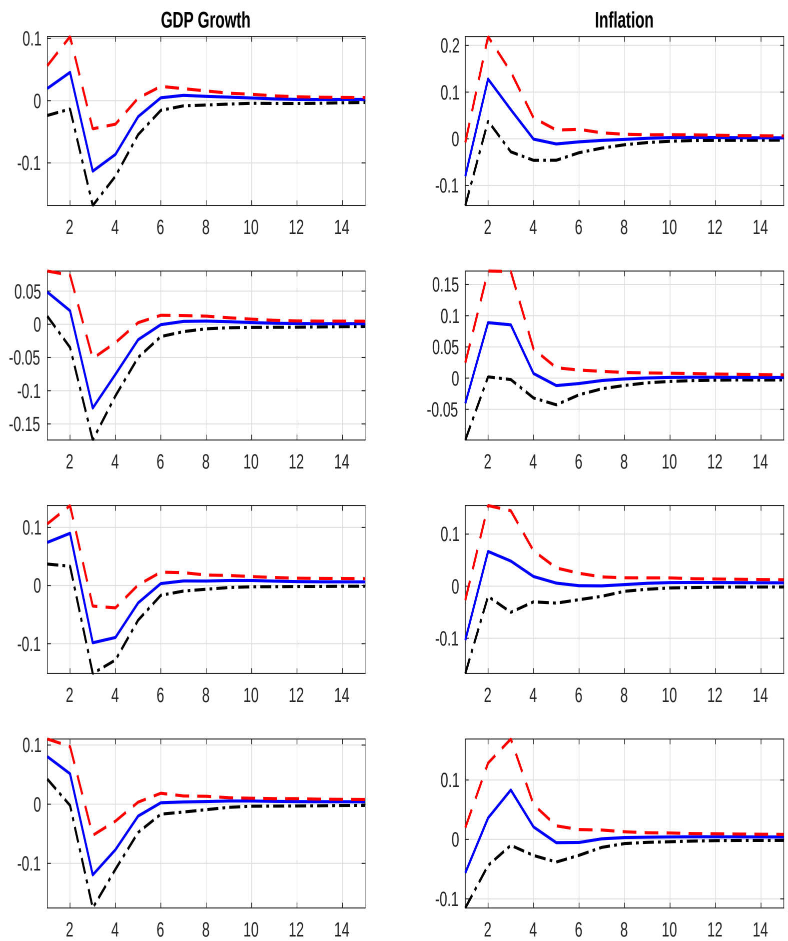

Figure A2: Quarterly VAR, alternative trade policy measures for Canada. First panel: baseline measure. Second panel: measure counting products reported at 4-digits as ones. Third panel: baseline measure, less initiatives not ending in imposition of antidumping tariff. Fourth panel: measure counting products reported at 4-digits as ones less initiatives not ending in imposition of antidumping tariff. Impulse responses to a one-standard deviation increase in the trade policy measure. GDP growth is in percentage points. The inflation rate is annualized.

