Protectionism and Inequality*

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Abstract

This paper studies the distributional outcomes of protectionism. First, we investigate the short-run distributional effects on workers with different skill levels by estimating structural vector autoregressions (VARs) using high-frequency measures of temporary trade barriers for the United States. We then estimate a panel VAR for a sample of thirty-six countries using the applied tariff rates. Across our empirical exercises, we find robust evidence that protectionism reduces the skill premium but increases the employment ratio between high-skilled and low-skilled workers. To rationalize these findings, we build a two-country dynamic general equilibrium model featuring asymmetric search-and-matching (SAM) frictions, capital-skill complementarity (CSC) in production and producer dynamics, which successfully replicates the VAR evidence. Our counterfactual analysis highlights the interaction between asymmetric SAM and CSC in qualitatively shaping the distributional patterns of protectionism, with producer dynamics magnifying these effects quantitatively.

Keywords: Protectionism, Skill premium, Employment ratio, Search and matching, Capital-skill complementarity, Producer dynamics

JEL Codes: E24, F13, F16, F41, J31, J63

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1 Introduction

Over the past few years, the world has been hit with large disruptions in international trade, with Brexit and the US-China trade war brutally shaking the firm ground of the globalization process. The Covid-19 pandemic adds further momentum to protectionism on the rise, as it provides a new rationale for increasing trade barriers.[1] With the White House and the European Parliament moving up protectionism to key priorities, two questions that remain crucial for policymakers, yet barely discussed by the burgeoning literature on the macroeconomic effects of protectionism,[2] are: first, what are the distributional effects of protectionist trade policies in terms of wages and employment across heterogeneous workers? Second, what are the economic channels, if any, through which protectionism affects the dynamic adjustment of the distributional outcomes? In this paper, we try to answer these questions. In particular, we empirically and theoretically investigate the short-run effects of temporary trade barriers (TTBs) on the relative wage between high-skilled and low-skilled workers (i.e. skill premium) and their employment ratio.

We start by estimating structural vector autoregressions (VARs) using high-frequency measures of TTBs for the United States. We construct monthly and quarterly measures of TTBs as the number of HS-6 products for which an antidumping investigation begins in a given month (or quarter) following Bown and Crowley (2013) and Barattieri et al. (2021). In addition, we estimate an annual panel VAR for a sample of thirty-six countries using the applied tariff rates. Across our empirical exercises, we find robust evidence that protectionism reduces the skill premium but increases the employment ratio in the short run. This implies that protectionism temporarily alleviates wage inequality but worsens the employment opportunities relatively more for the low-skilled workers.

In the second part of our paper, we develop a theoretical model to rationalize these

[1]See, for example, Mansfield and Solodoch (2022) on a discussion about the Covid-19 pandemic and protectionist sentiments in America. Other discussions on the protectionist sentiments brought by Covid-induced disruptions to Global Value Chains include Baldwin and Tomiura (2020), and Irwin (2020).

[2]See, for example, Furceri et al. (2020), Barattieri et al. (2021), Bown et al. (2021), Imura (2022) and Barattieri and Cacciatore (2023) for the recent literature on the macroeconomic effects of protectionism.

findings and dissect the underlying mechanisms. Our model incorporates the features of asymmetric search-and-matching (SAM) frictions of high-skilled versus low-skilled workers and capital-skill complementarity (CSC) in production in a two-country dynamic general equilibrium framework with endogenous producer entry and selection into export markets. The choice of our framework is motivated by the findings in Dolado et al. (2021) and Barattieri et al. (2021). Using a closed economy new Keynesian DSGE model, Dolado et al. (2021) show that the interaction of asymmetric SAM, which is manifested by asymmetric separation rates, bargaining power and matching efficiency across the two groups of labor, and CSC plays a key role in determining the responses of the skill premium and the employment ratio following monetary policy shocks. They also show that the importance of these two model ingredients in explaining distributional patterns applies more generally to any shocks that generate changes in the aggregate demand pressure. Barattieri et al. (2021) build a small open economy version of Ghironi and Melitz (2005)'s model with nominal rigidity and demonstrate that protectionism tends to generate downward aggregate demand pressure, and producer dynamics play an essential role in affecting the magnitude of the changes. The theoretical results from these two papers motivate us to combine asymmetric SAM, CSC and producer dynamics in a two-country dynamic equilibrium framework to study the effects of protectionism on the labor market inequality. Our model also builds on the framework developed by Cacciatore (2014), which incorporates SAM frictions into Ghironi and Melitz (2005)'s model to study how labor market frictions affect the aggregate effects of trade integration. In contrast to our model, it abstracts from CSC in production and heterogeneous workers, which are important elements of our model that aims to provide insights into labor market inequality in response to protectionist trade policy shocks.

