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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 selection into trade, 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 aggregate investment dynamics and micro-level reallocations 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.

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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 G-20 and G-7 meetings have been raising the concern that key powers are taking steps away from existing alliances that had been forged also to exorcise this specter. The U.S. administration of President Donald Trump has withdrawn from the Trans-Pacific Partnership (TPP), started renegotiating the North American Free Trade Agreement (NAFTA), and imposed punitive tariffs against a number of trading partners. Like-minded political leaders in other countries have made no secret of their penchant for protectionism.

Since the threat of protectionism started looming in the run-up to the 2016 U.S. presidential election, 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. In the first part, 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 twenty-one small open economies that addresses the 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 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) 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 Ghironi and Melitz, endogenous tradability 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 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 dominate 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, lowering aggregate productivity. In turn, higher domestic prices reduce aggregate real income (expenditure reduction), lowering investment in physical capital and product creation. Intuitively, since physical capital includes both domestic and imported goods, the import tariff increases the price of investment. Moreover, since households spend more of their real income to consume any given amount of imports, the demand for domestic goods declines, reducing the number of producers on the market. In addition to this, the central bank's response to higher inflation further imparts a contractionary impulse.

Lower aggregate demand and monetary policy contraction dominate expenditure switching,

causing a recession in the aftermath of an increase in protectionism. The decline in investment propagates the negative effects of higher tariffs over time. 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, the model and empirical investigation line up closely in terms of qualitative and quantitative 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 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 costly—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.

Related Literature 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.¹ 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 (2011) 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 macroeconomic 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 consequences 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 out-

¹See 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.

put 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 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.²

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 recent actions by the Trump administration, and the responses by China and the European Union (EU), it will be important to investigate the interaction of protectionism and macro dynamics when economies are large and their policies 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.³ Finally, we do not address the distributional consequences of protectionism or the dynamic impact it could have on the sectoral structure of the economy. These are all interesting, important topics

²By 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).

³Eaton 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 policy shocks.

that we leave for future research.

Outline 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 twenty-one 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 (TTBs)—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 1980s across country users.⁴ The database provides information about the dates in which antidumping investigations are initiated, their outcomes (i.e., the amount of ad-valorem or specific antidumping duties), and the products involved. Given the structure of the dataset, it is possible to build time series data for antidumping

⁴As of June 2018, the data are available at <https://sites.google.com/site/chadpbown/GAD.zip>. The time coverage varies across countries.

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.⁵

We focus on two countries in the main text: Turkey and Canada. For robustness, we also report the results for India in the Appendix. Turkey and India are the largest and most active users of temporary trade barriers (Bown, 2011); Canada is the largest and most active user among developed small-open economies. In Turkey, up to 5.3 percent of imported products are subject to temporary trade barriers over the period 1994-2009 (Bown, 2011), amounting to 1 percent of GDP.⁶ For Canada, the percent of imported products is 2.2 percent, amounting to 0.4 percent of GDP.

Figures 1 and 2 report the dynamics of new antidumping initiatives at quarterly frequency together with the growth rate of real GDP. Both figures show substantial variation over time in the trade policy measure. Furthermore, the figures highlight the lack of systematic correlation between antidumping investigations and aggregate conditions. In Canada, the unconditional contemporaneous correlation between GDP growth and new antidumping investigations is 0.04 (the figure is very similar when considering linearly detrended GDP). The three largest spikes in antidumping investigations occur at times of positive economic growth, with a rather modest increase during the Great Recession. The picture is similar for Turkey. In this case, there is a more pronounced increase in 2000:Q4, which predates by a year the trough of GDP following the Turkish financial crisis of 2001. As discussed below, our results are qualitatively unaffected when we restrict the Turkish sample to the period after 2002.

⁵A very small fraction of observations are recorded at the 4-digit 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-digit observations.

⁶Notice that since 1995, Turkey has a customs union agreement with the EU. Therefore, the temporary trade barriers we focus on represent the country's main discretionary trade policy tool.

Empirical Strategy

For each country, we estimate a structural VAR: $Y_t = \Theta + \sum_{i=1}^p \Phi_i Y_{t-i} + Au_t$, where Y_t is a vector that collects the trade policy measure and the macroeconomic variables; u_t is a vector of structural innovations such that $E(u_t u_t') = I_N$; and A is the matrix that links structural- and reduced-form innovations. 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.

We identify structural trade policy shocks by exploiting the contemporaneous exogeneity of antidumping investigations with respect to macroeconomic variables. The assumption that antidumping initiatives do not respond to macroeconomic shocks within a month or a quarter reflects the existence of decision lags in the opening of investigations. As summarized in Figure 3, decision lags stem from technical aspects of regulation and coordination issues among producers: 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.⁷

For these reasons, we order the trade policy measure first in the VAR and impose a recursive ordering of the structural shocks. Since we are not interested in identifying shocks to macroeconomic variables, their ordering (i.e., the corresponding exclusion restrictions) is irrelevant for the purpose of our analysis.

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. First, the opening of an investigation is immediately announced to the public and agents can access the supporting evidence about the margins of dumping. Since antidumping duties are commensurate to the margins of dumping, antidumping tariffs are predictable at the time of the investigation. Second, the application of antidumping duties is in general retroactive (up to the beginning of the investigation). Third, 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

⁷For instance, in Turkey the industry application must represent at least 25 percent of the product's total production. Once producers have gathered evidence about the margins of dumping, they bring the petition before the board. The preliminary assessment of compliance takes up to 60 days (see the Turkish Official Gazette, article 20295 on September 27, 1989).

of cases in Canada). For these reasons, our benchmark specification focuses on the initiation of antidumping investigations.⁸

Another issue related to anticipation effects concerns the possibility that antidumping investigations also reflect expectations about future economic conditions that are not captured by past information from the variables included in the VAR. Decision lags in the opening of investigations imply that new information at time t does not affect the time- t number of new antidumping initiatives. However, lagged news about future economic conditions may affect current antidumping initiatives. We address this issue in two ways. First, we verify that the identified structural trade-policy shocks are not Granger-caused by time series that contain information about future economic activity. As discussed in the robustness analysis below, we consider four series: a stock market index, the real price of oil, an index of global real economic activity in industrial commodity markets (Kilian, 2009), and an index of future economic activity. In addition, we re-estimate the VAR including these time series.

Finally, a few words on the relationship between our identification approach and the counter-cyclical, lagged response of TTBs to macroeconomic variables (Bown and Crowley, 2013) are in order. First, what matters for the identification of trade policy shocks is the exogeneity of TTBs with respect to contemporaneous macroeconomic shocks—the VAR structure already accounts for the lagged response of antidumping investigations to macroeconomic shocks that occurred in previous periods. Second, our analysis uses monthly and quarterly data. At such frequencies, the decision lags that characterize the opening of an investigation imply that the number of antidumping initiatives is not affected by current macroeconomic shocks. Third, as discussed below, our results are not sensitive to the identifying exclusion restriction. Finally, our results show that protectionism triggers negative comovement between output and inflation. This result is not compatible with the propagation of demand-side shocks (e.g., financial shocks), arguably the key drivers of business cycles in the countries in our sample.⁹

⁸Whether 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.

⁹A final observation further corroborates the contemporaneous exogeneity of antidumping investigations: The episodes in which antidumping investigations increase more significantly in Canada (e.g., 1997:Q4, 1999:Q3, 2001:Q1) involve steel-sector products that also feature antidumping investigation in the United States.

Results

We now turn to the discussion of macroeconomic variables 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.¹⁰ The data cover the period 1994:Q1 to 2015:Q4. Appendix A presents the details about the data. We estimate the VAR including two lags of each variable.¹¹

Figures 4 and 5 report the impulse responses to a one-standard deviation shock to antidumping initiations in Canada and Turkey, respectively.¹² In Canada, the shock implies a 50 percent increase in the average number of HS-6 products subject to new antidumping investigations. Figure 4 shows that Canadian inflation increases and the growth rate of GDP declines. There is a modest, albeit significant, increase in the trade balance to GDP ratio. Annualized inflation rises by approximately 0.2 percent at the peak, while GDP growth declines by 0.1 percent at the trough. To understand the magnitude of the responses, we examine the economic significance of antidumping investigations in the largest episodes in our sample. For instance, consider the highest Canadian peak in quarter 2001:Q1. In this episode, the products under investigation were all in the steel sector, accounting for approximately 30 percent of sectoral imports. In turn, the steel sector’s contribution to Canadian GDP was 1.1 percent, inclusive of input-output linkages.¹³ All these initiatives ended up with the imposition of tariffs, with a median rate equal to 56 percent. The figures are similar when considering the second highest peak in quarter 1998:Q4.

The results for Turkey are qualitatively identical, although the response of macroeconomic variables is stronger. Annualized inflation rises by approximately 1.5 percent at the peak, while GDP growth declines by 0.4 percent at the trough. These heightened effects are explained by three factors. First, the size of the shock is larger, since now a one-standard deviation shock doubles the number of antidumping initiatives. Second, the imposed tariffs remain in place longer (at least six

¹⁰Core inflation is more appropriate than headline inflation to assess the effects of antidumping investigations, since in practice antidumping policy is never applied to energy 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.

¹¹The Akaike information criterion suggests this is a plausible choice for both countries.

¹²The error bands are at 68 percent confidence level and obtained via bootstrapping as in Kilian (1998).

¹³We sum the share of NAICS-6 digit steel sector’s value added over GDP and the share of steel output used as an input in other industries. The steel sector directly accounted for 0.3 percent of Canadian GDP, while the intermediate-input usage was worth 0.8 percent of GDP.

and a half years). Third, in our sample, the cycle of the Turkish economy is five times more volatile than Canada, implying larger responses to macroeconomic shocks—the standard deviation of GDP growth is about 2.7 percent in Turkey and 0.6 percent in Canada. Moreover, in Turkey, the average inflation rate between 1994 and 2002 was 14.5 percent. This suggests that real frictions imply a stronger propagation of aggregate shocks in Turkey. When we restrict the Turkish sample to the period after 2002:Q1, the magnitude of the responses becomes similar to those for Canada. This finding reflects the substantial decline in aggregate volatility in the Turkish economy brought about by the adoption of inflation targeting and far-reaching reforms in the financial sector following the financial crisis of 2001.¹⁴

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 6 reports the results for Canada. The industrial production index declines slowly, and the response 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 not statistically significant. The nominal exchange rate displays an appreciation, which becomes significant at the fifth month.

Figure 7 reports the results for Turkey. Following the increase in antidumping initiations, inflation increases on impact, and the response remains positive for four months. A second positive and significant peak occurs at the seventh month. Industrial production declines for seven months

¹⁴In May 2001, the Banking Regulation and Supervision Agency initiated a comprehensive restructuring program for the banking system. In January 2002, Turkey adopted inflation targeting.

¹⁵For 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 Borsa 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.)

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.

Robustness In Appendix B, we conduct several exercises to assess further the robustness of our findings. First, as mentioned above, we consider four additional series: an index of share prices provided by the OECD, the real price of oil, Kilian’s (2009) index of global real economic activity in industrial commodity markets, and an index of future economic activity again constructed by the OECD.¹⁶ These four variables contain information on agents’ expectations about future economic activity—for instance, Kilian’s index produces accurate forecasts of world GDP. Thus, their inclusion helps us address possible concerns about the influence of future expected economic conditions on antidumping investigations. Moreover, the real price of oil is an additional control for supply-side determinants of GDP and inflation, while the index of global real economic activity provides information about world demand and supply. Impulse responses show that our results are robust to the inclusion of these additional variables. Moreover, in Appendix B, we show also that none of the four variables Granger cause the identified structural trade policy shocks.

Second, we consider an alternative identification scheme in which antidumping initiatives respond contemporaneously to all macroeconomic shocks. We obtain similar impulse responses to the benchmark specification.

Third, we consider alternative temporary trade policy measures:(i) we construct a measure that exploits information about the outcomes of antidumping investigations, restricting the sample to the initiatives that effectively end up with the imposition of a tariff; (ii) we consider an alternative treatment of observations recorded at the 4-digit level; (iii) we construct an overall temporary trade barrier measure that includes global safeguards and countervailing duties (in addition to antidumping investigations).

Fourth, we verify that our results are not driven by the largest spikes in the dynamics of antidumping investigations. Visual inspection of the time series of our trade policy measure reveals there are two such episodes in Turkey (2000:Q4 and 2009:Q3) and three in Canada (1997:Q4, 1998:Q4, and 2001:Q1). We construct dummy variables for each episode and re-estimate the VAR. The magnitude of the impulse responses is reduced, but the results are qualitatively the same.

¹⁶We use the global price of WTI Crude provided by the Federal Reserve Bank of St. Louis. See Appendix A for the details about the other three additional series.

Finally, we replace the growth rate of real GDP with log-deviations of real GDP from a deterministic trend. Across all the scenarios we consider, the results remain similar to the benchmark specification. In addition, in Appendix C, we estimate the VAR on Indian data. The results are in line with the evidence for Canada and Turkey.

Annual Tariff Data: A Panel Structural VAR 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.¹⁷

Since tariff data are only available at annual frequency, we estimate a panel structural VAR using harmonized data for a sample of twenty-one countries over the period 1999-2016.¹⁸ 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.¹⁹

Figure 8 plots the tariff data for the twenty-one countries in our sample. Over time, the applied tariff rates show a general decline in all the countries considered. However, there is significant variation around the downward trend in several countries. Given this observation, we measure temporary trade policy interventions by removing a deterministic trend from the tariff series.

Our benchmark VAR specification includes three macroeconomic variables: the growth rate of real GDP, CPI inflation, and net exports over GDP.²⁰ The data come from the World Development Indicators database (see Appendix A 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.

¹⁷We use HS-2 digits tariff rates from WITS. We use the concept of effectively applied tariff, which is defined as the lowest available tariff. If a preferential tariff exists, it is used as the effectively applied tariff. Otherwise, the MFN applied tariff is used. The import-weighted average of applied tariff rates is computed by using fixed weights, with imports fixed at the 1999 level. This addresses the concern that variation in the average may reflect changes in weights rather than in tariffs.

¹⁸We choose the sample period to include as many countries as possible in the analysis. The sample includes Australia, Brazil, Canada, Chile, Colombia, Iceland, Indonesia, India, Israel, South Korea, South Africa, Malaysia, Mexico, Norway, New Zealand, Peru, Philippines, Paraguay, Thailand, Turkey, and Uruguay.

¹⁹Malaysia 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.

²⁰The 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 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 9 (Panel A) reports the impulse responses to a one-standard deviation tariff increase (around 1.75 percentage points).²¹ Inflation rises by 0.3 percentage points, while GDP growth decreases by about 0.2 percent on impact. Net exports over GDP increase by 0.25 percent at the peak, and the effect is statistically significant.²² We obtain similar results (available upon request), when we include a measure of the short-term interest rate in the VAR. Following a tariff shock, the response of the interest rate is positive and statistically significant.

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 henceforth). As a consequence, the policy decisions and macroeconomic dynamics of the small open economy have no impact on Foreign. The small economy's terms of trade fluctuate endogenously in response to aggregate shocks due to the presence of firm monopoly power in both countries. Next we describe in detail the problems facing households and firms in the small open economy.

²¹As before, the error bands are at 68 percent confidence level and obtained via bootstrapping as in Kilian (1998). Panel B in Figure 9 presents the responses generated by the model described in the next section.

²²In Appendix C, we show that the improvement of the trade balance is the result of a decline in imports that more than offsets a decline in exports.

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

$$E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t(h)^{1-\gamma_C}}{1-\gamma_C} - \frac{L_t(h)^{1+\gamma_L}}{1+\gamma_L} \right), \quad (1)$$

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. 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 :

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

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 $P_t = \left[(1 - \alpha_N) (P_t^T)^{1-\phi_N} + \alpha_N (P_t^N)^{1-\phi_N} \right]^{\frac{1}{1-\phi_N}}$, 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 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 $\phi_T > 0$:

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

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

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. A similar basket describes the imported consumption bundle: $C_{X,t}^{T*} = \left[\int_{\omega \in \Omega^*} C_{X,t}^{T*}(\omega)^{(\theta_T-1)/\theta_T} d\omega \right]^{\theta_T/(\theta_T-1)}$. As in Ghironi and Melitz (2005), at any given point in time, only a subset of goods $\Omega_t \in \Omega$ is available to consumers. Hence, 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 $P_{X,t}^{T*} = \left\{ \int_{\omega \in \Omega_t} \left[(1 + \tau_t^{IM}) P_{X,t}^{T*}(\omega) \right]^{1-\theta_T} d\omega \right\}^{1/(1-\theta_T)}$, where $\tau_t^{IM} \geq 0$ 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 households in lump-sum fashion.²³

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.

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

²³Our assumptions about preferences over consumption sub-bundles imply standard demand functions that depend on the relevant relative prices and quantities. We omit them for brevity and just note that the ad-valorem tariff acts as an import demand shifter: all else given, higher tariffs increase the relative price of Foreign exports and shift demand away from Foreign products.

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

The Home intermediate sector firm chooses L_t and K_t to maximize per-period profit: $d_t^I \equiv \varphi_t Y_t^I - (w_t^n/P_t)L_t - r_{K,t}K_t$, where φ_t is the real price (in units of final consumption) of the intermediate input, and $r_{K,t}$ is the real rental rate of capital.

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 uses intermediate inputs in linear fashion. 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 that can be sold domestically and abroad. Firms are heterogeneous since they produce with different technologies indexed by relative productivity z . 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 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.

²⁴We 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.

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 dock export price, i.e., $P_{X,t}^T(z)$ does not include Foreign import tariffs (if any). All firms set flexible prices that reflect the same proportional markup $\theta_T/(\theta_T - 1)$ over marginal cost. Let $\rho_{D,t}^T(z) \equiv P_{D,t}^T(z)/P_t$ and $\rho_{X,t}^T(z) \equiv P_{X,t}^T(z)/P_t^*$ denote real prices relative to the consumer price index in the destination market. The optimal prices are then given by: $\rho_{D,t}^T(z) = [\theta_T/(\theta_T - 1)] \varphi_t/z$ and $\rho_{X,t}^T(z) = (1 + \tau_t) \rho_{D,t}^T(z)/Q_t$, 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, a firm exports in a given period if and only if the export profit, $d_{X,t}^T(z)$, is non-negative. This will be the case as long as productivity z is above a cutoff level $z_{X,t}$ such that: $z_{X,t} = \inf\{z : d_{X,t}^T(z) > 0\}$ —see Appendix D for the analytical details. Firms with productivity below 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.

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 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. We relegate the details to Appendix D and only note here that, in every period, there is a mass $N_{D,t}$ of tradable-sector firms that produce in the Home country. Among these firms, there are $N_{X,t} = [1 - G(z_{X,t})] N_{D,t}$ exporters. For future reference, we follow Melitz (2003) in defining the average productivity of Home firms in the tradable sector as:
$$\tilde{z}_t = \left\{ \tilde{z}_D^{\theta_T - 1} + [\tilde{z}_{X,t}/(1 + \tau_t)]^{\theta_T - 1} (N_{X,t}/N_{D,t}) \right\}^{1/(\theta_T - 1)}.$$

Firm Entry and Exit In every period there is an unbounded mass of prospective entrants in both countries. Entrants at time t start producing only at $t + 1$, a plausible assumption given the quarterly calibration we will pursue. The exogenous exit shock hits incumbents and new entrants with equal probability at the end of each period. Hence, the law of motion for the number of producing firms is $N_{D,t} = (1 - \delta)(N_{D,t-1} + N_{E,t-1})$. The expected post-entry value, \tilde{e}_t , that a prospective entrant computes in taking the entry decision is given by the expected present discounted value of the stream of per-period average profits: $\tilde{e}_t \equiv E_t \left[\sum_{s=t+1}^{\infty} \beta_{t,s} (1 - \delta)^{s-t} \tilde{d}_s^T \right]$, where $\beta_{t,t+s} \equiv \beta^s (C_{t+s}/C_t)^{-\gamma_C}$ is the stochastic discount factor and \tilde{d}_s^T the average total profits,

returned to households as dividends.²⁵ Entry occurs until average firm value equals the entry cost, leading to the free-entry condition $\tilde{e}_t = \varphi_t f_{E,t}$.