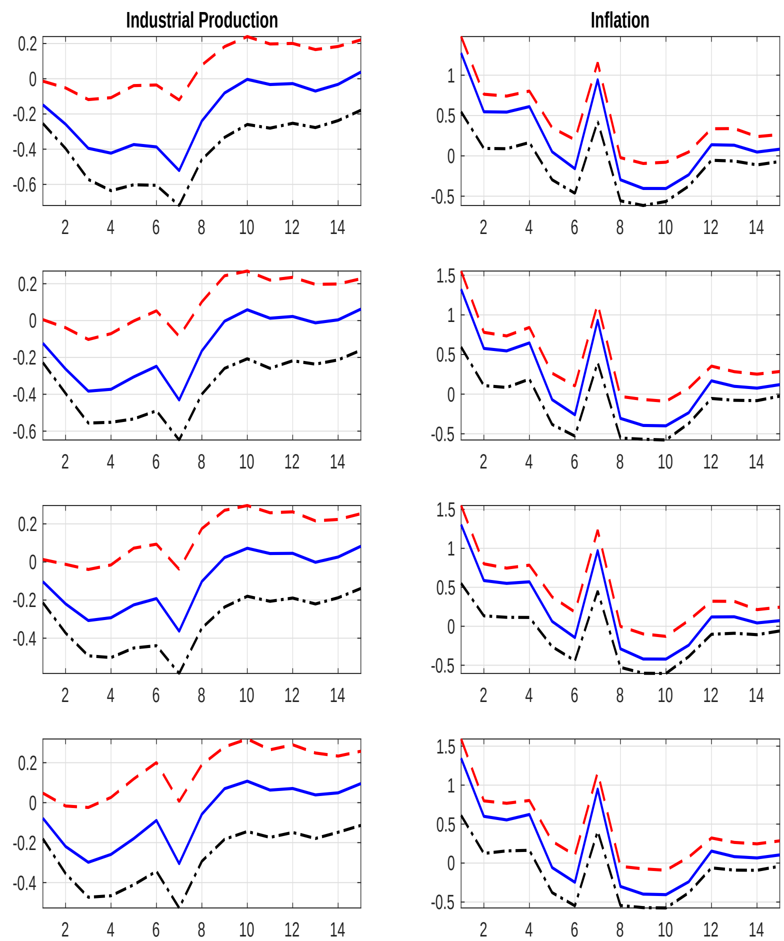

Figure A3: Monthly VAR, alternative trade policy measures for Turkey. First panel: baseline measure. Second panel: measure counting products reported at 4-digits as ones. Third panel: baseline measure, less initiatives not ending in imposition of antidumping tariff. Fourth panel: measure counting products reported at 4-digits as ones less initiatives not ending in imposition of antidumping tariff. Impulse responses to a one-standard deviation increase in the trade policy measure. Industrial production is in percentage points. The inflation rate is annualized.

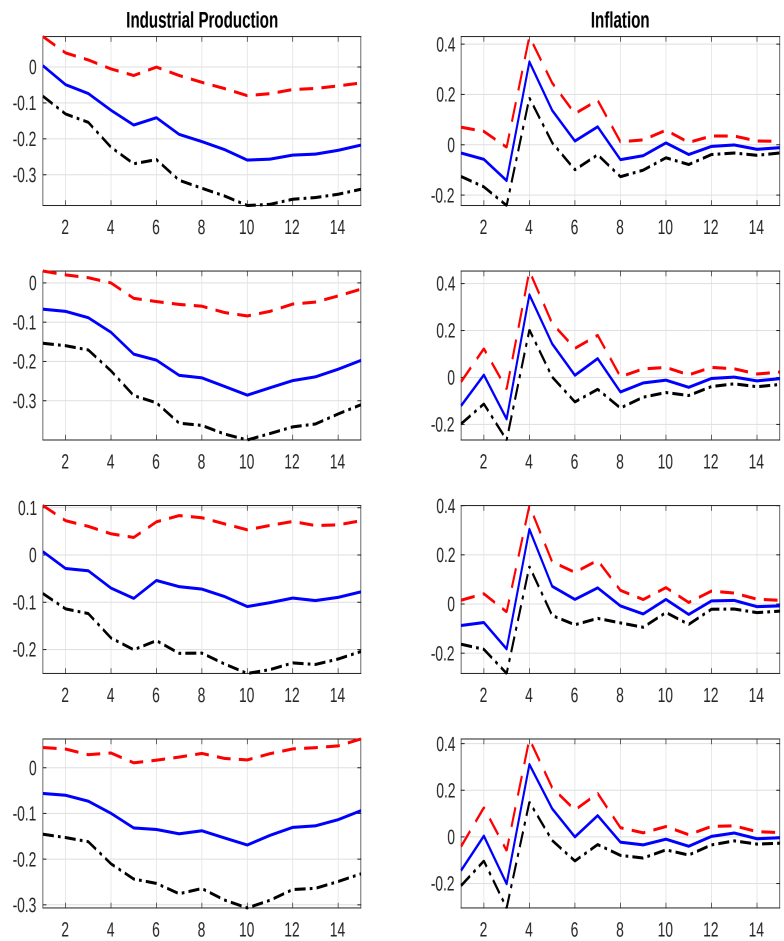

Figure A4: Monthly VAR, alternative trade policy measures for Canada. First panel: baseline measure. Second panel: measure counting products reported at 4-digits as ones. Third panel: baseline measure, less initiatives not ending in imposition of antidumping tariff. Fourth panel: measure counting products reported at 4-digits as ones less initiatives not ending in imposition of antidumping tariff. Impulse responses to a one-standard deviation increase in the trade policy measure. Industrial production is in percentage points. The inflation rate is annualized.

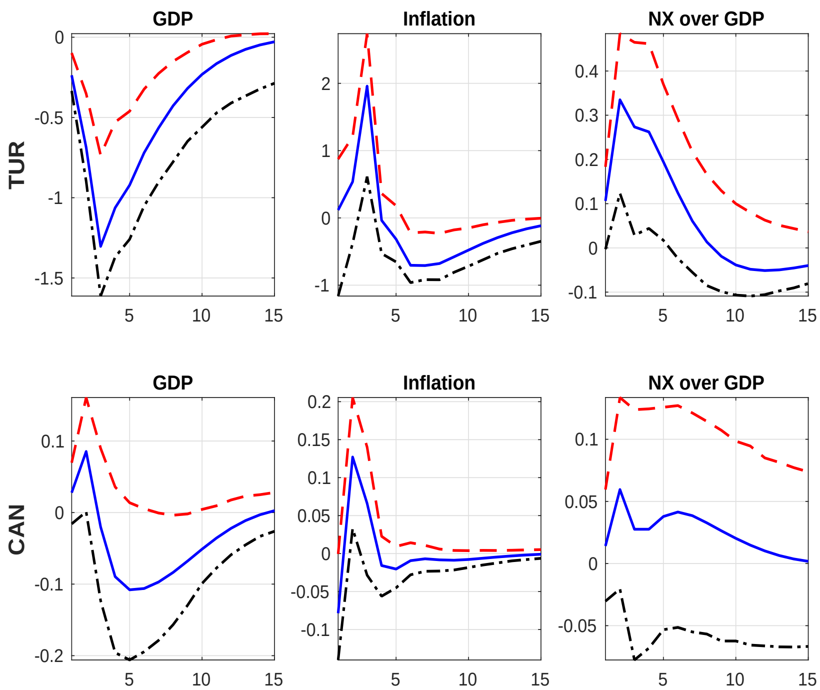

Figure A5: Quarterly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Turkey and Canada. GDP and net exports over GDP are in percentage points. The inflation rate is annualized.

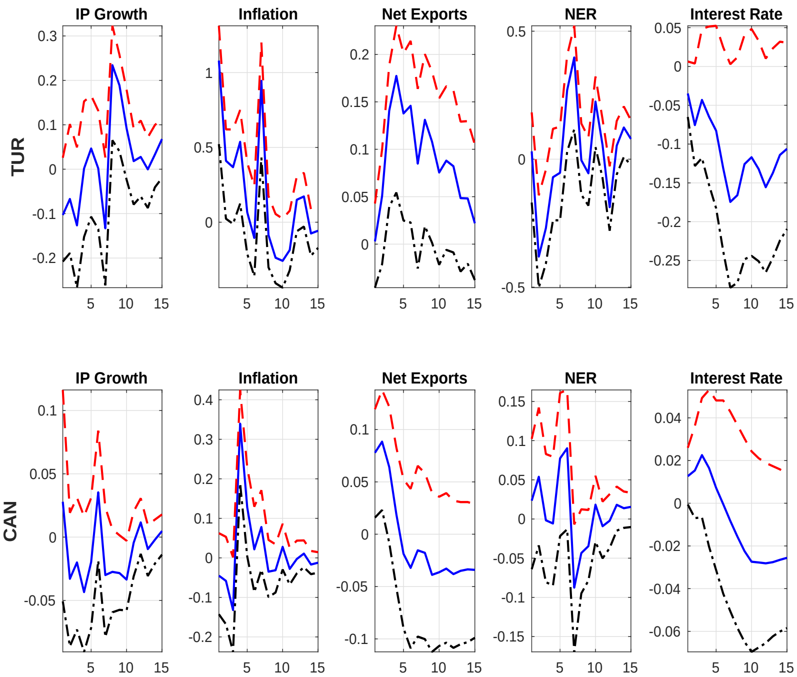

Figure A6: Monthly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in Turkey and Canada. Industrial production and nominal exchange rates are in percentage points. Net exports are in 2010 USD billions. The inflation rate and the interest rate are annualized.