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 $\psi [A_{*,t+1}(h)/P_t]^2/2$.²⁶ These costs are paid to financial intermediaries which 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. This is the mechanism through which household savings are made available to prospective entrants to cover their entry costs. The mutual fund pays a total real dividend in each period 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. 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: $K_{t+1}(h) = (1 - \delta_K) K_t(h) + I_{K,t}(h)$, where $\delta_K \in (0, 1)$ denotes the depreciation rate of capital.

Households set the nominal wage $w_t^n(h)$ subject to a quadratic adjustment cost $(\nu_w/2) \pi_{w,t}^2 w_t^n(h) L_t(h)$,

²⁵The average profit from domestic sales in period t is $\tilde{d}_{D,t}^T \equiv d_{D,t}^T(\tilde{z}_D)$, while the average export profit is $\tilde{d}_{X,t}^T \equiv d_{X,t}^T(\tilde{z}_{X,t})$. Thus, the average total profit of each Home firm is given by $\tilde{d}_t^T = \tilde{d}_{D,t}^T + (N_{X,t}/N_{D,t}) \tilde{d}_{X,t}^T$.

²⁶Since 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 $\pi_{w,t}(h) = w_t^n(h)/w_{t-1}^n(h) - 1$ denotes nominal wage inflation. 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:

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

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 first-order condition for $w_t^n(h)$ implies that the real wage, $w_t(h) \equiv w_t^n(h)/P_t$, is a time-varying markup, $\mu_{w,t}(h)$, over the marginal rate of substitution between hours and consumption. Eliminating the household-identifier h , since symmetric households make identical choices: $w_t = \mu_{w,t} L_t^{\gamma_L} / C_t^{-\gamma_C}$. The endogenous wage markup is given by:

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

Intuitively, households 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 $\tilde{e}_t = (1 - \delta) E_t [\beta_{t,t+1} (\tilde{d}_{t+1}^T + \tilde{e}_{t+1})]$. Finally, the Euler equations for bond holdings are:

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

where $a_{*,t+1} \equiv A_{*,t+1}/P_t$. 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: $\Lambda_{at} = \rho_{\epsilon_a} \Lambda_{at-1} + \epsilon_{at}$, where $\epsilon_{at} \stackrel{i.i.d.}{\sim} N(0, \sigma_{\epsilon_a}^2)$.²⁷

We present the details of the symmetric equilibrium in Appendix D, and we limit ourselves to presenting the law of motion for net foreign assets below. 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: $Q_t a_{*,t+1} = Q_t (1 + r_t^*) a_{*,t} + TB_t$, where r_t^* is the foreign real interest rate, defined by $1 + r_t^* = (1 + i_t^*) / (1 + \pi_{C,t}^*)$ and $\pi_{C,t}^* \equiv P_t^* / P_{t-1}^* - 1$, and $TB_t \equiv N_{X,t} Q_t \tilde{\rho}_{X,t}^T C_{X,t}^T - N_{X,t}^* \tilde{\rho}_{X,t}^{*T} C_{X,t}^{*T}$ is the trade balance. The change in net foreign assets between t and $t + 1$ is determined by the current account: $Q_t (a_{*,t+1} - a_{*,t}) = CA_t \equiv Q_t r_t^* a_{*,t} + TB_t$.

Monetary Policy

To close the model, we specify a rule for monetary policy. Our benchmark policy specification considers a flexible exchange rate. We explicitly take into account the possibility that the nominal interest rate i_{t+1} cannot fall below some lower bound i^{zlb} , so that, in each period, the interest rate is constrained to be such that $i_{t+1} \geq i^{zlb}$. We set i^{zlb} equal to zero in our simulations. Thus, the monetary authority sets the nominal interest rate following a feedback rule of the form $1 + i_{t+1} = \max \left\{ 1 + i^{zlb}, (1 + i_t)^{\epsilon_i} \left[(1 + i) (1 + \tilde{\pi}_{Ct})^{\epsilon_\pi} \left(\tilde{Y}_{gt} \right)^{\epsilon_Y} \right]^{1 - \epsilon_i} \right\}$, where i is the steady-state nominal interest rate. Since gains from variety are mostly unmeasured in CPI data (Broda and Weinstein, 2010), we assume that the central bank responds to data-consistent measures for CPI inflation and the output gap, $\tilde{\pi}_{Ct}$ and \tilde{Y}_{gt} respectively.²⁸ Following Ghironi and Melitz (2005), we obtain a data-consistent price index, \tilde{P}_t that removes the pure product variety effect from the welfare-consistent index P_t as explained in Appendix E. In turn, $\tilde{\pi}_{Ct} = \tilde{P}_t / \tilde{P}_{t-1} - 1$ and $\tilde{Y}_{gt} = P_t Y_{gt} / \tilde{P}_t$, where the GDP gap, Y_{gt} , measures deviations of GDP, $Y_t \equiv C_t + I_{Kt} + TB_t$, from the flexible-wage outcome.

Table A.1 in the Appendix summarizes the equilibrium conditions of the model. Since we do not

²⁷We 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. Notice that the risk-premium shock is isomorphic to a discount factor shock (a ‘‘beta shock’’) only up to a first-order approximation.

²⁸In the presence of endogenous producer entry and preferences that exhibit ‘‘love for variety,’’ the welfare-consistent aggregate price index P_t can fluctuate even if product prices remain constant.

focus on the consequences of changes in entry costs and iceberg trade costs, we assume $f_{E,t} = f_E$, $f_{X,t} = f_X$, and $\tau_t = \tau$ in all periods. Moreover, we keep aggregate productivity constant at its steady-state value, $Z_t = Z_t^* = Z$. Eight Foreign variables directly affect macroeconomic dynamics in the small open economy: Y_t^* , i_{t+1}^* , π_t^{C*} , ρ_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, π_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, we assume that Foreign producers solve a profit maximization problem that is equivalent to that faced by Home producers (see Appendix D).

4 Calibration

We interpret periods as quarters. 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 Melitz (2005), we set the elasticity of substitution of tradable varieties θ_T equal to 3.8. We assume that firm-level productivity z is drawn from a Pareto distribution with lower bound z_{\min} and shape parameter $\kappa > \theta_T - 1$. We set κ equal to 3.4, and we normalize z_{\min} and f_E to 1.²⁹ We choose the fixed export cost f_X such that, in steady state, 21 percent of tradable-sector firms export output abroad (Bernard, Eaton, Jensen, and Kortum, 2003). 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 1, a conventional value in the literature. Finally, to ensure steady-state determinacy and model

²⁹This calibration ensures that the lower-bound productivity z_{\min} is low enough relative to the export costs that $z_{X,t}$ is above z_{\min} .

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. 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): $\varrho_i = 0.5$, $\varrho_\pi = 2.80$, $\varrho_Y = 0$.

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 Harberger-Laursen-Metzler effect. This rise in saving reduces aggregate demand, and aggregate supply falls to clear the goods market.³⁰ 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 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.

³⁰According to the Harberger-Laursen-Metzler effect, a terms of trade deterioration reduces real income, which in turn increases the real expenditure needed to maintain the same standard of living. As a result, saving declines and the current account deteriorates.

We study macroeconomic dynamics following a temporary increase in Home import tariffs, τ_t^{IM} .³¹ 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 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

We assume that a tariff shock in the model corresponds to the tariff shock identified in the panel VAR. Therefore, we parametrize τ_t^{IM} consistent with the stochastic process estimated in Section 2. This requires setting the quarterly persistence of the shock equal to 0.56, with a standard deviation of innovations equal to 0.034.³²

Figure 10 (continuous lines) shows the effects of a temporary increase in τ_t^{IM} at time 0, assuming that the economy was at the deterministic steady state until time -1 . Consistent with the VAR evidence, output falls and inflation increases in the aftermath of the tariff shock. Moreover, the ratio of net exports over GDP increases.³³ In order to assess the quantitative fit of the model, we construct model-based, annualized measures of the macroeconomic variables included in the panel VAR (GDP growth, inflation, and net exports over GDP). Panel B in Figure 9 shows that the impulse responses from the model are quantitatively in line with the panel VAR estimates.³⁴

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

$$P_t = \left\{ (1 - \alpha_N) \left[\varpi_{D,t}^T \left(\tilde{P}_{D,t}^T \right)^{1-\phi_T} + \varpi_{X,t}^{T*} \left(\varepsilon_t \frac{\tilde{P}_D^{T*}}{\tilde{z}_{X,t}^*} (1 + \tau_t^{IM}) \right)^{1-\phi_T} \right]^{\frac{1-\phi_N}{1-\phi_T}} + \alpha_N (P_t^N)^{1-\phi_N} \right\}^{\frac{1}{1-\phi_N}}, \quad (3)$$

where $\varpi_{D,t}^T = (1 - \alpha_X) N_{D,t}^{(1-\phi_T)/(1-\theta_T)}$ and $\varpi_{X,t}^{T*} = \alpha_X [(1 + \tau) \tilde{z}_D^*]^{1-\phi_T} N_{X,t}^{*(1-\phi_T)/(1-\theta_T)}$ are time-varying weights on prices of Home and Foreign tradable goods that depend on producer dynamics.³⁵

³¹In the model, a tariff increase has allocative effects for various reasons: trade is not balanced, there are non-traded goods, we focus on a temporary shock, and we abstract from export subsidies. For this reason Lerner's symmetry does not hold.

³²This implies that τ_t^{IM} increases by 1.75 percent in the first year, returning to its initial level after 1 year as in Figure 9 Panel A.

³³Consistent with the data, net exports increase because imports fall by more than exports.

³⁴Appendix E shows that results are similar when constructing measures for real GDP and inflation using the data-consistent price index \tilde{P}_t .

³⁵Equation (3) combines the definition of the Home price index, with the equilibrium conditions $P_{D,t}^T =$

Higher 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 $\varpi_{D,t}^T$ relative to $\varpi_{X,t}^{T*}$. The reallocation of market share lowers the average productivity content of goods sold to Home consumers, raising the price index other things equal.³⁶ 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 that dampens aggregate consumption and investment; 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, $(1 + \tau_t^{IM*}) \tilde{P}_{X,t}^T$, which is only partly mitigated by the appreciation of the nominal exchange rate.³⁷

At the same time, higher tariffs reduce aggregate real income (expenditure reduction).³⁸ The reason is again a combination of macroeconomic and microeconomic forces. At the macro level, the increase in the price of imports makes investment in physical capital—which combines both Home and Foreign goods—more costly. As a result, $I_{K,t}$ declines, reducing output over time. Moreover, since households also 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. At the micro level, the appreciation of the domestic currency lowers Home exports (both the number of exporting firms and their average output 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.³⁹ Lower real income causes imports to decline, so net exports increase, and Home experiences a current account surplus. But this improvement comes at the cost of a recession.

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

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

³⁶ Notice that, in absolute terms, even $\varpi_{D,t}^T$ declines initially, since the number of domestic producers, $N_{D,t}$, falls.

³⁷ Notice that the Foreign domestic price $\rho_{D,t}^{T*}$ and the iceberg trade cost τ_t^* are not affected by Home protectionism.

³⁸ The effects we describe are only partially mitigated by the increase in the tariff revenue that the government rebates to households.

³⁹ 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.⁴⁰ To isolate the role of contractionary monetary policy, Figure 10 (dashed lines) plots the dynamics in an economy without nominal rigidities. The contractionary effects of protectionism remain similar to the benchmark model, although the decline in output is one-third smaller.

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. In Appendix F, we show that the contractionary effects of protectionism are larger the higher and more persistent the tariff increase.

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. 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.⁴¹ 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. In Appendix H, we show that endogenous producer dynamics and physical capital accumulation are central to match

⁴⁰Notice that the real exchange rate appreciation holds true both when considering the welfare-consistent exchange rate, Q_t , and its data consistent counterpart, $\tilde{Q}_t = \varepsilon_t \tilde{P}_t^* / \tilde{P}_t$.

⁴¹Notice 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.

quantitatively the VAR impulse responses presented in Figure 9 Panel A.

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 on output and inflation is smaller 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 Appendix G, we extend the model to include nominal price rigidities following Cacciatore and Ghironi (2012). We consider the empirically-motivated case of dollar pricing in the tradable sector, in which both export and import prices in the small open economy are sticky in U.S. dollars (see Goldberg and Tille, 2008, Gopinath and Rigobon, 2008, and Gopinath, Itskhoki, and Rigobon, 2010). In addition, we also consider producer currency pricing and local currency pricing 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.

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.⁴² Next, we assume that at quarter 1 the small open economy increases trade barriers. As before, we treat this policy shock as unanticipated.⁴³

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 (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 protec-

⁴²We 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.

⁴³This 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-premium shock.

tionism) lowers the real interest rate other things equal, boosting aggregate demand and output. Ultimately, whether temporary protectionism can be expansionary at the ZLB is a quantitative issue.

The first two rows of Figure 12 present the responses to the risk premium shock in the absence of protectionism (solid lines) and the responses to the same risk premium shock when tariffs increase (dashed lines). The last two rows of Figure 12 compare the net effects of the temporary increase in τ_t^{IM} in the recession (solid lines) to the effect of the same tariff increase in normal times (dashed lines). The net effect of protectionism in a recession 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.⁴⁴ Figure 12 conveys two main messages. First, protectionism is not an effective tool to boost economic activity in a liquidity trap (first two rows), since GDP is lower when the recession is followed by higher tariffs. Second, protectionism has more detrimental economic effects in a liquidity trap relative to normal times (last two rows).

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 dynamics. 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 to negative—since agents expect deflation already after one quarter, the expected real interest rate $E_0(1+r_1)$ that determines time-0 decisions increases. (Home’s real interest rate is defined by $1+r_t = (1+i_t)/(1+\pi_{C,t})$ and $\pi_{C,t} \equiv P_t/P_{t-1} - 1$.) This worsens the ZLB problem instead of ameliorating it. Notice that the net effect of protectionism on inflation is very similar in the liquidity trap relative to normal times. Since at the ZLB the central bank does not offset the inflationary effects of the trade policy shock, this result may seem surprising. The explanation is that our parameterization implies a short-lived tariff increase. In such a circumstance, the deflationary pressure brought about by the contractionary effects of higher tariffs

⁴⁴The 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.

dominates. In Appendix F, we show that the results are not sensitive to the size and persistence of the trade shock: Protectionism remains contractionary in a liquidity trap. Nevertheless, with more persistent tariff shocks, the response of inflation at the ZLB becomes larger relative to normal times.

6 Protectionism and Business Cycle Dynamics under 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.⁴⁵

Figure 13 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 13 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.

⁴⁵The 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.

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 capital account, the Home policy rate is tied to the (constant) Foreign interest rate—under our perfect foresight scenario, it is straightforward to verify that $1 + i_{t+1} = (1 + i^*) / (1 + \psi a_{*,t+1})$, 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.⁴⁶

7 Conclusions

We studied the consequences of protectionism for macroeconomic fluctuations. Using trade-policy data at different frequencies, 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 costly—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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⁴⁶The presence of price stickiness does not affect these results, as the dynamics are only marginally stronger relative to the flexible-price scenario. Details are available upon request.

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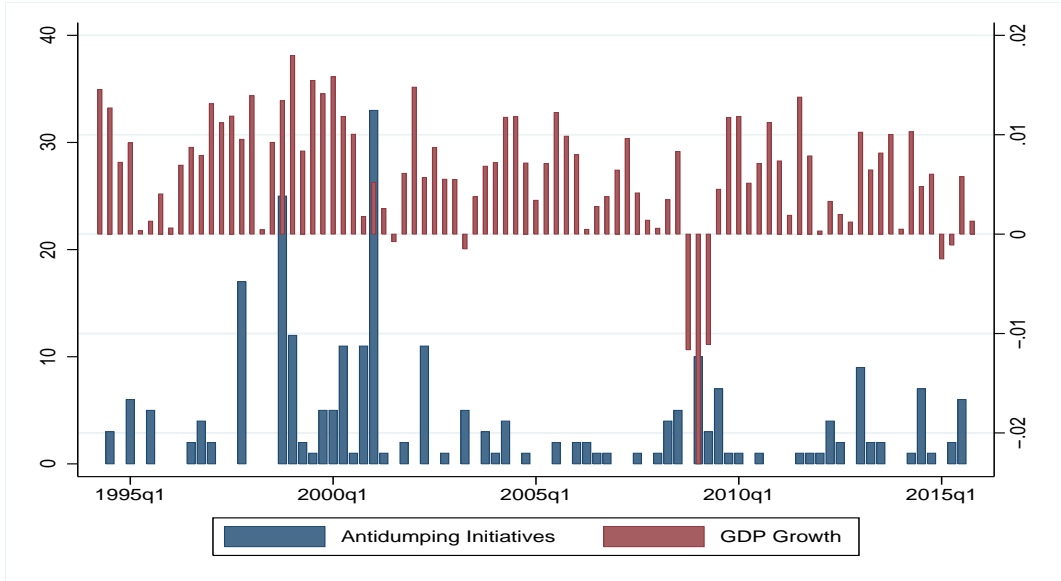


Figure 1: Anti-dumping initiatives and real GDP growth, Canada

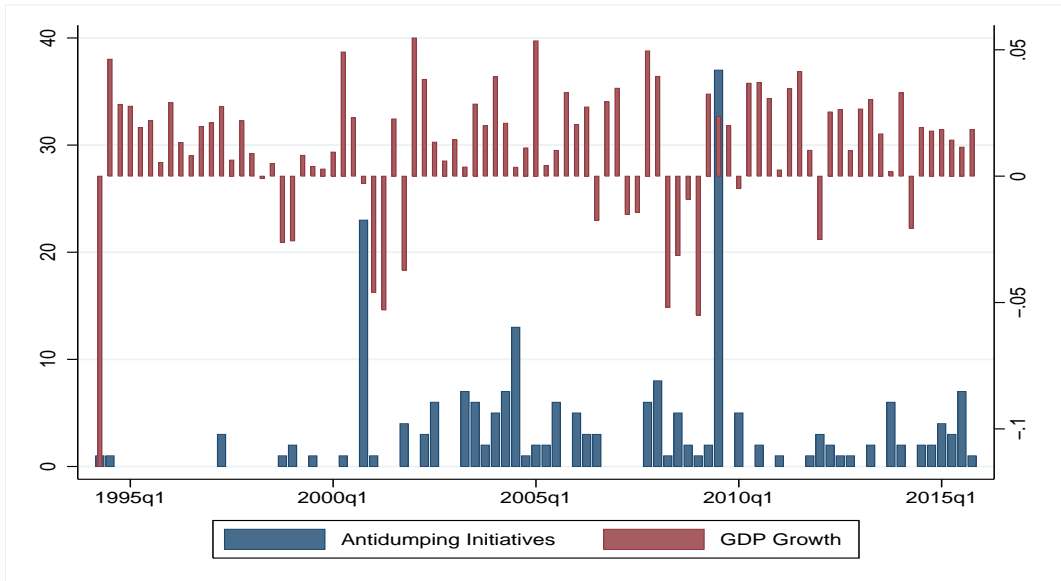


Figure 2: Anti-dumping initiatives and real GDP growth, Turkey.