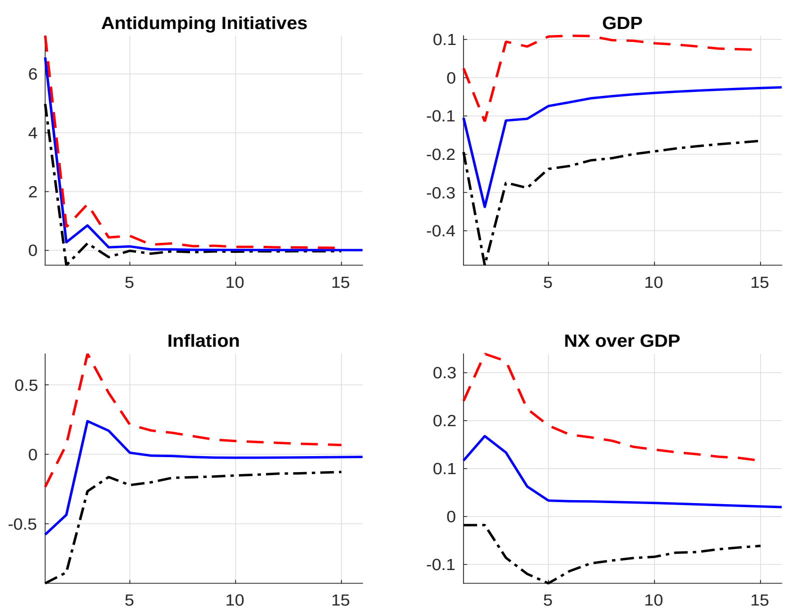

Figure A7: Quarterly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in India. GDP and net exports over GDP are in percentage points. The inflation rate is annualized.

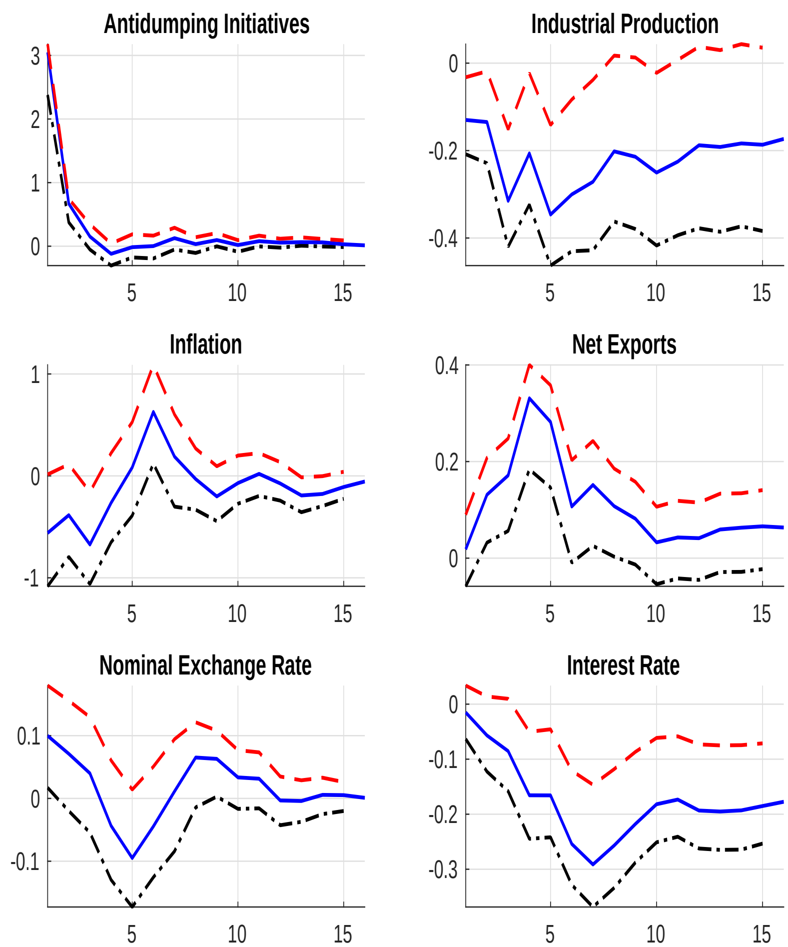

Figure A8: Monthly VAR, impulse responses to a one-standard deviation increase in the number of products subject to new antidumping investigations in India. Industrial production and nominal exchange rate are in percentage points. Net exports are in 2010 USD billions. The inflation rate and the interest rate are annualized.

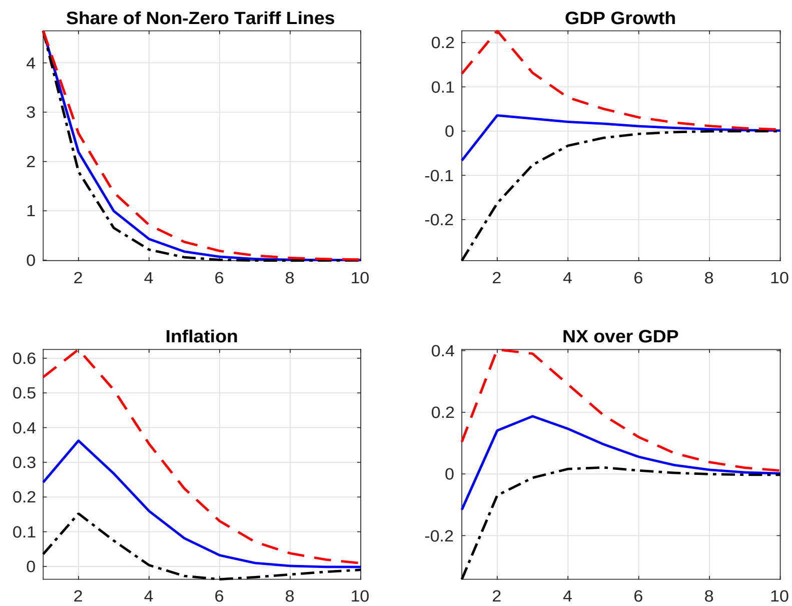

Figure A9: Panel-VAR, impulse responses to a one-standard deviation increase in the share of non-zero tariff lines. The share of non-zero tariff lines, GDP and net exports over GDP are in percentage points. The inflation rate is annualized.