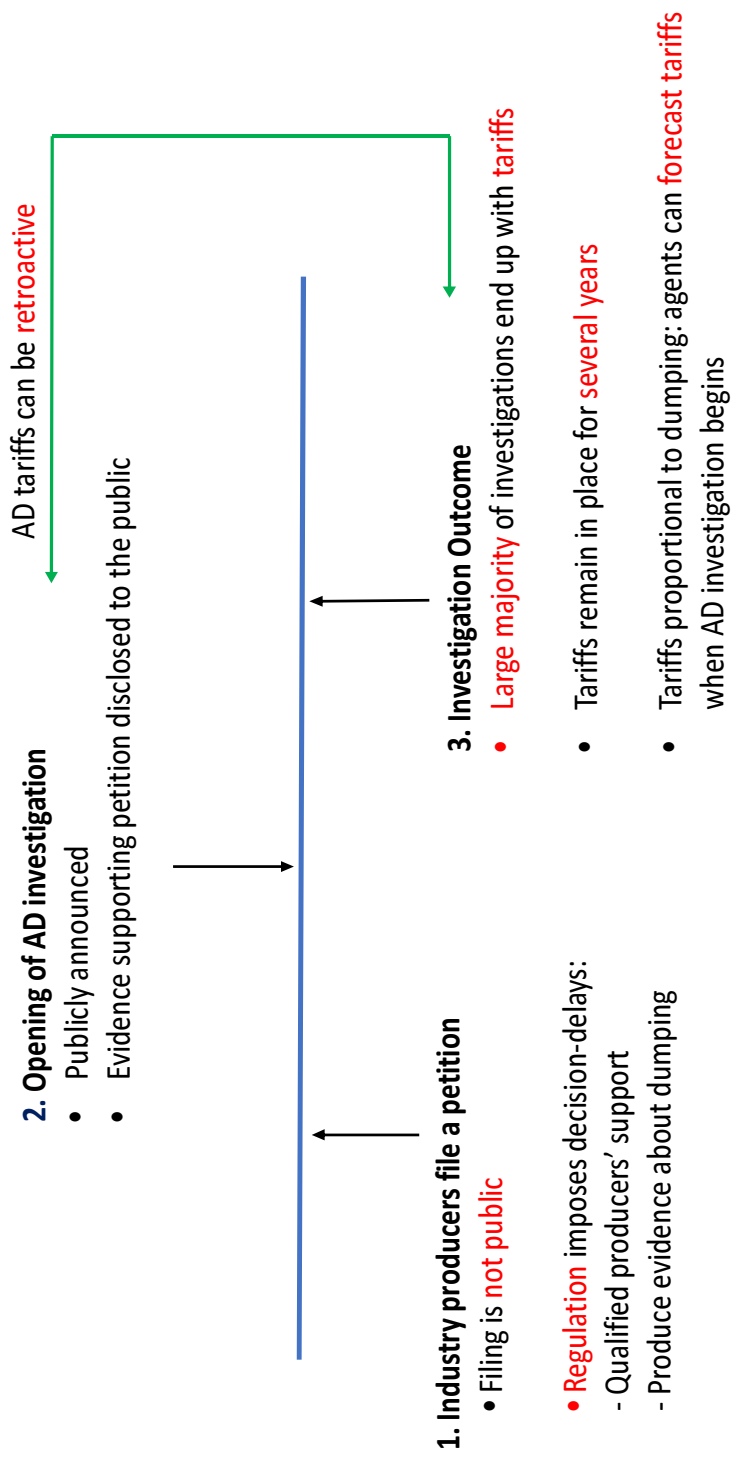


Figure 3: Institutional details about antidumping investigations and applied antidumping tariffs.

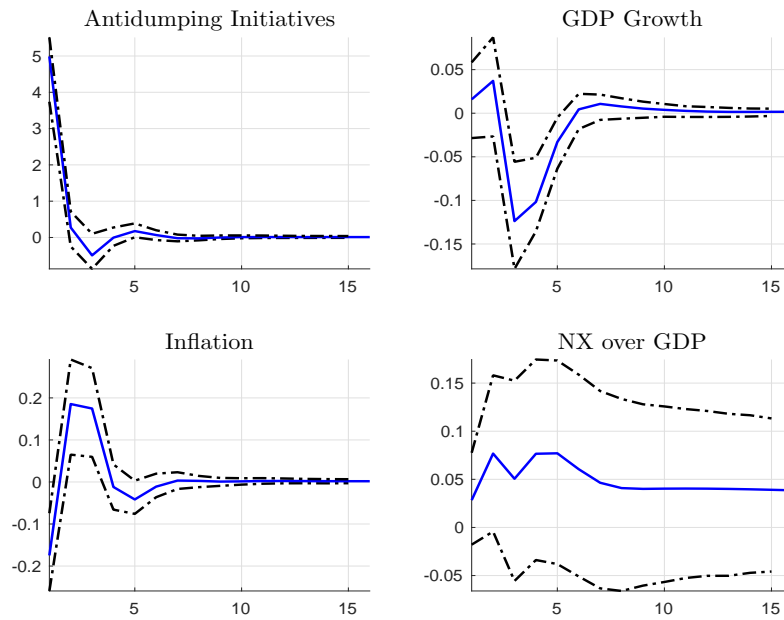


Figure 4: Quarterly VAR, one-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

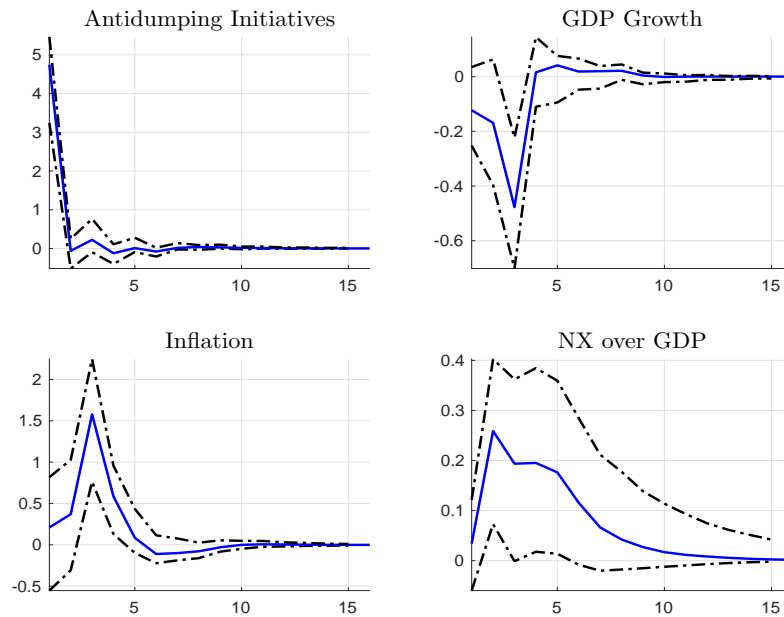


Figure 5: Quarterly VAR, one-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

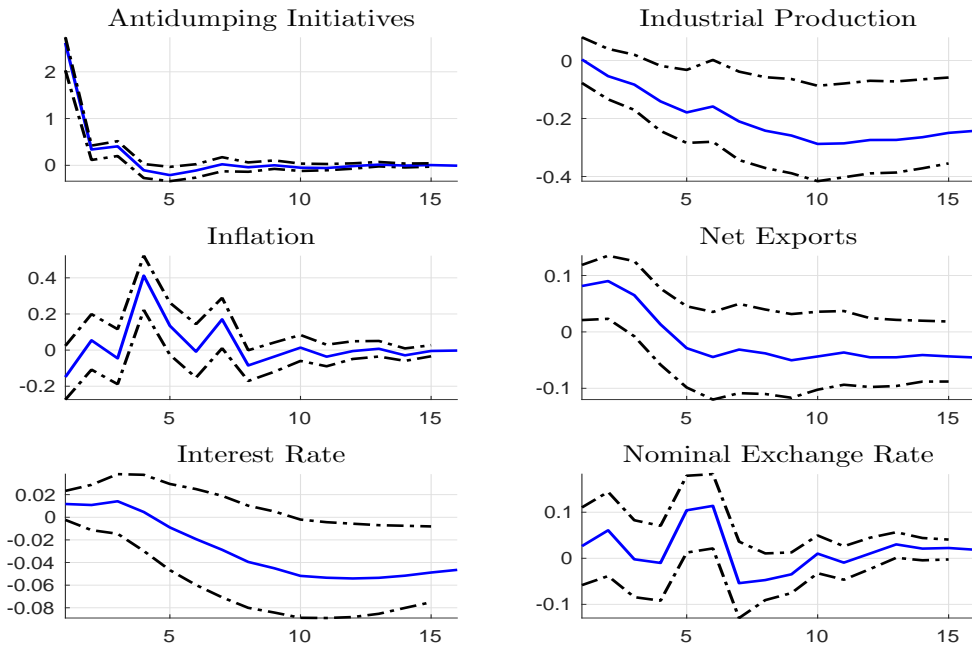


Figure 6: Monthly VAR, one-standard deviation increase in antidumping initiatives in Canada. Industrial production, net exports, and nominal exchange rate are in percentage points. The inflation rate and the interest rate are annualized.

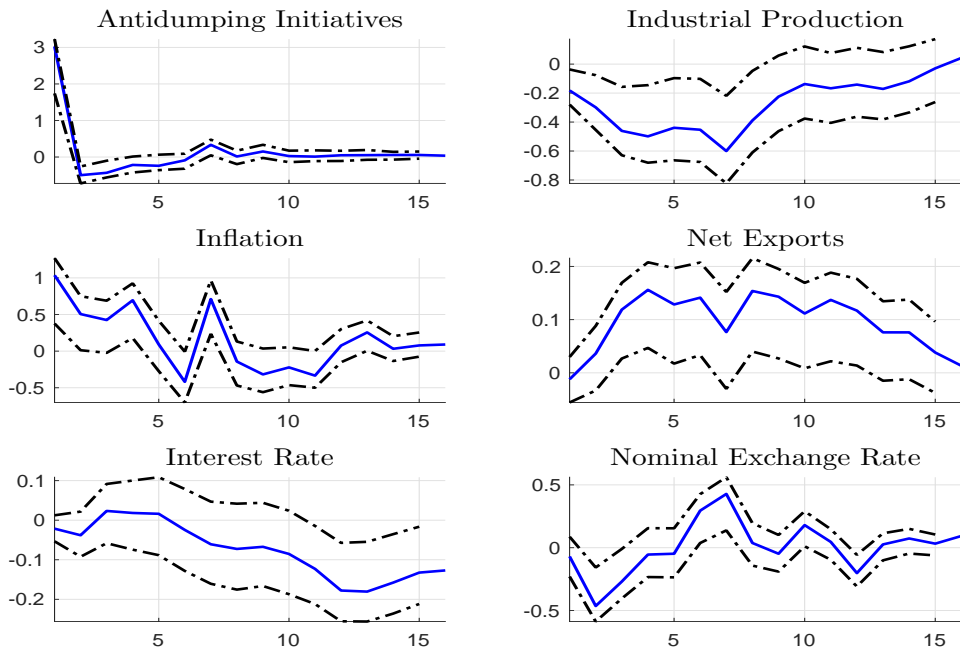


Figure 7: Monthly VAR, one-standard deviation increase in antidumping initiatives in Turkey. Industrial production, net exports, and nominal exchange rate are in percentage points. The inflation rate and the interest rate are annualized.

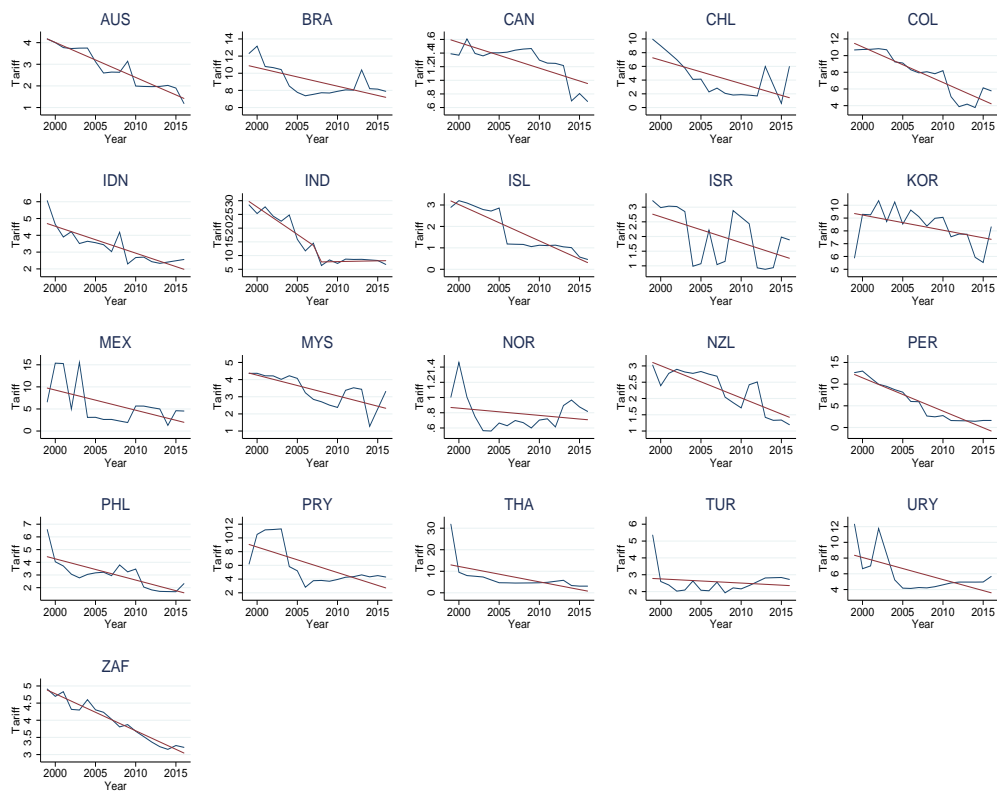


Figure 8: Weighted average of applied tariffs, 1999-2016.

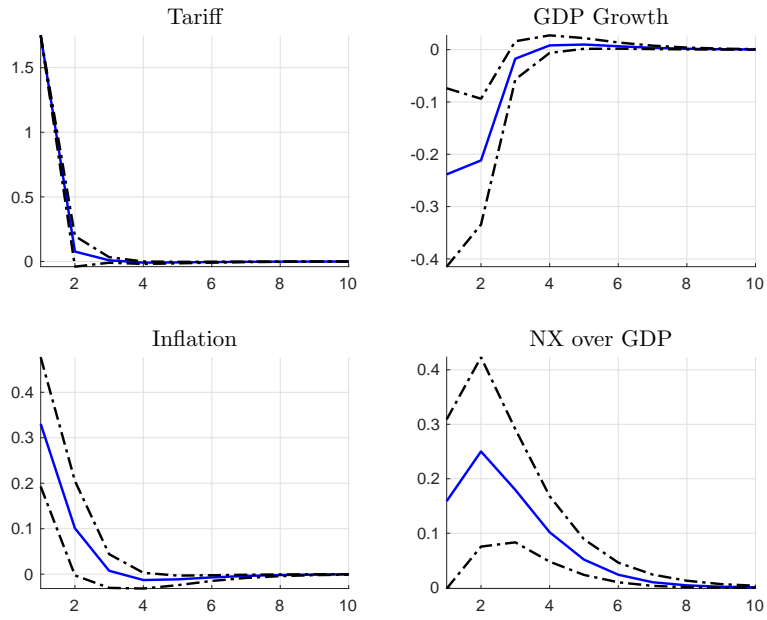


Figure 9, Panel A: Panel-VAR, impulse responses to a one-standard deviation increase in detrended tariffs. Tariffs, GDP growth, and net exports over GDP are in percentage points.

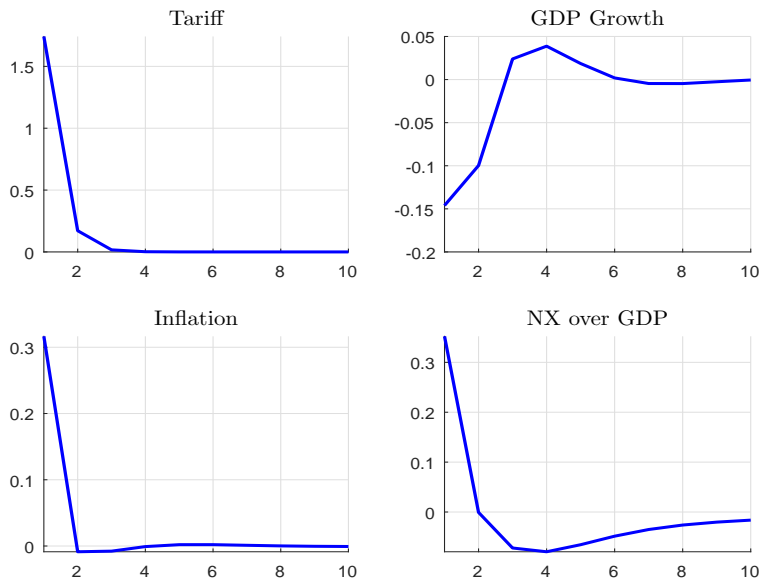


Figure 9, Panel B: Model-implied, annualized impulse responses to a tariff increase. The tariff shock matches size and persistence of the equivalent shock in the panel VAR (Figure 9A). Tariffs, GDP growth, and net exports over GDP are in percentage points.

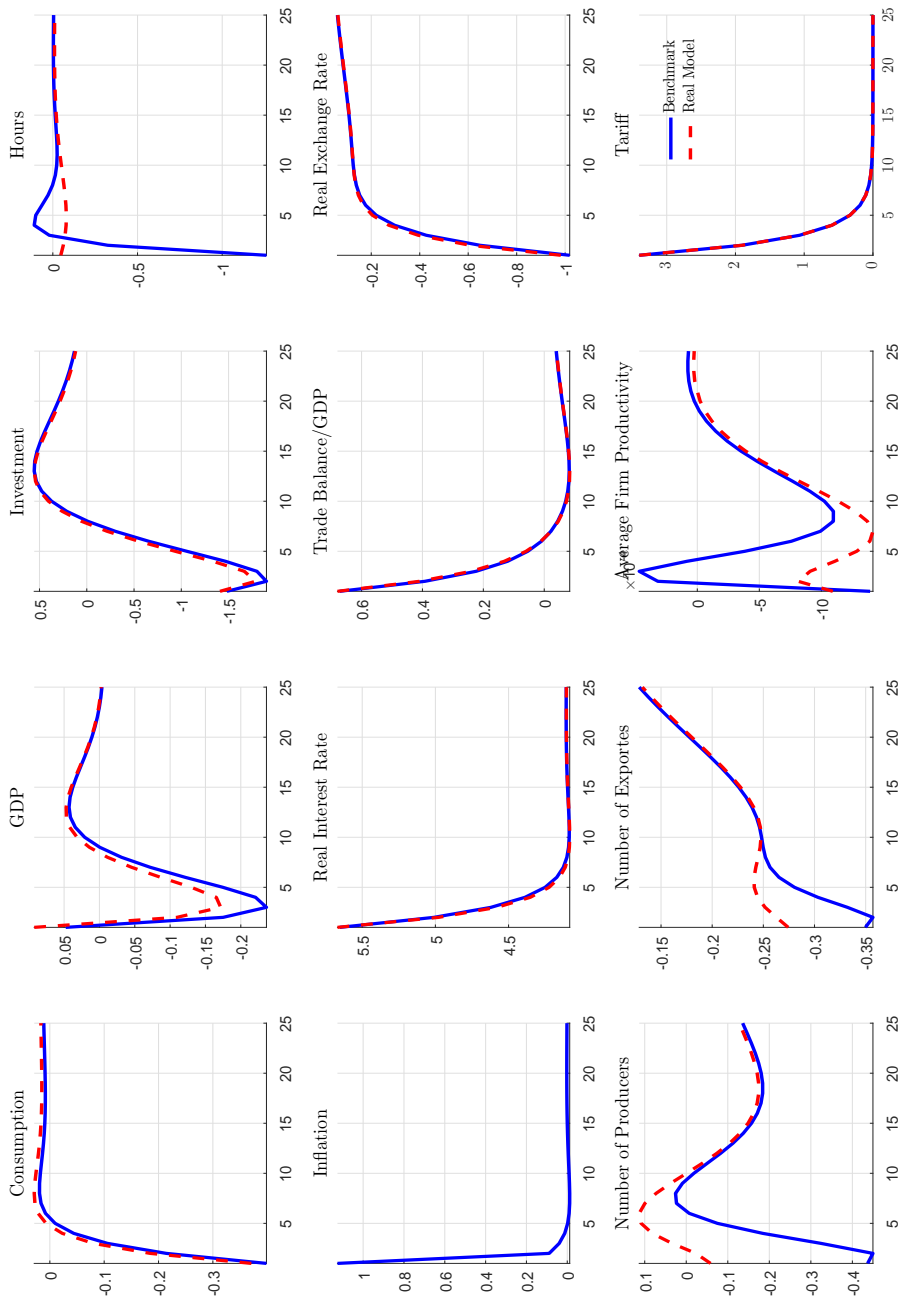


Figure 10: Responses to a temporary increase in Home trade barriers in normal times, benchmark model (continuous lines) and an alternative version without nominal rigidities (dashed lines). Responses show percentage deviations from the steady state. The inflation rate is annualized.