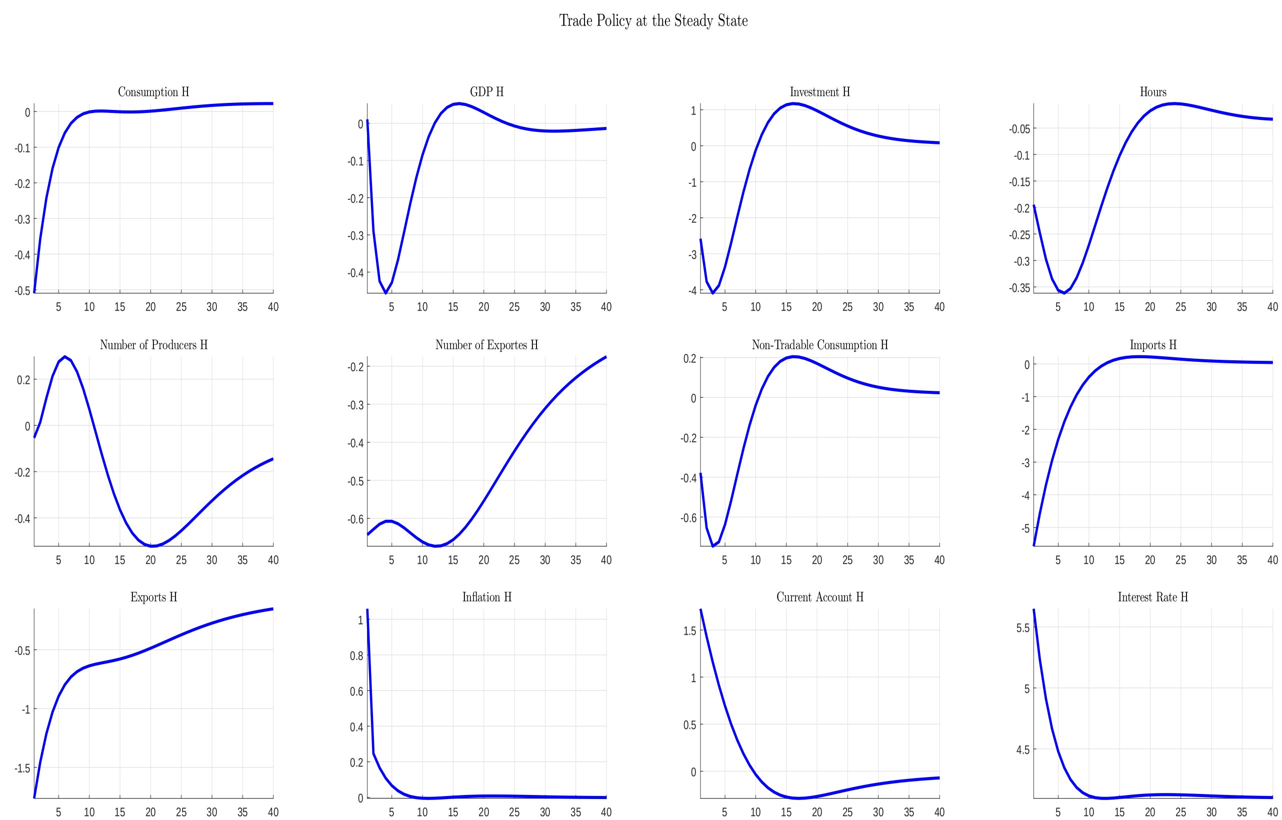

Figure A10: Responses to a temporary increase in Home trade barriers in normal times. Responses show percentage deviations from the steady state. The inflation rate is annualized.

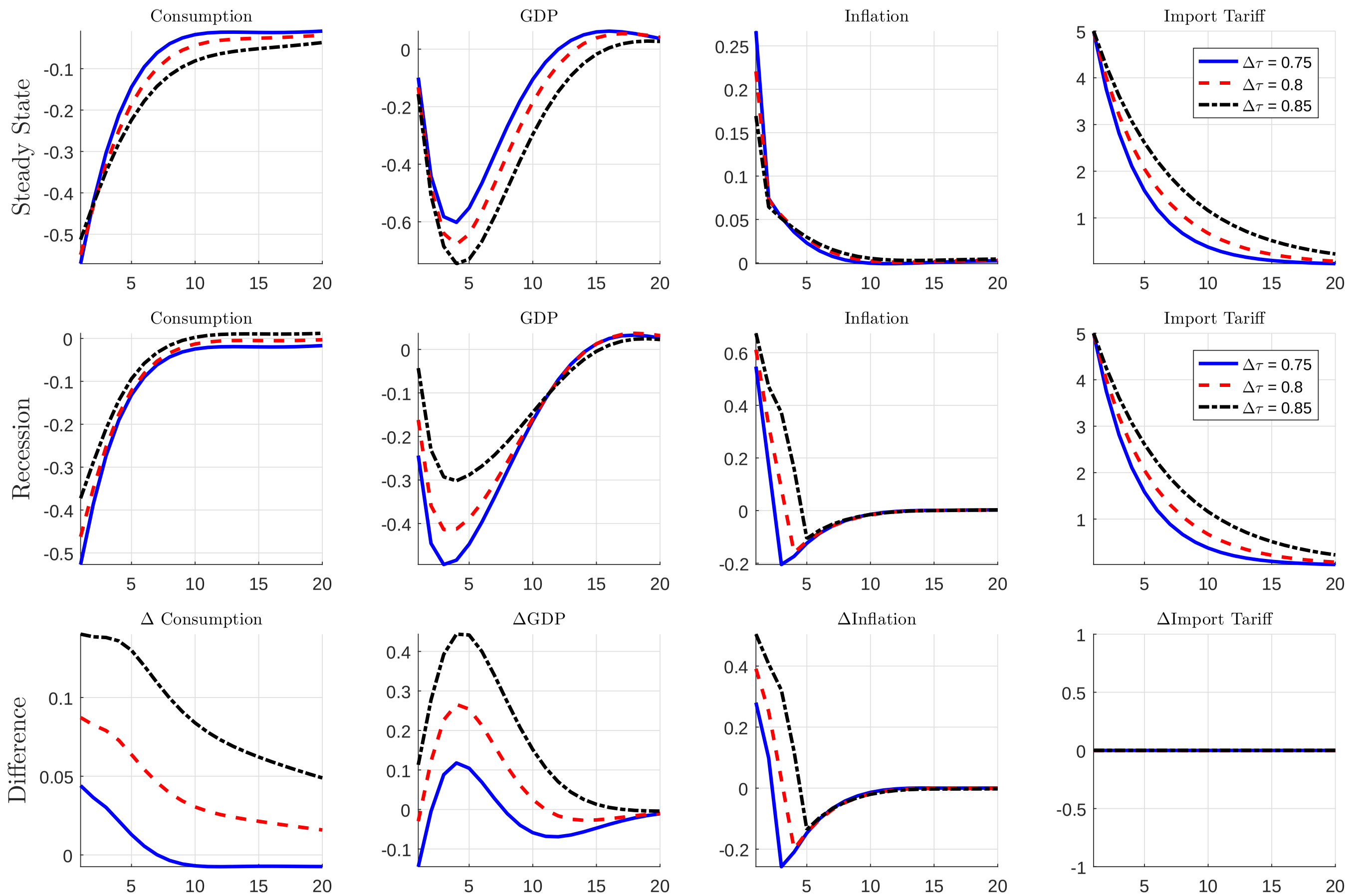

Figure A11: Responses to a temporary increase in Home tariffs, shocks with different persistence, normal times (continuos lines) vs. recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. The in‡ation rate is annualized.

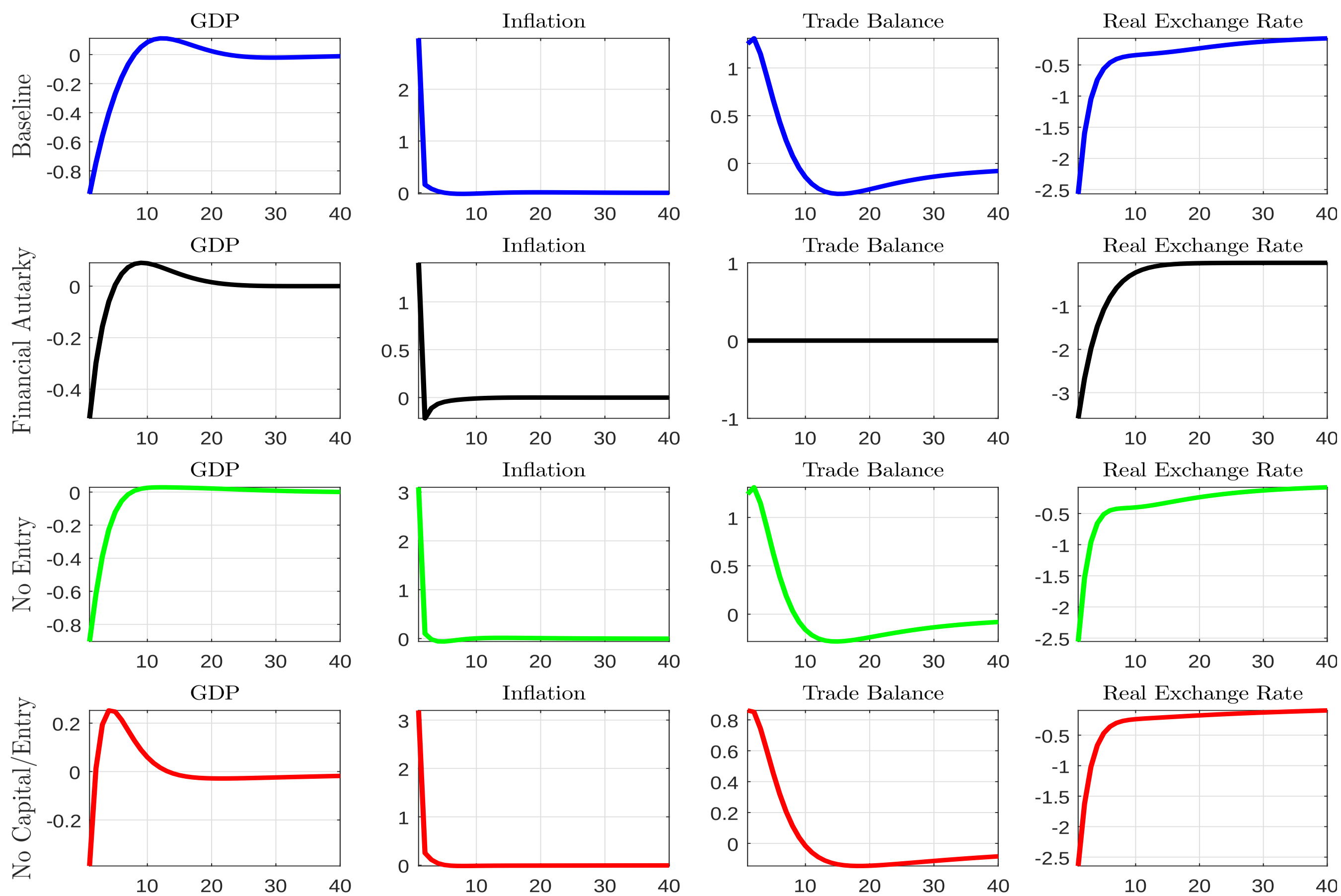

Figure A12: Effects of a temporary increase in Home trade barriers in normal times, sticky prices (producer currency pricing). The top raw: baseline model; second raw: baseline model under financial autarky; third raw: baseline model without firm dynamics; fourth raw: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