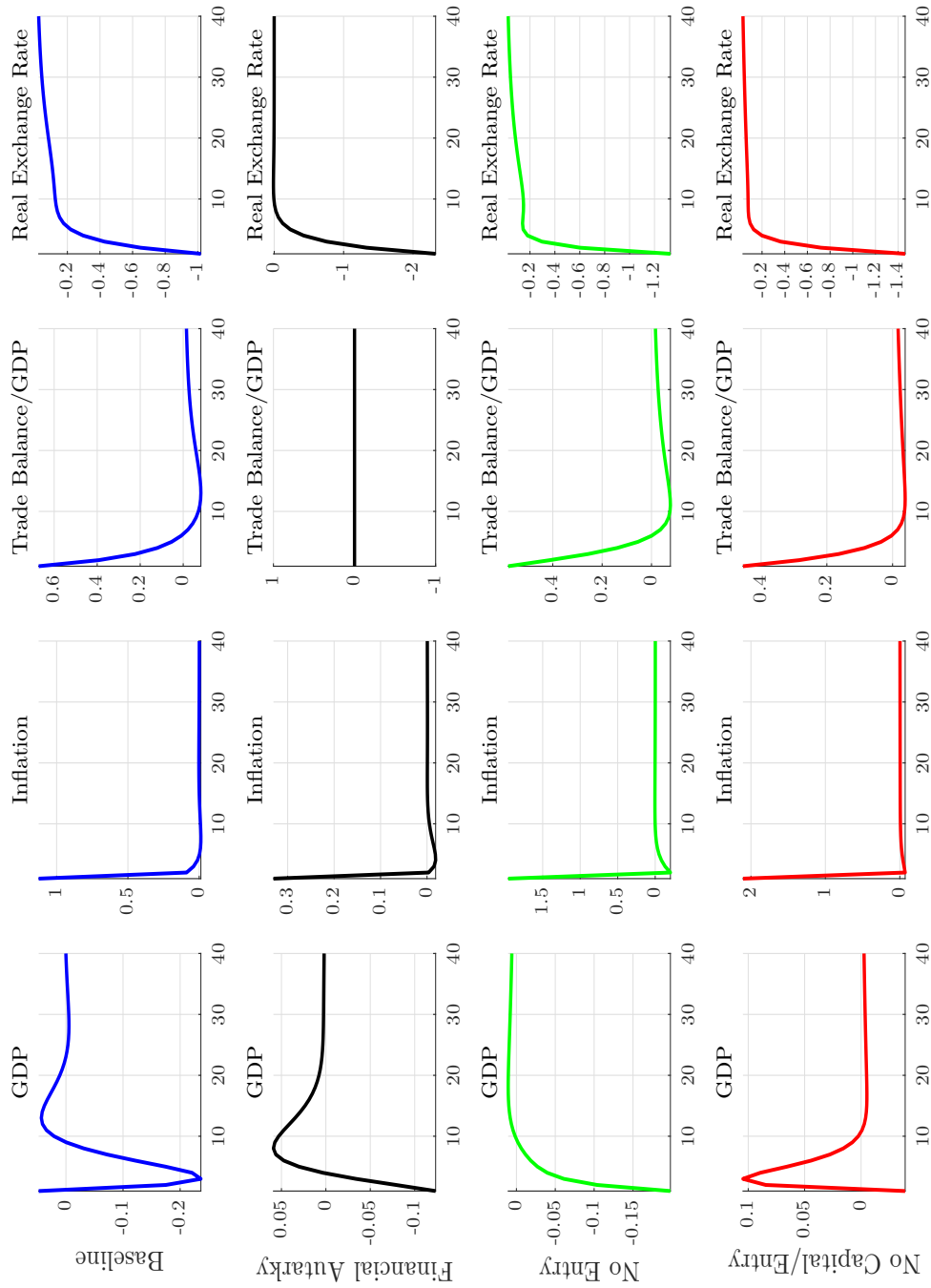


Figure 11: Responses to a temporary increase in Home tariffs in normal times, flexible exchange rate. The top row: baseline model; second row: baseline model under financial autarky; third row: baseline model without firm dynamics; fourth row: baseline model without firm dynamics and physical capital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

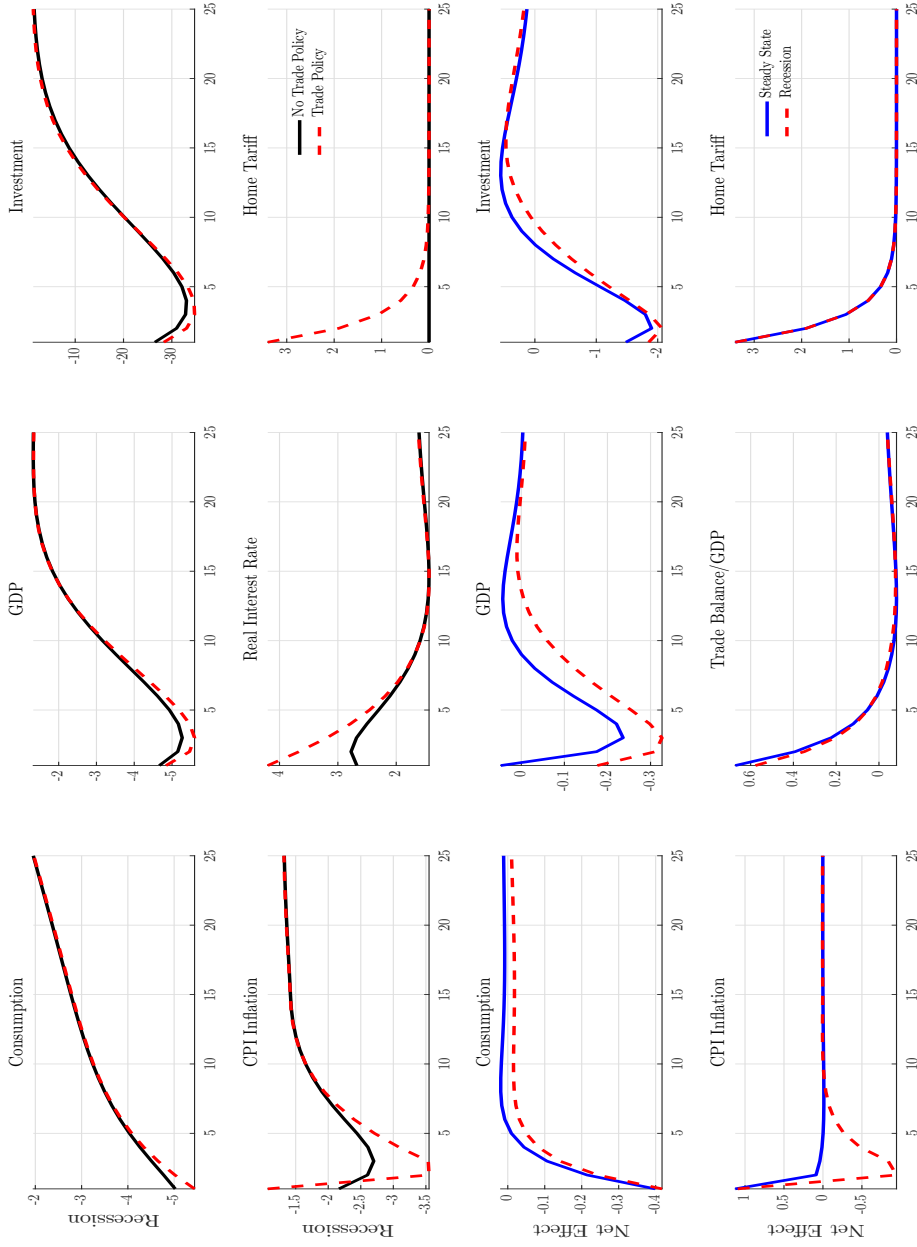


Figure 12: Top two panels: recession (continuous lines) versus recession followed by higher Home tariffs (dashed lines); Bottom two panels: net effect of higher Home tariffs in normal times (continuous lines) and in a recession with binding ZLB (dashed lines). Responses show percentage deviations from the initial steady state. The inflation rate is annualized.

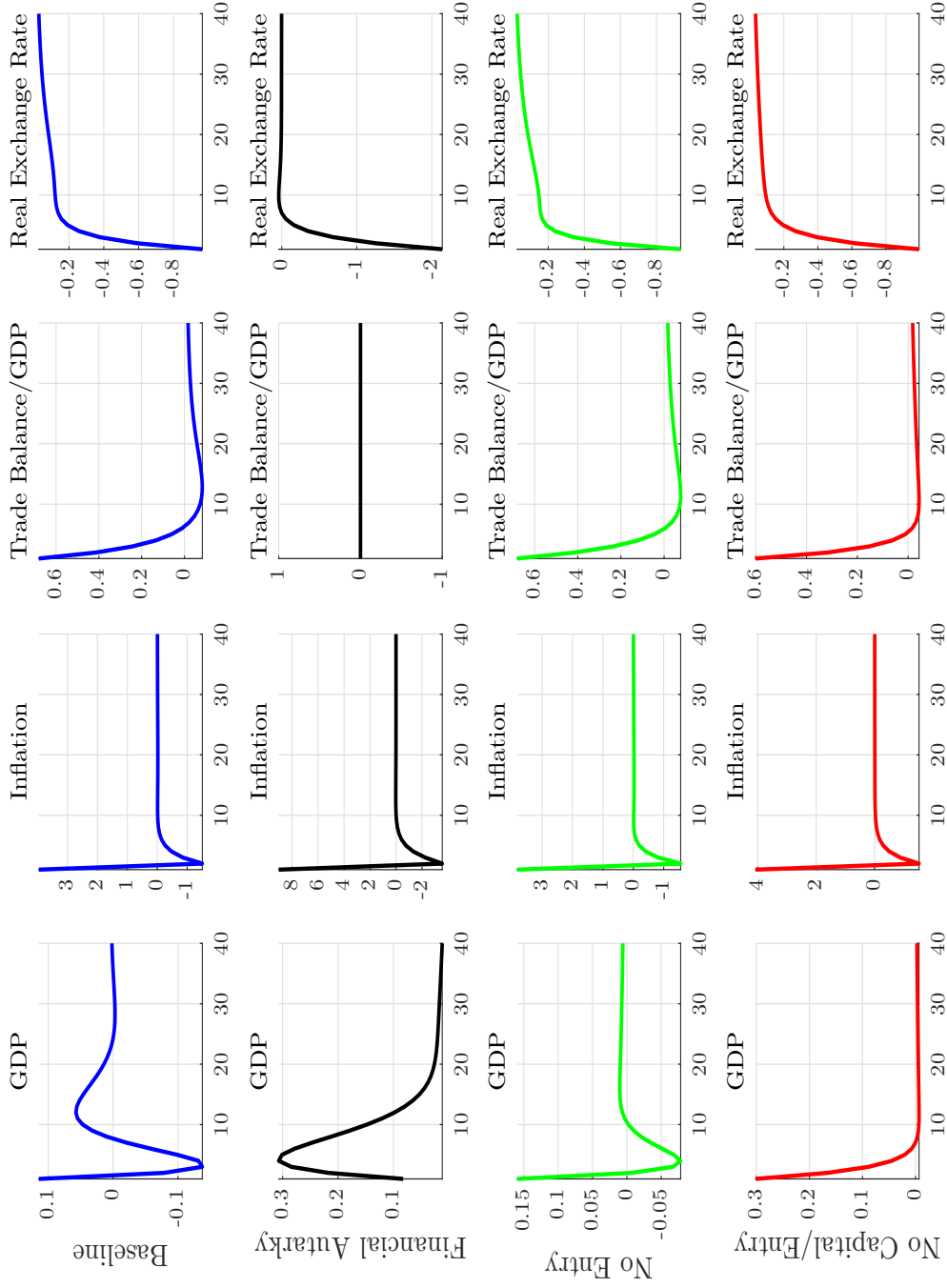


Figure 13: Responses to a temporary increase in Home tariffs in normal times, fixed exchange rate. The top row: baseline model; second row: baseline model under financial autarky; third row: baseline model without firm dynamics; fourth row: baseline model without firm dynamics and physical capital accumulation. 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 (2018).

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A Data Description

Here we describe in detail the variables used in Section 2 of the main paper.

Antidumping Initiatives. Our baseline measure of antidumping initiatives is the number of HS-6 products affected by new antidumping investigations in a given quarter or month. The data come from the Global Antidumping Database (Bown, 2016). We match the date of each anti-dumping investigation recorded in the GAD to the number of HS-6 products covered by each investigation.

Tariffs. In the panel VAR, we use data from the UN-WITS Database. We aggregate HS-2 product-level applied tariff rates using an import-weighted average of tariffs for each country and year. In our baseline specification, we use constant weights (using imports data for the year 1999). We linearly detrend the tariff measure for each country.

Real GDP. In the quarterly VAR, we use data from the OECD quarterly national account database. We use the measure *VPVOBARSA* (U.S. dollars, volume estimates, fixed PPPs, OECD reference year 2010, annual levels, seasonally adjusted). In the panel VAR, we use data from the World Bank World Developing Indicators. Annual GDP is measured in 2010 USD.

Inflation. For the quarterly and monthly VARs, we use the Core CPI Inflation series (“All Items, Less Food and Energy”) provided by the OECD prices database for Turkey and Canada. For India, only CPI Inflation (“All Items”) is available. Since these series are not seasonally adjusted, we deseasonalize each series by regressing the inflation rate on quarterly (monthly) dummies. Moreover, in Turkey, there is a clear regime shift before and after 2004 (Turkey announced the adoption of inflation targeting in 2002). We therefore use a regime-specific demeaned series for Turkey. In the panel VAR, we use annual CPI inflation data coming from the World Bank World Development Indicators.

Real Net Exports. In the quarterly VAR, exports and imports of good and services are from the OECD quarterly national account database. We use the measure *VPVOBARSA* (U.S. dollars, volume estimates, fixed PPPs, OECD reference year 2010, annual levels, seasonally adjusted). In the monthly VAR, we use data on exports and imports of goods from the OECD main indicator database. The data are reported in USD Billions. Thus, we deflate each series using country-specific CPI indexes. Since in India the dynamics of net exports feature clear time trends, we linearly detrend the series. In the panel VAR, we construct net exports over GDP using data on exports and imports from the World Bank Development Indicators.

Industrial Production. In the monthly VAR, we use data for from the OECD main economic indicators. In the baseline VAR, we linearly detrend the series.

Nominal Exchange Rates. The Nominal Effective Exchange Rates is from the Bank of International Settlement. We use the growth rate of the nominal effective exchange rate, where due to the BIS convention, an increase in the rate denotes an appreciation.

Interest Rates. In the quarterly VAR, we use the interbank overnight interest rate provided by the OECD main economic indicators. In the monthly VAR, we use the overnight interest rate provided by the OECD main economic indicators for India and Canada. For Turkey, we use the average daily interest rate on the interbank REPO rate provided by the Borsa Istanbul. We linearly detrend the Turkish series, since it features a clear downward trend during the sample period we consider.

Oil Price. The Oil price series is the Global Price of WTI Crude provided by the Federal Reserve Bank of St. Louis. The real price of oil is obtained by deflating the nominal price of oil using the U.S. CPI.

Real Economic Activity Index. We use the index of global real economic activity in commodity markets developed by Lutz Kilian. The series is available for the period 1968:M1 to 2017:M9.¹ We took simple averages when aggregating at quarterly frequency.

Stock prices. We use the year-to-year growth of overall stock prices provided at quarterly frequency by the OECD Main Economic Indicators for both Canada and Turkey.

OECD Composite Leading Indicators. We use the OECD amplitude-adjusted Composite Leading Indicator from the OECD's main economic indicators. The details about the index construction can be found at <http://www.oecd.org/sdd/leading-indicators/41629509.pdf>.

B VAR Robustness

As discussed in the main text, we conduct several robustness checks. We report the results for all the scenarios that we consider for the quarterly VAR. The results for the monthly VAR are very similar and are available upon request.

Additional Controls

An issue related to anticipation effects concerns the possibility that antidumping investigations also reflect expectations about future economic conditions that are not captured by past information

¹Data are available at <http://www-personal.umich.edu/~lkilian/paperlinks.html>.

from the variables included in the VAR. Decision lags in the opening of investigations imply that new information at time t does not affect the time- t number of new antidumping initiatives. However, lagged news about future economic conditions may affect current antidumping initiatives.

We address this issue in two ways. First, we include in the VAR variables that contain information about economic agents' expectations about future economic activity. We consider four time series: an index of share prices provided by the OECD, the real price of oil, an index of global real economic activity in industrial commodity markets (Kilian, 2009), and an index of future economic activity again constructed by the OECD. Figures A.1 to A.8 report the results obtained for Canada and Turkey. In all cases, and for both countries, our results are very similar to those presented in the main text.

Second, Table A.1 shows that the identified structural trade-policy shocks are not Granger-caused by the four time series described above. We report the F-statistic of joint significance of the coefficients of the first two lags of each control variable.

Alternative Identification Scheme

We investigated whether the results are sensitive to the specific recursive structure implied by the assumption that antidumping initiations are exogenous to current economic conditions. We then order the trade policy measure last in the VAR—thus allowing trade policy to react contemporaneously to economic conditions. Figures A.9 and A.10 report the results for Canada and Turkey. The results are similar to those presented in the main text.

Alternative Measures of Protectionism

Antidumping Initiatives

As explained in the main text, we consider alternative measures of antidumping initiatives. Our baseline measure does not include the products recorded at 4-digits level of disaggregation. A possible alternative approach could be imputing investigations recorded at 4-digits to all 6-digit sub-products contained in a given 4-digits sector. However, this would imply 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 compute a measure where each time a product is recorded as being subject to an antidumping investigation, we count it as one, regardless of the level of disaggregation provided by the GAD database. This allows us to account for the

fact that our baseline measure could miss some products effectively subject to an antidumping investigation. At the same time, this alternative measure avoids the risk of overstating the number of products subject to a new investigation.

In addition, for both the baseline measure and the alternative measure described above, we considered a version that only includes the subset of initiatives that effectively ended with the imposition of 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.11 and A.12. 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 product subject to an investigation. The third panel reports the results when the baseline measure only includes antidumping initiatives that resulted in an antidumping tariff. Finally, the fourth panel reports the results when the alternative measure only includes antidumping initiatives that resulted in an antidumping tariff. For both Canada and Turkey, the recessionary and inflationary effects of protectionism are very robust to the alternative measures used.

Total Temporary Trade Barriers

As explained in the main text, antidumping investigations account for between 80 and 90 percent of total temporary trade barriers. We checked whether our results are robust to the use of a trade policy measure that includes other temporary trade barriers (global safeguards and countervailing duties). Figures A.13 and A.14 report the results obtained for Canada and Turkey using this different trade policy measure. Also in this case, the results are very similar to those reported in the main text.

Detrended GDP

In the main text, we presented evidence using the growth rate of real GDP for the quarterly VAR. Here we present the results we obtained using the detrended level of GDP.

Figure A.15 reports the responses of GDP, inflation and net exports over GDP for Canada (top panel) and Turkey (bottom panel). We omit the responses of the trade policy measure to improve the readability of the figure (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.

Panel VAR: Imports and Exports Dynamics

Figure A.16 reports impulse responses from the panel-VAR including (linearly detrended) real imports and exports. The figure shows that following a tariff increase, both imports and exports decrease. However, the decline in imports is stronger than the decline in exports.

C Additional Empirical Evidence: India

We corroborate the evidence provided in the main text for Turkey and Canada by using Indian data—together with Turkey, India is the main user of antidumping initiatives among developing countries. Figure A.17 reports the results using quarterly data from 1996:Q2 to 2015:Q4.² Following a trade policy shock, there is a statistically significant decline in real GDP. Net exports over GDP increase, while we do not find a significant inflationary effect. It is important to stress, however, that data limitations imply that only a series for headline inflation (as opposed to core inflation) is available.

In Figure A.18 we report the results obtained for India using monthly data.³ Also in this case, the results are similar to those obtained for Canada and Turkey: protectionism triggers a fall in industrial production, increasing net exports over GDP. Inflation, as in the VAR with quarterly data, at first decreases (though the fall is not significant) and then slowly rises to a positive and significant peak that is reached after 6 months.

D Model Equilibrium Conditions

Demand Schedules

The demand for tradables is $C_t^T = (1 - \alpha_N) (P_t^T / P_t)^{-\phi_N} C_t$; the demand for non-tradables is $C_t^N = \alpha_N (P_t^N / P_t)^{-\phi_N} C_t$. Home demand for domestic tradable consumption is $C_{D,t}^T = (1 - \alpha_X) (P_{D,t}^T / P_t^T)^{-\phi_T} C_t^T$, while the demand for the imported bundle is $C_{X,t}^{T*} = \alpha_X (P_{X,t}^{T*} / P_t^T)^{-\phi_T} C_t^T$. Finally, Home demand for a domestic tradable variety is $C_{D,t}^T(\omega) = (P_{D,t}^T(\omega) / P_{D,t}^T)^{-\phi_T} C_{D,t}^T$, while the demand for a Foreign tradable product is $C_{X,t}^{T*}(\omega) = \left[(1 + \tau_t^{IM}) P_{X,t}^{T*}(\omega) / P_{X,t}^{T*} \right]^{-\phi_T} C_{X,t}^{T*}$.

²The choice of the sample period is due to data availability. Here we report the responses using detrended GDP and industrial production. We also considered the growth rates, obtaining similar qualitative results.

³The period covered is 1995:M5 to 2015:M2, due to the limited availability of the industrial production series from the OECD.

Model Aggregation

Home domestic demand is $Y_{D,t}^T(z) = \left(P_{D,t}^T(z)/P_{D,t}^T\right)^{-\theta_T} Y_{D,t}^T$, while export demand is

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

where $\tau_t^{IM*} \geq 0$ is an ad-valorem import tariff imposed by Foreign. The terms $Y_{D,t}^T$ and $Y_{X,t}^{T*}$ denote, respectively, Home and Foreign aggregate demand of the basket of Home tradable goods. 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, $d_{D,t}^T(z)$, and from potential export sales, $d_{X,t}^T(z)$. These profit levels, expressed in units of Home consumption, are given by the following expressions:

$$d_{D,t}^T(z) \equiv \left(\rho_{D,t}^T(z) - \frac{\varphi_t}{z}\right) Y_{D,t}^T(z),$$

and

$$d_{X,t}^T(z) \equiv \left[Q_t \rho_{X,t}^T(z) - (1 + \tau_t) \frac{\varphi_t}{z}\right] Y_{X,t}^T(z) - \varphi_t f_{X,t}.$$

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: $z_{X,t} = \inf\{z : d_{X,t}^T(z) > 0\}$. 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.

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:

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

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 $\tilde{\rho}_{D,t}^T \equiv \rho_{D,t}^T(\tilde{z}_D)$, while the average price of Home exports is $\tilde{\rho}_{X,t}^T \equiv \rho_{X,t}^T(\tilde{z}_{X,t})$. Average domestic tradable output is $\tilde{Y}_{D,t}^T = \left(\tilde{\rho}_{D,t}^T/\rho_{D,t}^T\right)^{-\theta_T} Y_{D,t}^T$, while average export is $\tilde{Y}_{X,t}^T = \left(\tilde{\rho}_{X,t}^T/\rho_{X,t}^T\right)^{-\theta_T} Y_{X,t}^T$. The average profit from domestic sales is $\tilde{d}_{D,t}^T \equiv d_{D,t}^T(\tilde{z}_D)$, while the average export profit is $\tilde{d}_{X,t}^T \equiv d_{X,t}^T(\tilde{z}_{X,t})$. Thus, the average total profit of Home firms is given by $\tilde{d}_t^T = \tilde{d}_{D,t}^T + (N_{X,t}/N_{D,t}) \tilde{d}_{X,t}^T$.

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 $N_{X,t}/N_{D,t} = (z_{\min}/\tilde{z}_{X,t})^\kappa [\kappa/(\kappa - \theta_T + 1)]^{\kappa/(\theta_T - 1)}$, while the zero-profit condition that determines the productivity cutoff $\tilde{z}_{X,t}$ is such that $\tilde{d}_{X,t}^T = (\theta_T - 1)/[\kappa - \theta_T + 1] \varphi_t f_{X,t}$.

Equilibrium Conditions

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

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

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:

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

Table A.2 summarizes the equilibrium conditions of the model. Eight Foreign variables directly affect macroeconomic dynamics in the small open economy: Y_t^* , i_{t+1}^* , π_t^{C*} , ρ_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, π_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, ρ_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:

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

where $\tilde{\rho}_{X,t}^* = Q_t(1 + \tau_t^*) \rho_{D,t}^{*T}$ 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:

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

where $\tau_t^* \geq 0$ denotes iceberg trade costs faced by Foreign exporters. Finally, $\rho_t^{T*} = \rho_{D,t}^{T*} = [\theta_T/(\theta_T - 1)] \varphi_t^*/\tilde{z}_D$ 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.

E Data-Consistent Variables

Definition

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

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

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

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

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:

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

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:

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

Model Fit

In the main paper, we present impulse responses for welfare-consistent variables, i.e., variables deflated by the CPI index P_t . Here we show that our results are not affected by deflating nominal variables using the data-consistent price index \tilde{P}_t . For instance, Figure A.19 reproduces Panel B in Figure 9 using the data-consistent price index \tilde{P}_t to construct inflation and real GDP. In each subplot, dashed lines plot confidence bands from the panel-VAR estimates.

F Sensitivity Analysis: Size and Persistence of Tariff Shocks

Figure A.20 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 top row assumes that the tariff increase occurs in normal times, while the bottom row refers to a recession. The third row plots the difference between the first and the second row. 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.

Figure A.21 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.20, 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 Figure A.20). 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.

G 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.⁴ Per-period (real) profits are given by

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

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 :

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

⁴The 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.

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

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

where $\pi_{N,t}(i) \equiv (P_t^N(i) / P_{t-1}^N(i)) - 1$. 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 $C_t^N = \alpha_N (\rho_t^N)^{-\phi_N} Y_t$.

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).⁵ We now present the details of this alternative model, considering three alternative cases: producer currency pricing (PCP), local currency pricing (LCP), and the empirically relevant scenario for small open economies of dollar currency pricing (i.e., export prices are set in U.S. dollar everywhere).

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

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

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

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

⁵This 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 $C_{D,t}^T$ aggregates sectoral consumption goods $C_{D,t}^T(i)$:

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

A similar basket describes Foreign tradable consumption: $C_{X,t}^{T*} = \left[\int_0^1 C_{X,t}^{T*}(i)^{(\theta_T-1)/\theta_T} di \right]^{\theta_T/(\theta_T-1)}$.

The corresponding price indexes are $P_{D,t}^T = \left[\int_0^1 P_{D,t}^T(i)^{1-\theta_T} di \right]^{1/(1-\theta_T)}$ and $P_{X,t}^{T*} = \left[\int_0^1 P_{X,t}^{T*}(i)^{1-\theta_T} di \right]^{1/(1-\theta_T)}$, 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 : $Y_t^T(i) = \left(\int_{\omega \in \Omega} Y_t^T(\omega, i)^{(\theta_\omega-1)/\theta_\omega} d\omega \right)^{\theta_\omega/(\theta_\omega-1)}$, where $\theta_\omega > 1$ denotes the symmetric elasticity of substitution across product varieties.⁶ 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.⁷ 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

⁶Sectors (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 .

⁷Alternatively, 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.

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 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.⁸

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:

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

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:

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

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

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

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

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:

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

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

⁸Notice that $z_{X,t}$ is the lowest level of plant productivity such that the profit from exporting is positive.

the price (in Foreign currency) of the exported bundle $Y_{X,t}^T(i)$. Each producer i faces the following domestic and foreign demand:

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

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

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 two alternative assumptions about the currency denomination of export prices: producer currency pricing (PCP) and local currency pricing (LCP).

Producer Currency Pricing (PCP)

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:

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

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 $\tilde{z}_{X,t}(i) = \alpha^{1/(\theta_\omega - 1)} z_{X,t}(i)$.⁹

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 export.

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

$$\varphi_t f_{E,t} = E_t \left\{ (1 - \delta) \beta_{t,t+1} \left[\begin{aligned} & \varphi_{t+1} \left(f_{E,t+1} - \frac{N_{X,t+1}}{N_{D,t+1}} f_{X,t+1} \right) \\ & + \frac{1}{\theta_\omega - 1} \left(\varphi_{D,t+1}^T \frac{Y_{D,t+1}^T}{N_{D,t+1}} + \varphi_{X,t+1}^T \frac{Y_{X,t+1}^T}{N_{X,t+1}} \frac{N_{X,t+1}}{N_{D,t+1}} \tau_{t+1} \right) \right] \right\}.$$

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 $\mu_{D,t}^T$ over the domestic marginal cost, $\varphi_{D,t}^T$:

$$\rho_{D,t}^T \equiv \frac{P_{D,t}}{P_t} = \mu_{D,t}^T \varphi_{D,t}^T.$$

⁹Equation (A-2) implies that by choosing $z_{X,t}$ the producer also determines $N_{X,t}$.

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

$$\mu_{D,t}^T \equiv \frac{\theta_T}{(\theta_T - 1) \left[1 - \frac{\nu_T}{2} (\pi_{D,t}^T)^2 \right] + \nu_T \left\{ -E_t \left[\beta_{t,t+1} \frac{(1 + \pi_{D,t+1}^T)^2}{1 + \pi_{C,t+1}} \pi_{D,t+1}^T \frac{Y_{D,t+1}^T}{Y_{D,t}^T} \right] \right\}},$$

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

$$\rho_{X,t}^T \equiv \frac{P_{X,t}^T}{P_t^*} = \mu_{X,t}^T \frac{(1 + \tau_t) \varphi_{X,t}^T}{Q_t}.$$

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

$$\mu_{X,t}^T = \frac{\theta_T}{(\theta_T - 1) \left[1 - \frac{\nu_T}{2} (\pi_{X,t}^{T,h})^2 \right] + \nu_T \left\{ -E_t \left[\beta_{t,t+1} \frac{(1 + \pi_{X,t+1}^{T,h})^2}{1 + \pi_{C,t+1}} \pi_{X,t+1}^{T,h} \frac{Y_{X,t+1}^T}{Y_{X,t}^T} \right] \right\}}, \quad (\text{A-6})$$

where

$$1 + \pi_{X,t}^{T,h} = \frac{P_{X,t}^{T,h}}{P_{X,t-1}^{T,h}} = \frac{Q_t}{Q_{t-1}} \frac{\rho_{X,t}^T}{\rho_{X,t-1}^T} (1 + \pi_{C,t}).$$

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

$$Y_{D,t}^T = \left[1 - (\nu/2) (\pi_{D,t}^T)^2 \right]^{-1} C_{D,t}^T$$

and

$$Y_{X,t}^T = \left[1 - (\nu/2) (\pi_{X,t}^{T,h})^2 \right]^{-1} C_{X,t}^T.$$

Local Currency Pricing (LCP)

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

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

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

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

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

$$\mu_{X,t}^T \equiv \frac{\theta_T}{(\theta_T - 1) \left[1 - \frac{\nu_T}{2} \left(\pi_{X,t}^T \right)^2 \right] + \nu_T \left\{ \begin{array}{l} \left(1 + \pi_{X,t}^T \right) \pi_{X,t}^T \\ - E_t \left[\beta_{t,t+1} \frac{Q_{t+1}}{Q_t} \frac{(1 + \pi_{X,t}^T)^2}{1 + \pi_{C,t+1}} \pi_{X,t}^T \frac{Y_{X,t+1}^T}{Y_{X,t}^T} \right] \end{array} \right\}},$$

where $1 + \pi_{X,t}^T = P_{X,t}^T / P_{X,t-1}^T$.

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 $P_{X,t}^T(i) = P_{X,t}^{T,h}(i) / \varepsilon_t$. Therefore the adjustment cost under PCP can be written as

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

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

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

which is identical to the cost under LCP. Furthermore, $P_{X,t}^T(i) = P_{X,t}^{T,h}(i)$ in deviations from steady state, since $\varepsilon_t = \varepsilon$ (constant).¹⁰

Dollar Currency Pricing (DCP)

In this case, Home export prices are determined as under LCP, while U.S. exporters set prices under PCP.

¹⁰ 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.

Impulse Responses

Figure A.22 presents the impulse responses following a temporary increase in tariffs under PCP, Figure A.23 considers LCP, while Figure A.24 plots dynamics under DCP. In all 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 (second row), the baseline model without endogenous firm dynamics (third row), and the baseline model without firm dynamics and endogenous physical capital accumulation. In the three scenarios, 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.¹¹

H The Role of Macro and Micro Dynamics

Figure A.25 and A.26 assess the relative importance of macro and micro forces for the model's ability to match the panel-VAR evidence presented in Figure 9 (Panel A). Figure A.25 plots welfare-consistent measures for inflation and real GDP, while Figure A.26 considers data-consistent measures. We consider 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. Each margin of adjustment plays an important role in matching the data. Both figures show that physical capital accumulation and producer-level dynamics are central to reproduce the panel-VAR evidence. The intuition mirrors the discussion in the main text.

¹¹Results are similar when considering a fixed exchange rate. Notice that in this case, the equilibrium allocation implied by the model is identical under producer currency pricing and local currency pricing. While the exact equivalence depends on the existence of producer heterogeneity, allocations remain nearly identical even in the absence of endogenous producer entry.

Table A.1

	$\hat{u}_{\tau,t}^{Canada}$	$\hat{u}_{\tau,t}^{Turkey}$
$Poil_{t-1}$	0.093 [0.070]	0.080 [0.064]
$Poil_{t-2}$	-0.079 [0.070]	-0.077 [0.064]
<i>pval F test</i>	0.388	0.457
$GREAt_{-1}$	-0.051 [0.043]	0.040 [0.042]
$GREAt_{-2}$	0.005 [0.043]	-0.031 [0.042]
<i>pval F test</i>	0.136	0.629
$Stock_{i,t-1}$	-0.023 [0.60]	-0.013 [0.012]
$Stock_{i,t-2}$	0.071 [0.059]	0.005 [0.012]
<i>pval F test</i>	0.282	0.478
$CLLt_{-1}$	-0.681 [1.27]	0.100 [0.326]
$CLLt_{-2}$	0.671 [1.27]	-0.099 [0.328]
<i>pval F test</i>	0.689	0.948

Note: OLS regressions where the dependent variable is the estimated structural trade-policy structural shock in the quarterly VAR (either $\hat{u}_{\tau,t}^{Canada}$ or $\hat{u}_{\tau,t}^{Turkey}$). The regressors include: the real price of oil ($Poil_t$), an index of global real economic activity in industrial commodity markets ($GREAt$), a country-specific index of share prices ($Stock_{it}$), and a country-specific index of future economic activity ($CLLt$). *pvalFtest* denotes the p-value of a F-test of joint significance of the coefficients.

TABLE A.2: MODEL EQUATIONS

$$\begin{aligned}
1 &= (1 - \alpha_N) (\rho_t^T)^{1-\phi_N} + \alpha_N (\rho_t^N)^{1-\phi_N} \\
\rho_t^T &= (1 - \alpha_X) \left(\rho_{D,t}^T \right)^{1-\phi_T} + \alpha_X \left(\rho_{X,t}^{T*} \right)^{1-\phi_T} \\
\rho_{D,t}^T &= N_{D,t}^{1/(1-\theta_T)} \tilde{\rho}_{D,t}^T \\
\rho_{X,t}^T &= N_{X,t}^{1/(1-\theta_T)} \tilde{\rho}_{X,t}^T \\
Z_t K_t^\alpha L_t^{1-\alpha} &= Y_t^N + N_{D,t}^{\frac{1}{1-\theta_T}} \frac{Y_{D,t}^T}{\tilde{z}_D} + N_{X,t}^{\frac{1}{1-\theta_T}} \frac{Y_{X,t}^T}{\tilde{z}_{X,t}} + N_{E,t} f_{E,t} + N_{X,t} f_{X,t} \\
Y_t &= C_t + I_{K,t} + \left[1 - \frac{\nu_w}{2} (\pi_{w,t})^2 \right] w_t L_t \\
Y_t^N &= \alpha_N (\rho_t^N)^{-\phi_N} Y_t \\
\rho_t^N &= \frac{\theta_N}{(\theta_N - 1)} \varphi_t \\
Y_{D,t} &= N_{D,t}^{\frac{\theta_T - 1}{\theta_T}} \tilde{Y}_{D,t} \\
Y_{X,t} &= N_{X,t}^{\frac{1}{\theta_T - 1}} \tilde{Y}_{X,t} \\
\tilde{Y}_{D,t}^T &= (1 - \alpha_X) (1 - \alpha_N) \left(\tilde{\rho}_{D,t}^T \right)^{-\phi_T} N_{D,t}^{\frac{\theta_T - \phi_T}{1 - \theta_T}} (\rho_t^T)^{\phi_T - \phi_N} Y_t \\
\tilde{Y}_{X,t}^T &= \alpha_X (1 - \alpha_N) \left(\tilde{\rho}_{X,t}^T \right)^{-\phi_T} N_{X,t}^{\frac{\theta_T - \phi_T}{1 - \theta_T}} (\rho_t^{T*})^{\phi_T - \phi_N} Y_t^* \\
\tilde{\rho}_{D,t}^T &= \frac{\theta_T}{(\theta_T - 1)} \frac{\varphi_t}{\tilde{z}_D} \\
\tilde{\rho}_{X,t}^T &= \frac{\theta_T}{(\theta_T - 1)} \frac{\tau_t}{Q_t \tilde{z}_{X,t}} \\
N_{D,t} &= (1 - \delta) (N_{D,t-1} + N_{E,t-1}) \\
N_{X,t} &= \left(\frac{z_{\min}}{\tilde{z}_{X,t}} \right)^{-k} \kappa^{\frac{k}{\theta_T - 1}} N_{D,t} \\
\varphi_t f_{E,t} &= E_t \left\{ (1 - \delta) \beta_{t,t+1} \left[\begin{aligned} &\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_T - 1} \left(\frac{\varphi_{t+1}}{\tilde{z}_D} \frac{Y_{D,t+1}}{N_{D,t+1}} + \frac{\varphi_{t+1}}{\tilde{z}_{X,t}} \frac{Y_{X,t+1}}{N_{X,t+1}} \frac{N_{X,t+1}}{N_{D,t+1}} \tau_{t+1} \right) \right] \right\} \\
\frac{k - (\theta_T - 1)}{(\theta_T - 1)k} \frac{\varphi_t}{\tilde{z}_{X,t}} \frac{Y_{X,t}}{N_{X,t}} \tau_t &= f_{X,t} \varphi_t \\
w_t &= \frac{\eta}{(\eta - 1) \left(1 - \frac{\nu_w}{2} \pi_{w,t}^2(h) \right) + \nu_w \left\{ \pi_{w,t} (1 + \pi_{w,t}) - E_t \left[\beta_{t,t+1} \pi_{w,t+1} \frac{(1 + \pi_{w,t+1})^2}{1 + \pi_{C,t+1}} \frac{L_{t+1}}{L_t} \right] \right\}} \frac{v_{L,t}}{u_{C,t}} \\
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} &= (1 + i_{t+1}^*) E_t \left(\frac{\beta_{t,t+1}}{1 + \pi_{C,t+1}^*} \frac{Q_{t+1}}{Q_t} \right) \\
Q_t a_{*,t+1} &= Q_t \frac{1 + i_t^*}{1 + \pi_{C,t}^*} a_{*,t} + 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*} \\
(1 + i_t) &= \max \left\{ 1, (1 + i_{t-1})^{\varrho_i} \left[(1 + i) (1 + \pi_{C,t})^{\varrho_\pi} (Y_{gt})^{\varrho_Y} \right]^{1 - \varrho_i} \right\} \\
(1 + \pi_{w,t}) &= \frac{w_t}{w_{t-1}} (1 + \pi_{C,t}) \\
(1 + \pi_{N,t}) &= \frac{\rho_t^N}{\rho_{t-1}^N} (1 + \pi_{C,t})
\end{aligned}$$