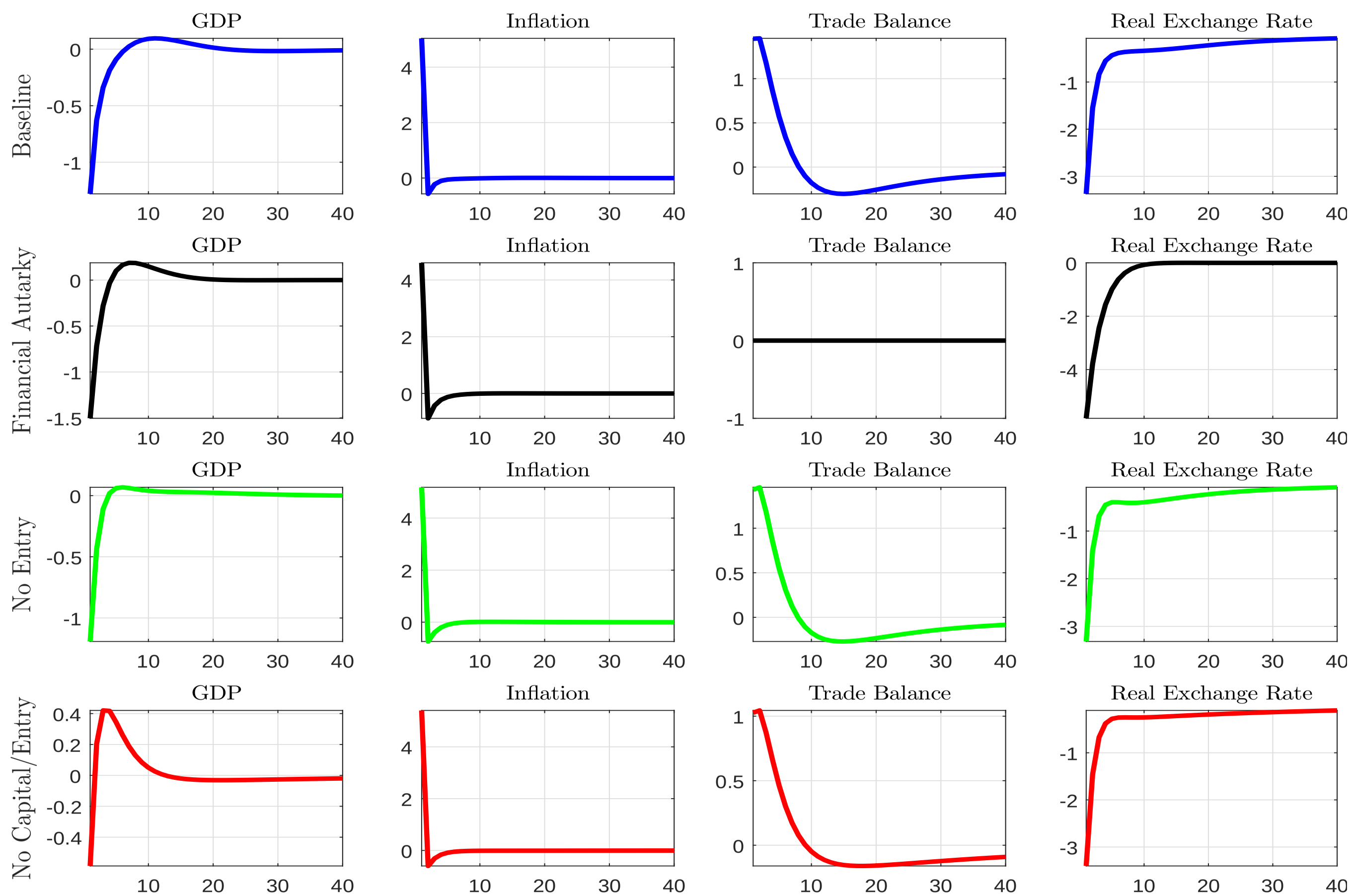

Figure A13: Effects of a temporary increase in Home trade barriers in normal times, sticky prices (local currency pricing). The top raw: baseline model; second raw: baseline model under financial autarky; third raw: baseline model without firm dynamics; fourth raw: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.