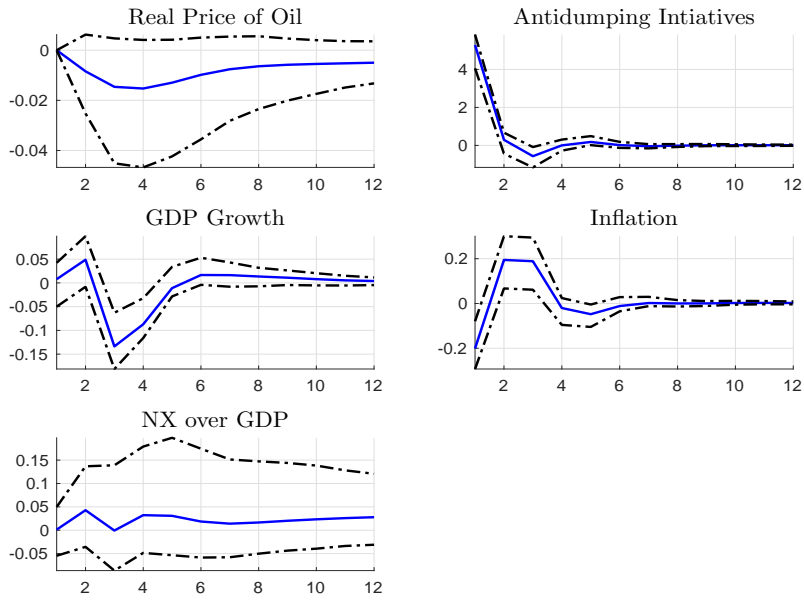


Figure A.1: Quarterly VAR including the real price of oil, one-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

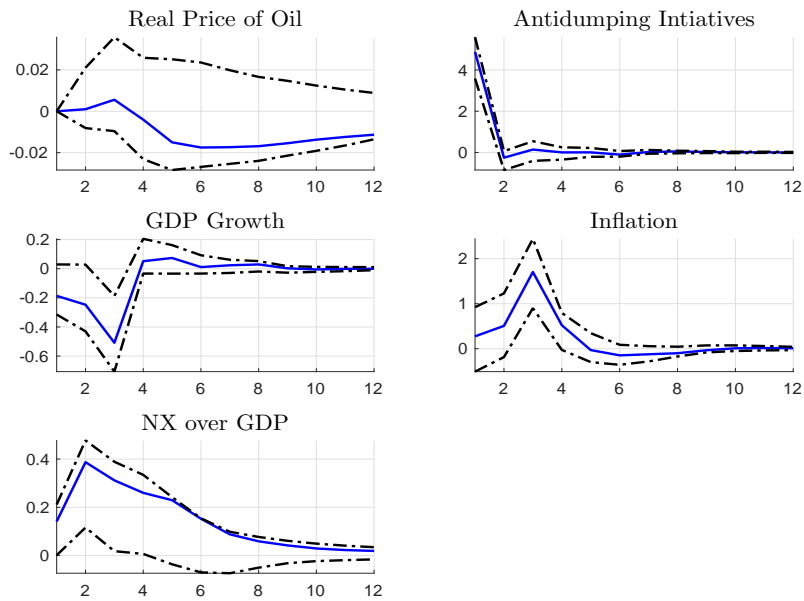


Figure A.2: Quarterly VAR including the real price of oil, one-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

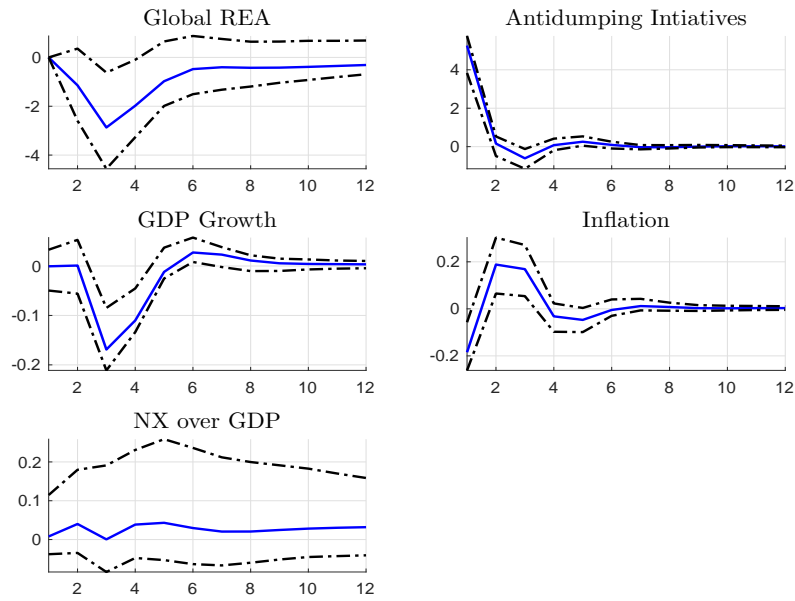


Figure A.3: Quarterly VAR including the real economic activity index, one-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

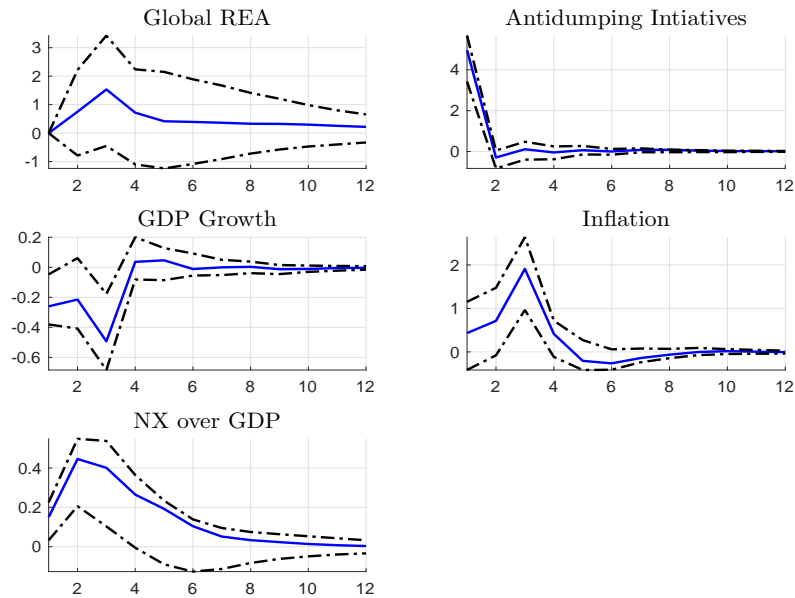


Figure A.4: Quarterly VAR including the real economic activity index, one-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

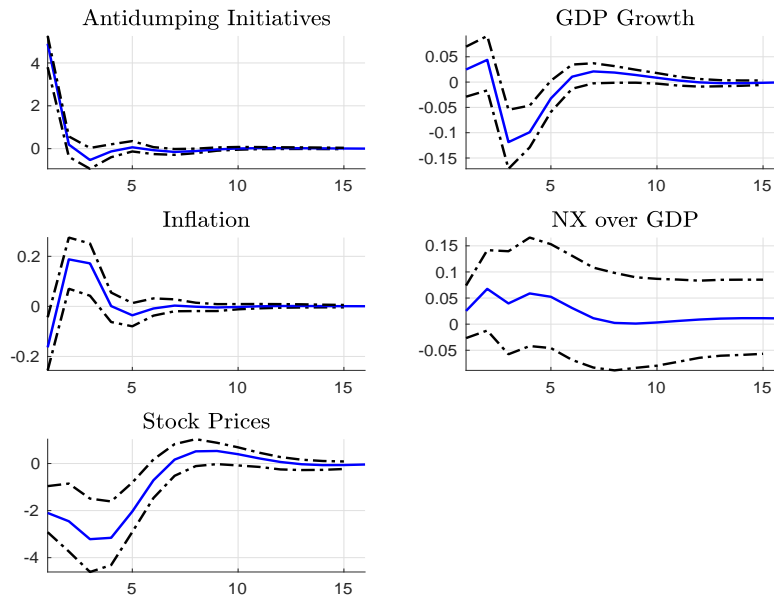


Figure A.5: Quarterly VAR including the OECD year-to-year growth of overall stock prices, one-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

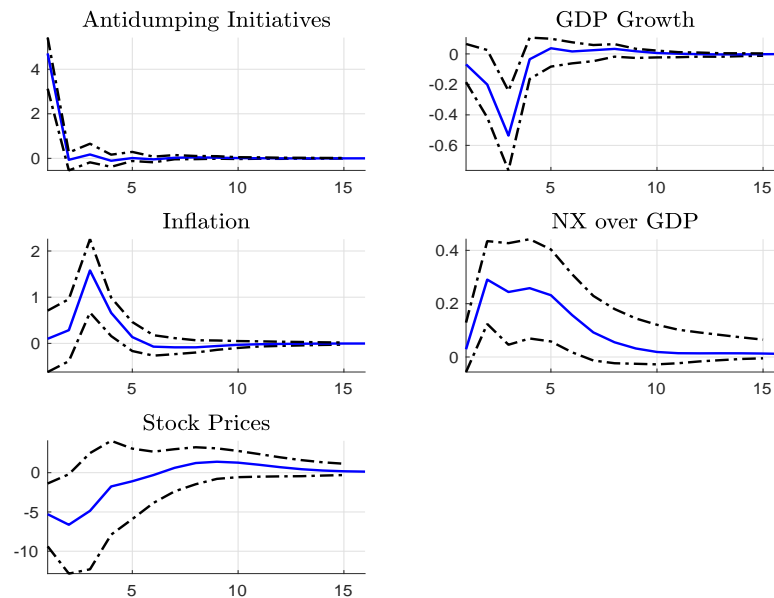


Figure A.6: Quarterly VAR including the OECD year-to-year growth of overall stock prices, one-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

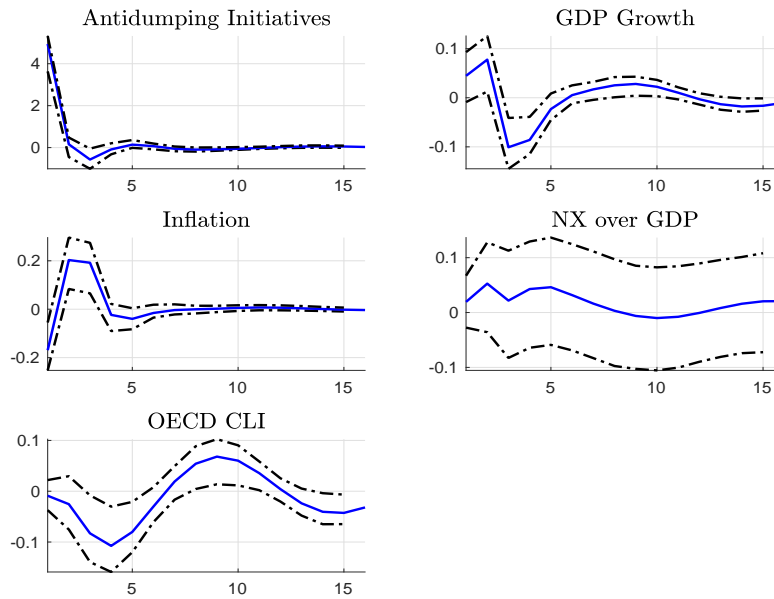


Figure A.7: Quarterly VAR including the OECD Composite Leading Indicator (CLI), one-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

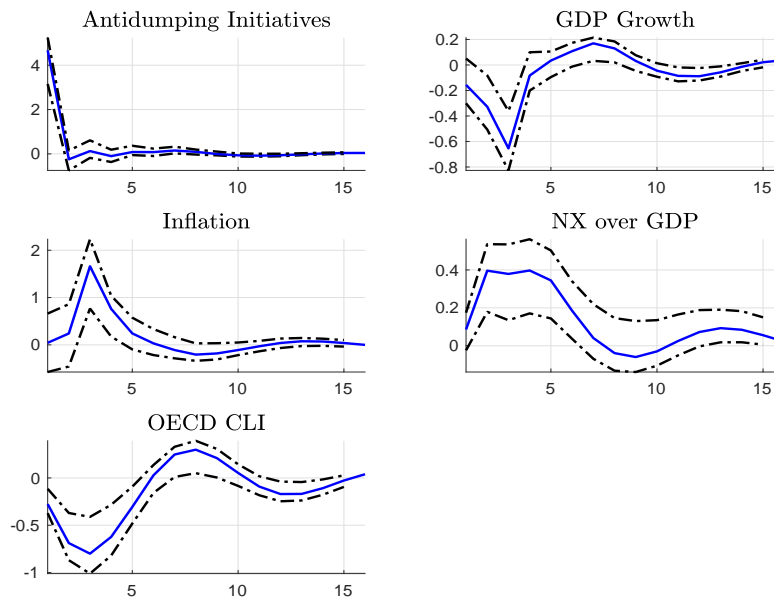


Figure A.8: Quarterly VAR including the OECD Composite Leading Indicator (CLI), one-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

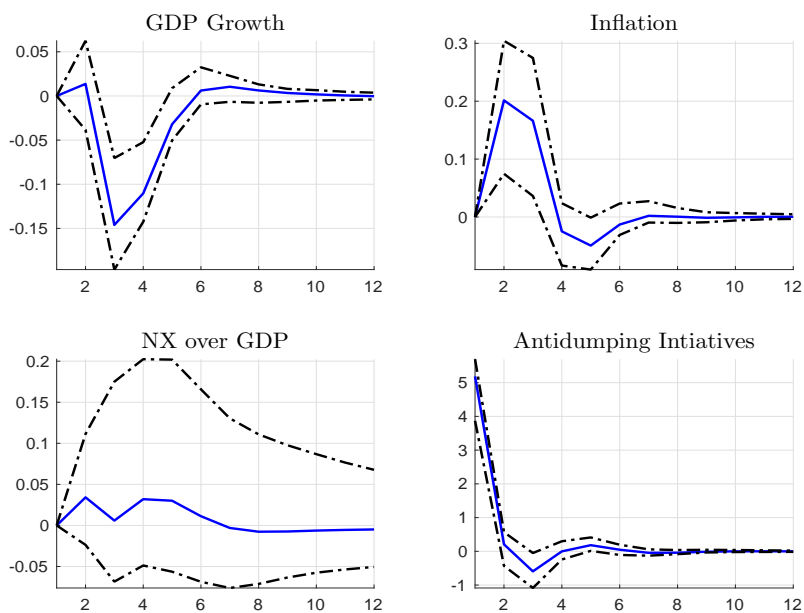


Figure A.9: Quarterly VAR, alternative recursive ordering, one-standard deviation increase in antidumping initiatives (ordered last) in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

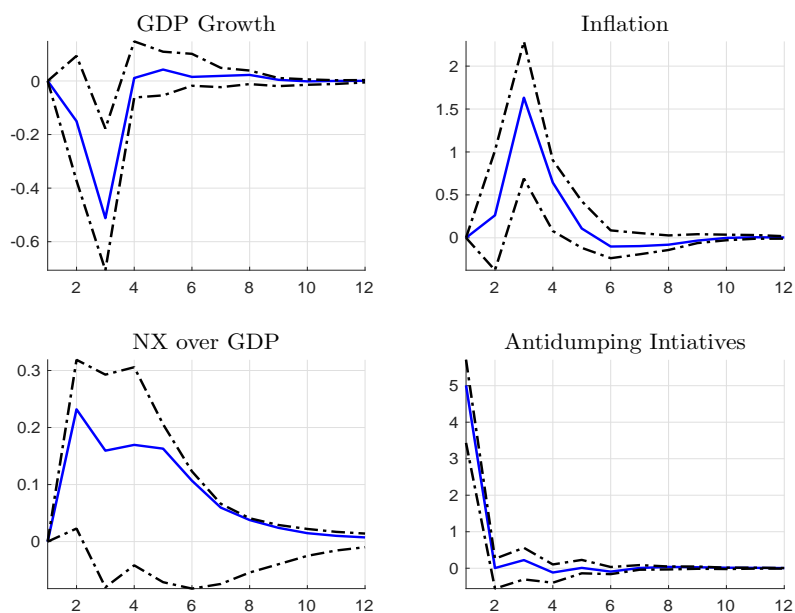


Figure A.10: Quarterly VAR, alternative recursive ordering, one-standard deviation increase in antidumping initiatives (ordered last) in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

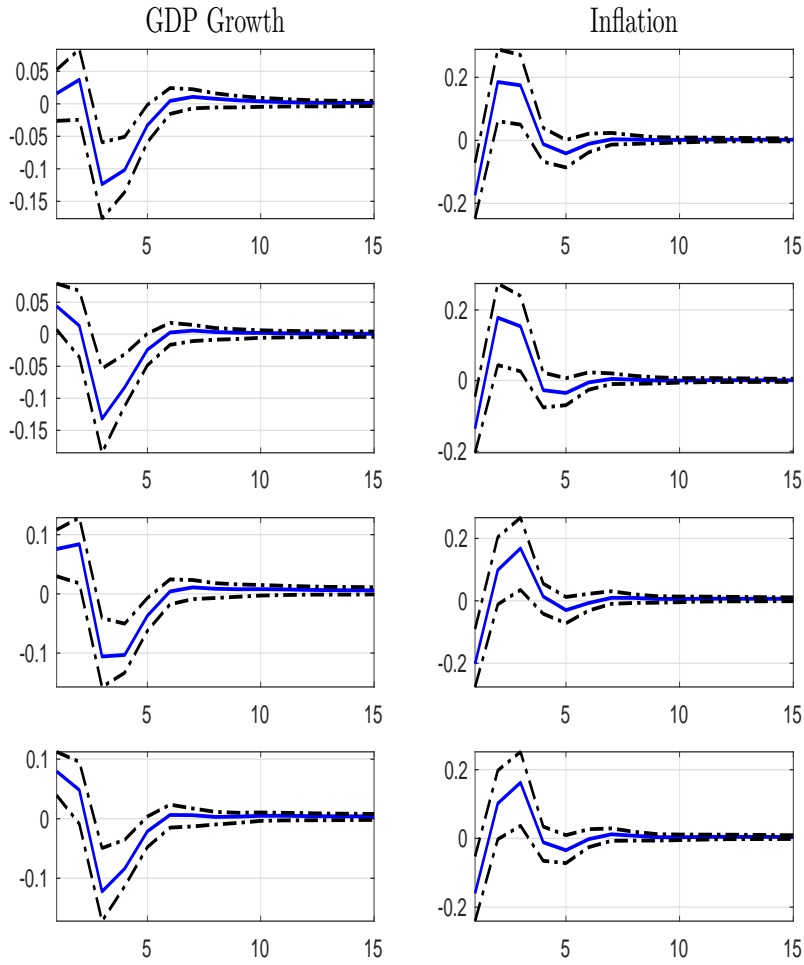


Figure A.11: Quarterly VAR, alternative trade policy measures. First panel: baseline measure; Second panel: antidumping initiatives include products recorded at 4-digits; Third panel: only initiatives that end up with the imposition of antidumping tariffs; Fourth panel: only initiatives that end up with the imposition of antidumping tariffs including products recorded at 4-digits. One-standard deviation increase in antidumping initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

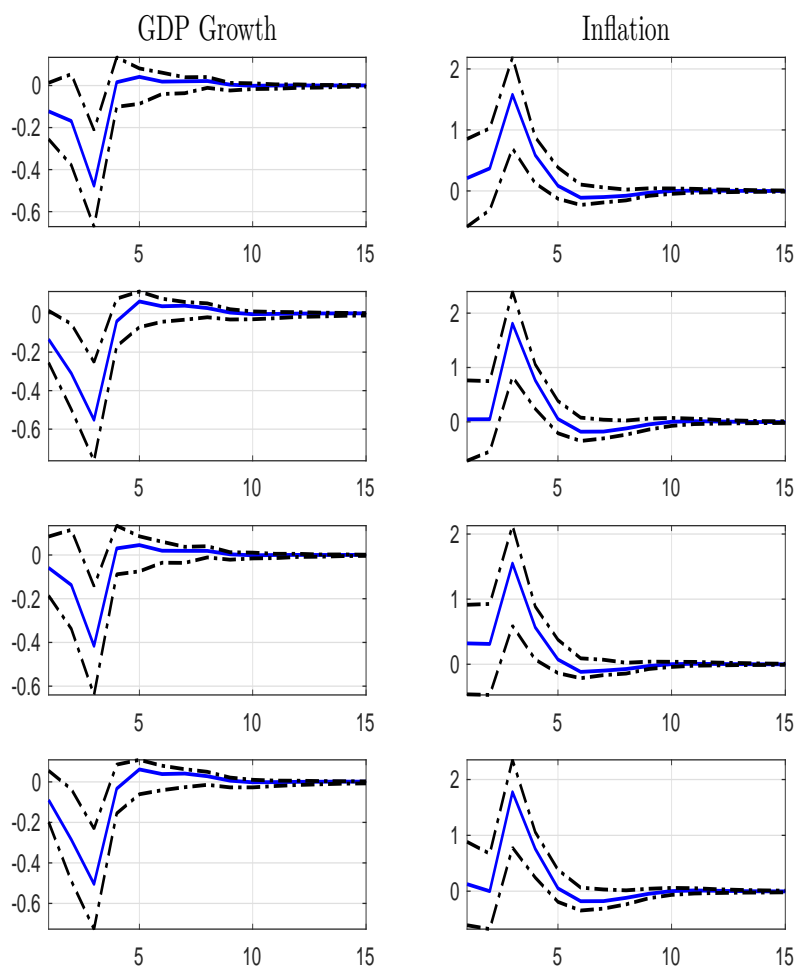


Figure A.12: Quarterly VAR, alternative trade policy measures. First panel: baseline measure; Second panel: antidumping initiatives include products recorded at 4-digits; Third panel: only initiatives that end up with the imposition of antidumping tariffs; Fourth panel: only initiatives that end up with the imposition of antidumping tariffs including products recorded at 4-digits. One-standard deviation increase in antidumping initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

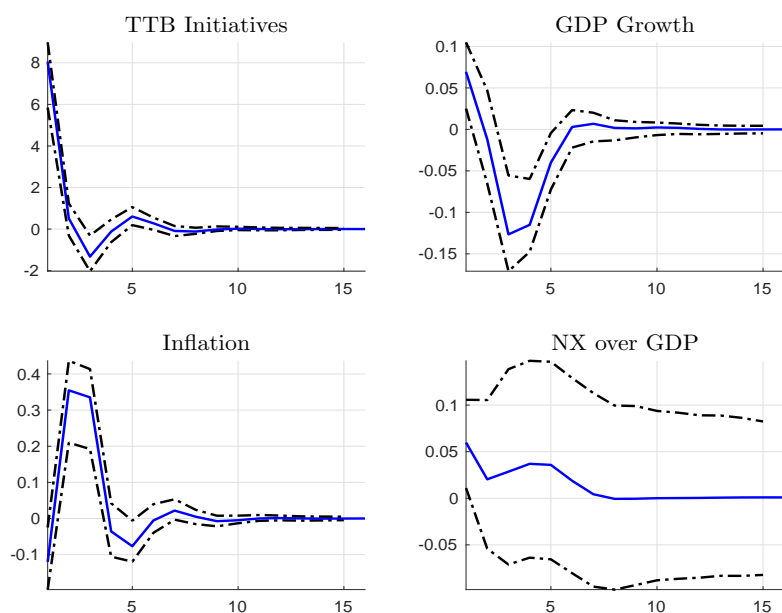


Figure A.13: Quarterly VAR, one-standard deviation increase in temporary trade barriers initiatives in Canada. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

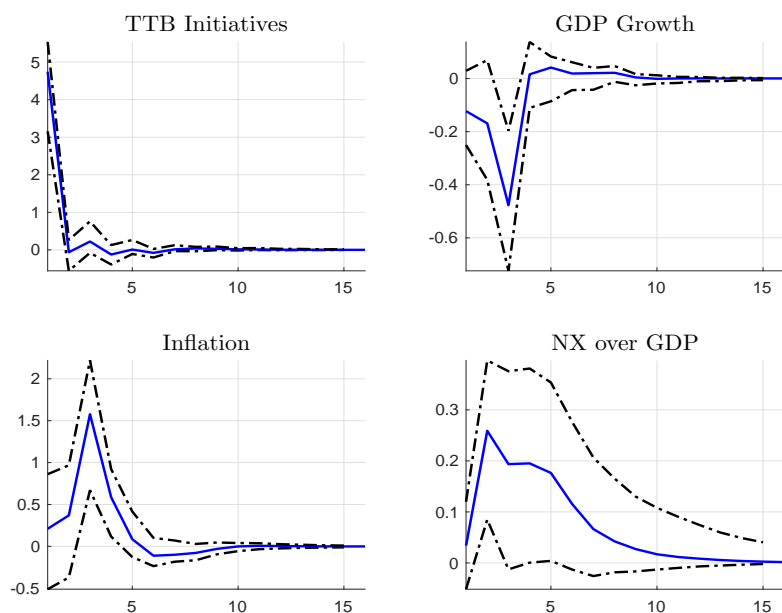


Figure A.14: Quarterly VAR, one-standard deviation increase in temporary trade barriers initiatives in Turkey. GDP growth and net exports over GDP are in percentage points. The inflation rate is annualized.

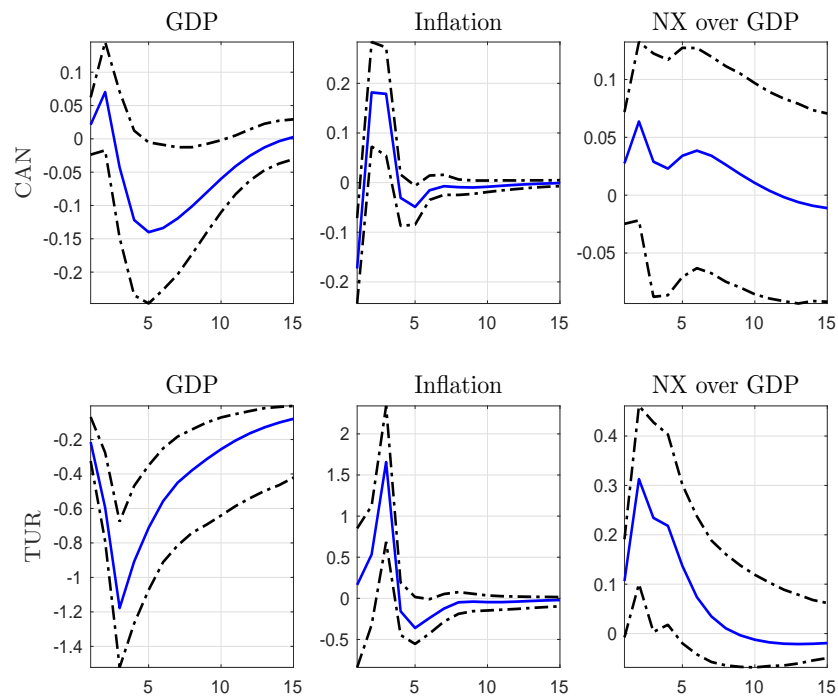


Figure A.15: Quarterly VAR, one-standard deviation increase in antidumping initiatives in Canada and Turkey. GDP and net exports over GDP are in percentage points. The inflation rate is annualized.

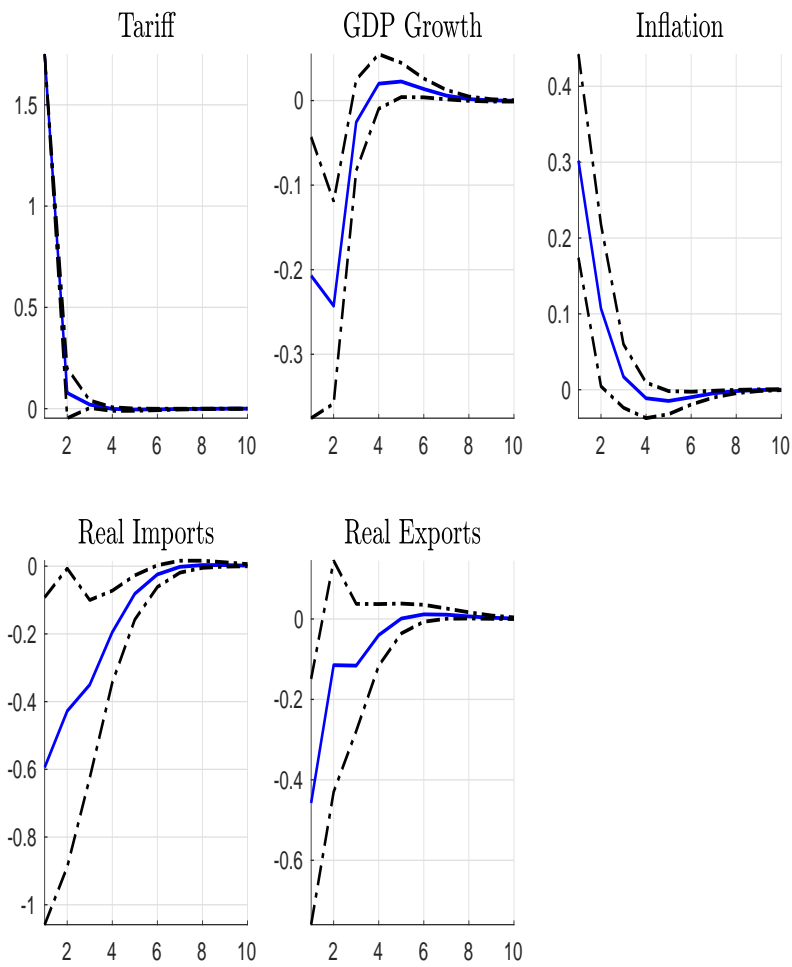


Figure A.16: Panel-VAR, impulse responses to a one-standard deviation increase in detrended tariffs. Tariffs, GDP growth, exports, and imports are in percentage points.

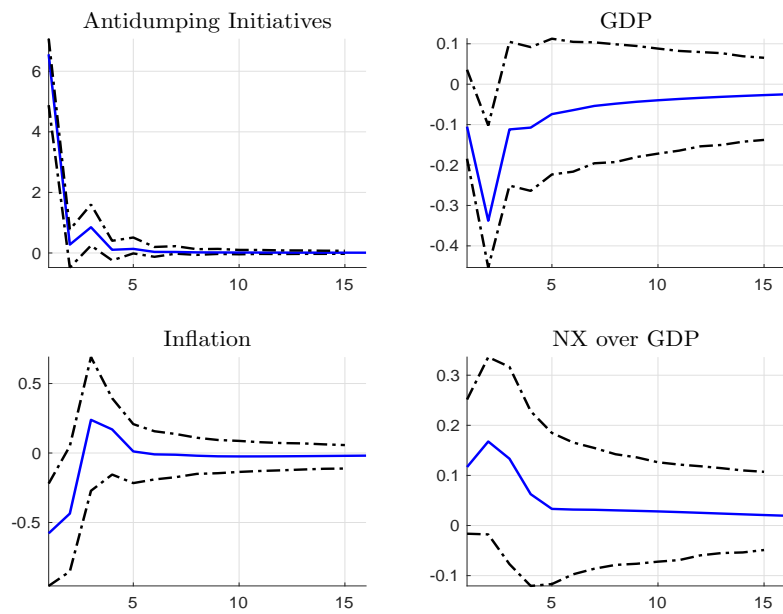


Figure A.17: Quarterly VAR, one-standard deviation increase in antidumping initiatives in India. GDP and net exports over GDP are in percentage points. The inflation rate is annualized.

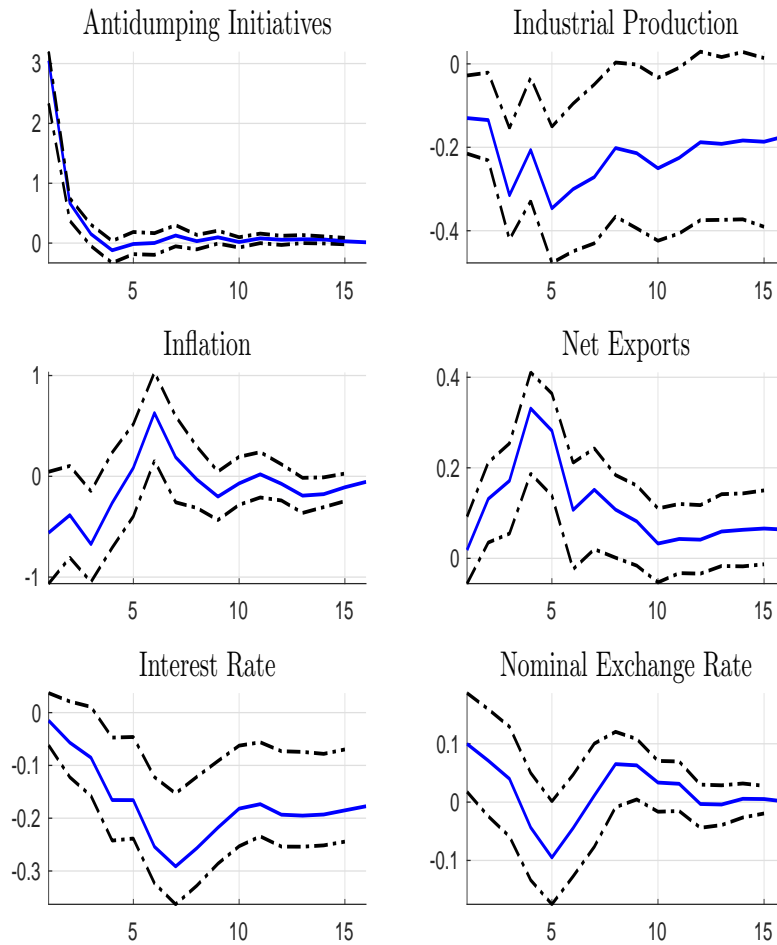


Figure A.18: Monthly VAR, one-standard deviation increase in antidumping initiatives in India. Industrial production, net exports, and nominal exchange rate are in percentage points. The inflation rate and the interest rate are annualized.

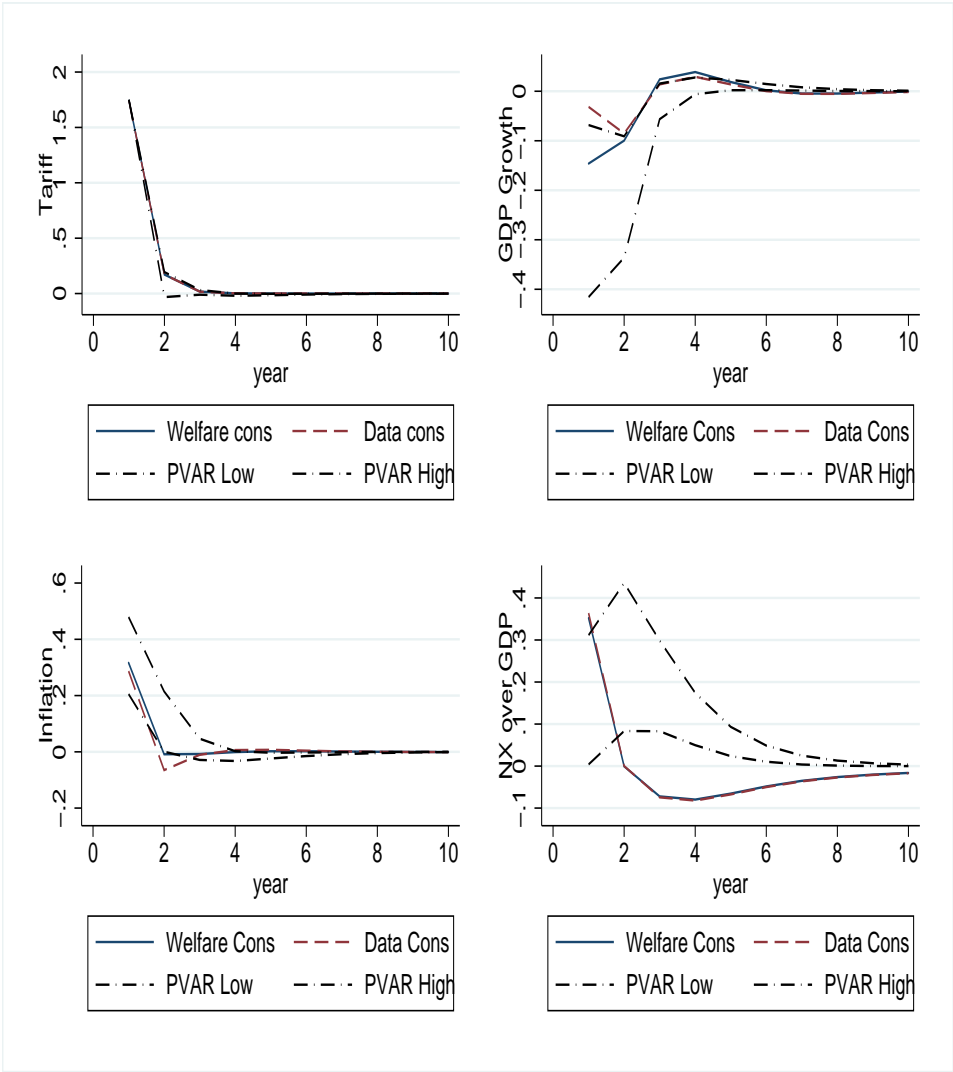


Figure A.19: Panel-VAR confidence bands (dashed lines) and annualized, model-based, impulse responses. Continuous lines plot welfare-consistent variables, while dashed lines plot data-consistent variables. The response of tariffs and net exports over GDP is not affected by the specific price deflator we consider.

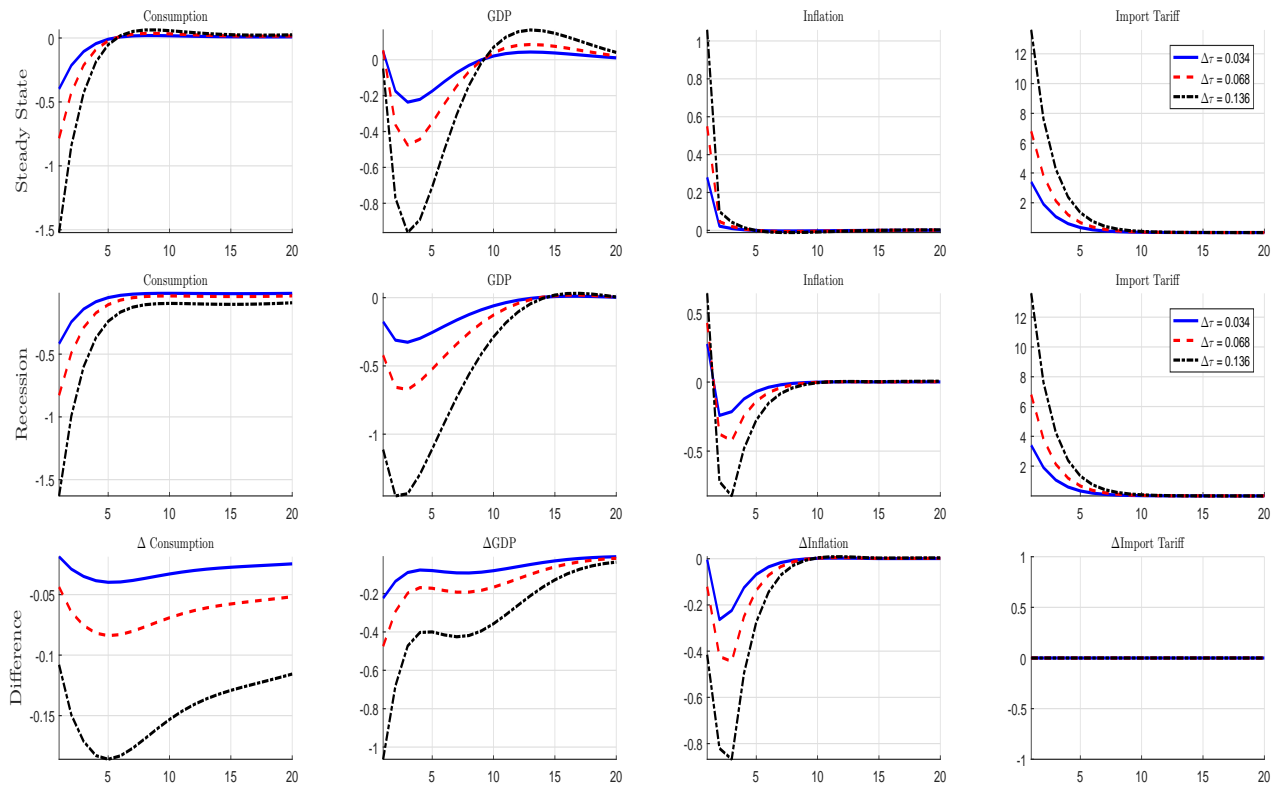


Figure A.20: Responses to a temporary increase in Home tariffs, shocks with different size (5, 10, and 15 percent) and different initial conditions: steady state (first row) and a recession with binding ZLB (second row). The third row plots the difference between the first and the second row for each variable. Responses show percentage deviations from the initial steady state. The inflation rate is annualized.

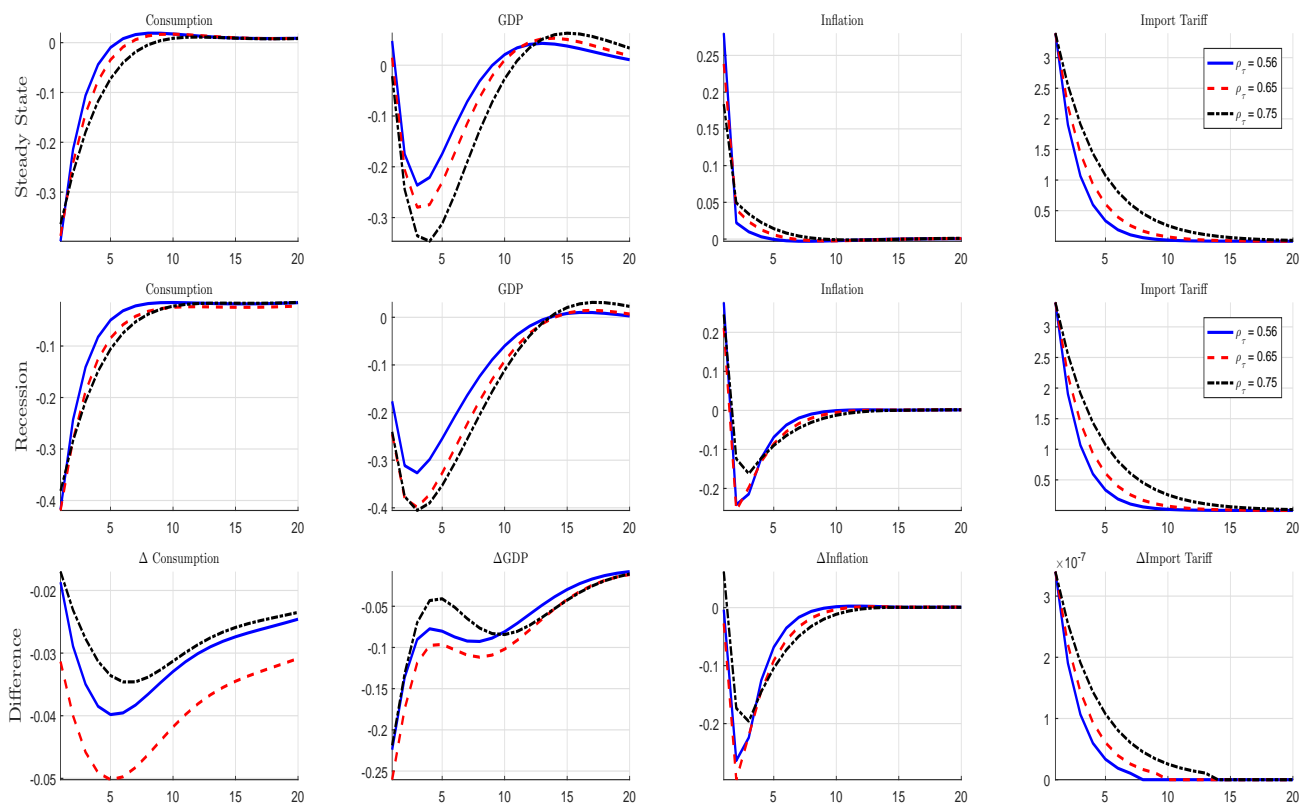


Figure A.21: Responses to a temporary increase in Home tariffs, shocks with persistence (0.56, 0.65, and 0.75) and different initial conditions: steady state (first row) and a recession with binding ZLB (second row). The third row plots the difference between the first and the second row for each variable. Responses show percentage deviations from the initial steady state. The inflation rate is annualized.

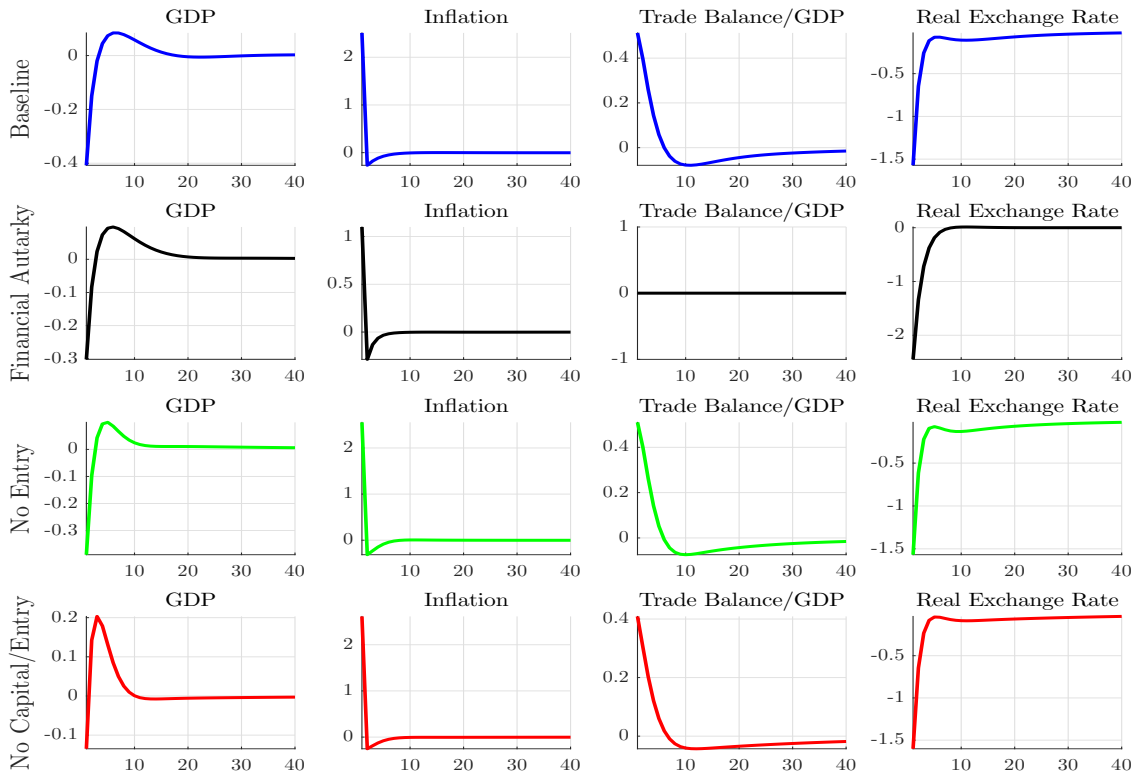


Figure A.22: Effects of a temporary increase in Home trade barriers in normal times, sticky prices (producer currency pricing). The top row: baseline model; second row: baseline model under financial autarky; third row: baseline model without firm dynamics; fourth row: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

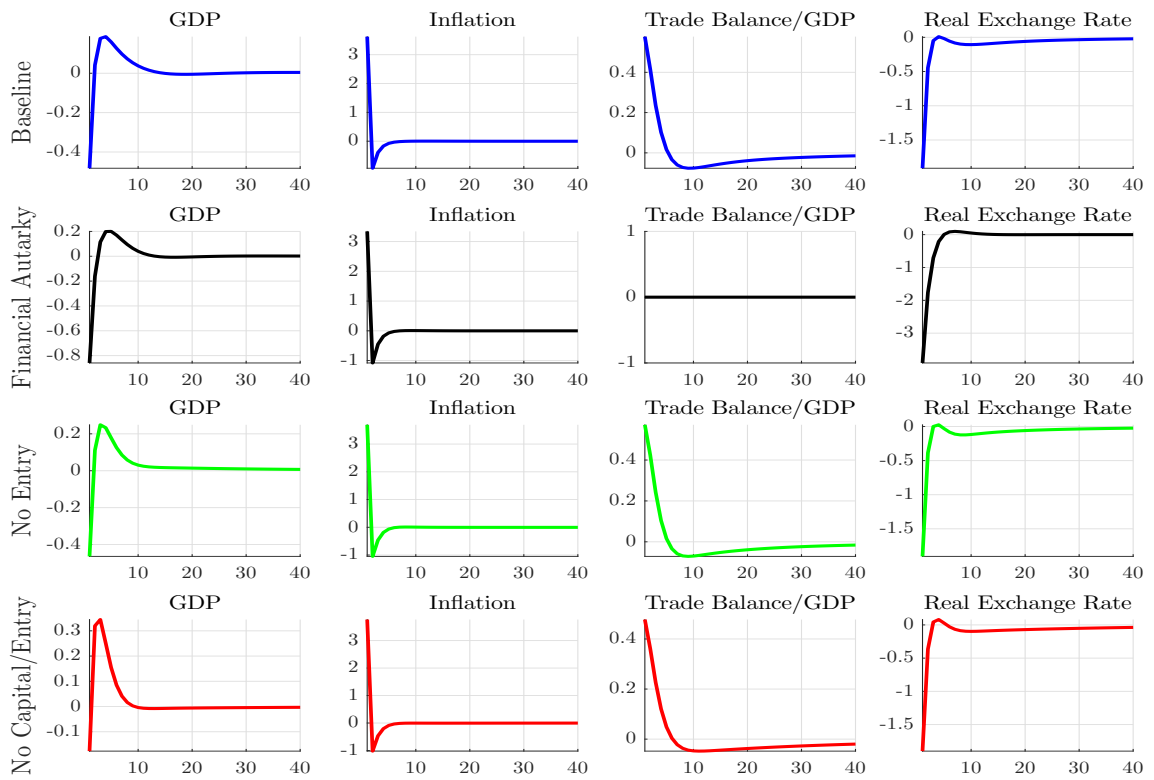


Figure A.23: Effects of a temporary increase in Home trade barriers in normal times, sticky prices (local currency pricing). The top row: baseline model; second row: baseline model under financial autarky; third row: baseline model without firm dynamics; fourth row: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

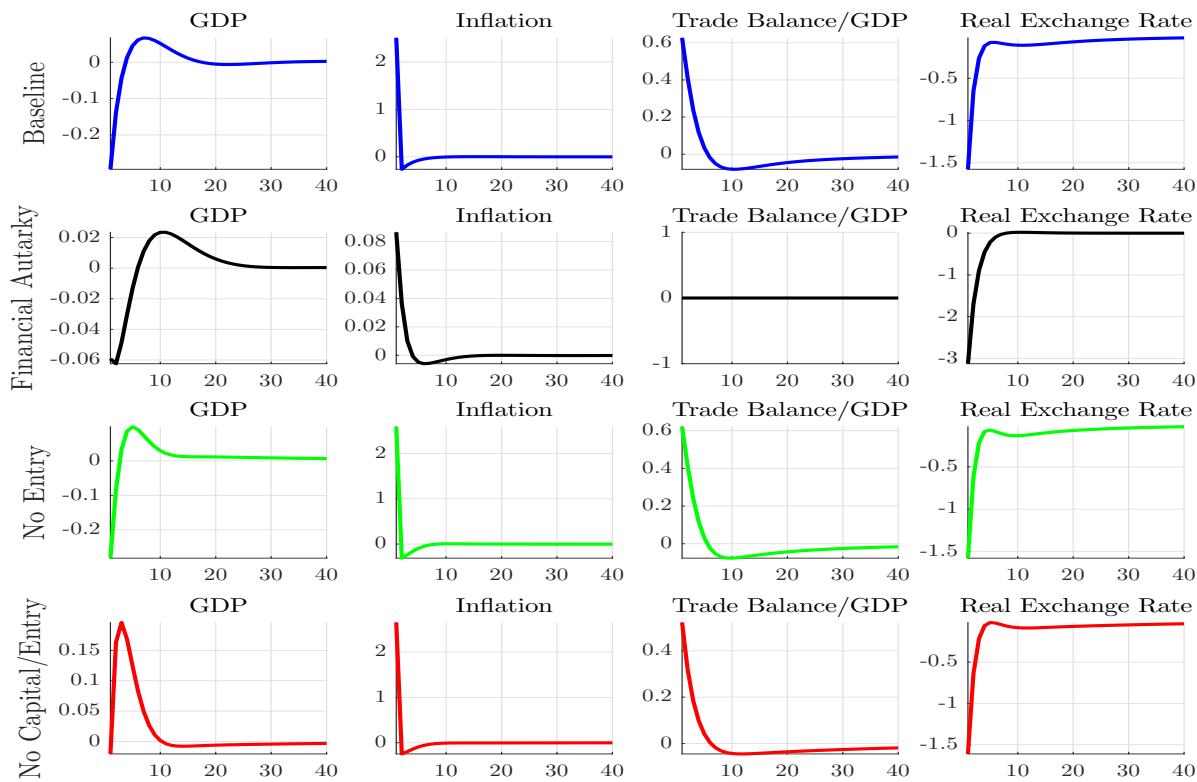


Figure A.24: Effects of a temporary increase in Home trade barriers in normal times, sticky prices (dollar currency pricing). The top row: baseline model; second row: baseline model under financial autarky; third row: baseline model without firm dynamics; fourth row: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

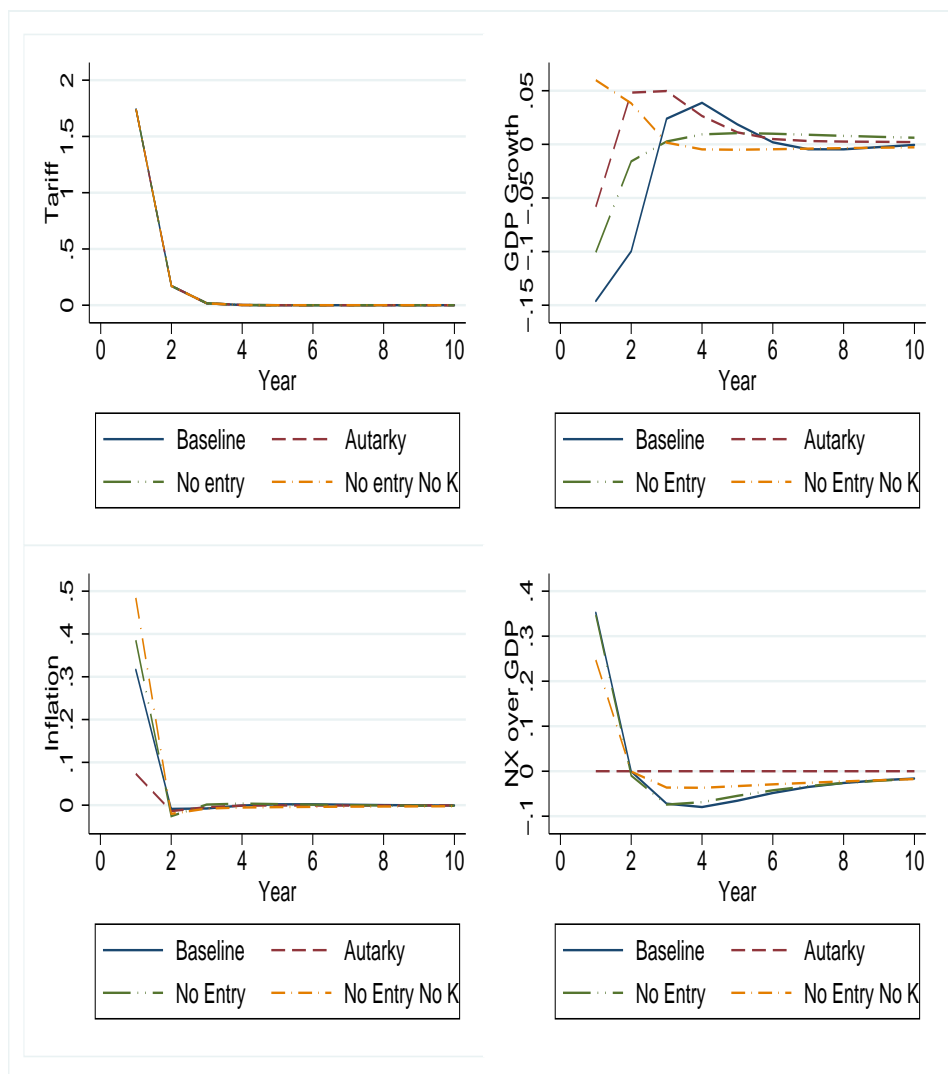


Figure A.25: Annualized responses to a temporary increase in Home tariffs in normal times. Real GDP and inflation are measured using the welfare-consistent price deflator P_t . Continuous line: baseline model; dashed lines: baseline model under financial autarky; dash-dot-dot lines: baseline model without firm dynamics; dash-dot lines: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.

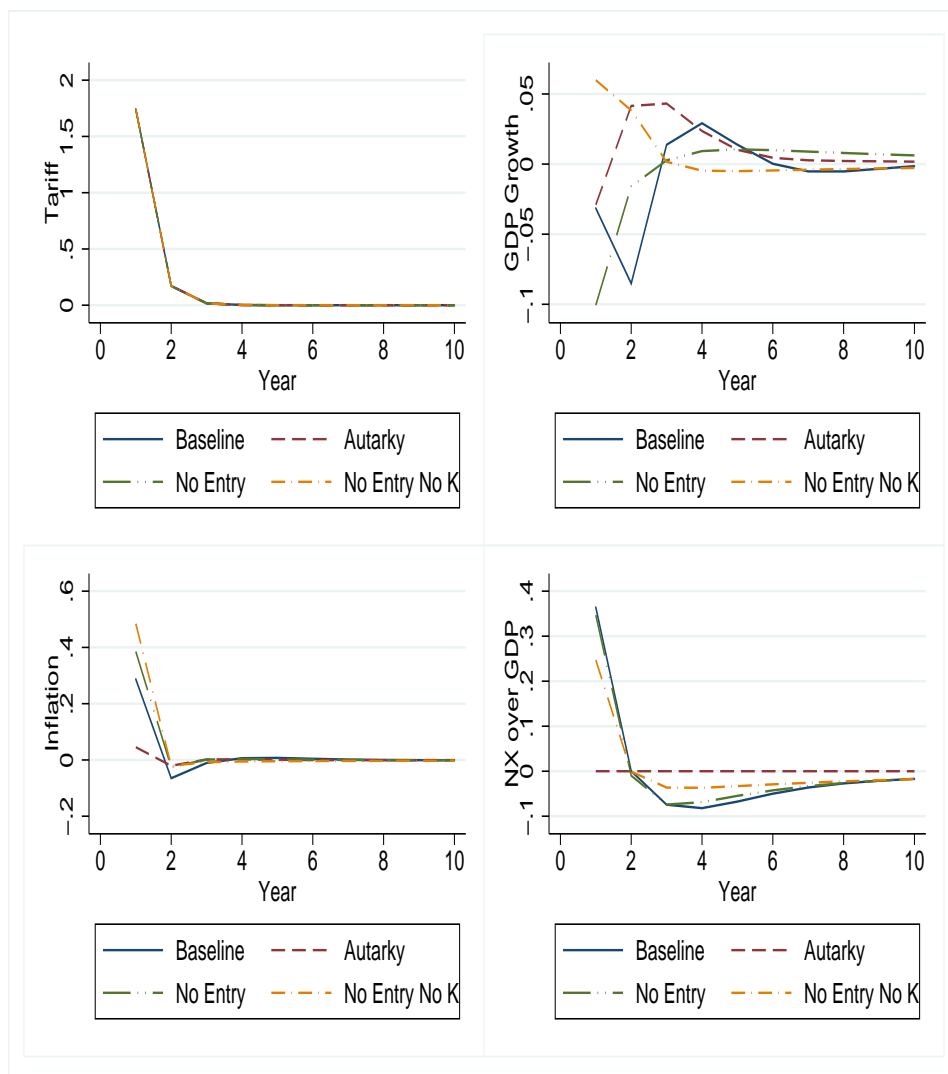


Figure A.26: Annualized responses to a temporary increase in Home tariffs in normal times. Real GDP and inflation are measured using the data-consistent price deflator \tilde{P}_t . Continuous line: baseline model; dashed lines: baseline model under financial autarky; dash-dot-dot lines: baseline model without firm dynamics; dash-dot lines: baseline model without firm dynamics and physical capital accumulation. Responses show percentage deviations from the steady state. The inflation rate is annualized.