Our calibrated model successfully replicate the responses of the skill premium and the employment ratio to a temporary increase in trade barriers as identified by our empirical exercises while also predicting other macroeconomic effects, which reflects a downward aggregate demand pressure, that are broadly consistent with the empirical evidence provided by Barattieri et al. (2021).

To dissect the underlying economic mechanisms that shape the distributional outcomes, we follow the methodology adopted by Dolado et al. (2021) and decompose the wage bargaining equation into five channels through which the trade shock drives the dynamics of the skill premium. We then compute the contribution of each of these channels to the skill premium under different scenarios and parameterizations in addition to the benchmark calibration.

Our counterfactual analysis shows that the asymmetry of SAM and CSC play key roles in qualitatively shaping the distributional patterns. More specifically, when we remove the asymmetry of SAM or reduce the strength of CSC, we find significant changes to the contributions of some channels which lead to sharply contrasting dynamics of the skill premium in comparison with the benchmark results.

In particular, removing the asymmetry of SAM eliminates the negative contribution to the skill premium driven by the downward aggregate demand pressure. Under symmetric SAM, which implies symmetric bargaining power, the downward demand pressure translates into equal negative contribution to the wages for the high-skilled and low-skilled labor, thus leaving no effect on the skill premium. In contrast, under asymmetric SAM, larger bargaining power of the skilled labor indicates that a larger fraction of their wages is tied to the marginal revenue product of labor, which further implies that their wages will take a larger hit when there is downward demand pressure, thus leading to a large decline of the skill premium.

Lowering the strength of CSC leads to a counterfactual increase in the skill premium through positive contributions from the labor market tightness channel and the marginal product of labor channel. For the first channel, when firms reduce vacancy posting under downward aggregate demand pressure triggered by the trade barriers shock, labor market tightness drops and it worsens the outside options, which tends to reduce the wages for both types of labor. The effects on the skill premium thus hinges on the relative strength of these two wage reduction forces, which is tied to the relative steady-state labor market tightness. With less complementarity between high-skilled labor and capital, it reduces the steady-state marginal product of labor of the high-skilled relative to the low-skilled labor, thus relatively reducing the marginal benefit of creating high-skilled job vacancies. This in turn decreases the relative steady-state labor market tightness and thus reducing the relative strength of the wage reduction force for the high-skilled labor, which then results in a positive contribution to the skill premium through the labor market tightness channel.

In terms of the marginal product of labor channel, as mentioned, lower CSC implies that the drop of labor market tightness hurts the high-skilled workers less, so they are less willing to accept lower wage and thus tend to reduce their labor supply. This results in a larger drop in the average high-skilled employment, and it in turn drives up the change in the ratio of the marginal product of labor between the two types of labor and leads to a positive contribution to the skill premium through the marginal product of labor channel. This, together with the positive contribution from the labor market tightness channel, implies a counterfactual increase of the skill premium under lower CSC.

Meanwhile, lower CSC also implies a counterfactual decline in the employment ratio. This is mainly because the larger drop in the average high-skilled employment driven by weaker high-skilled labor supply under lower CSC translates into a larger decrease in the aggregate high-skilled employment, which further results in the counterfactual decline in the employment ratio.

Lastly, we compare the distributional outcomes with and without producer dynamics, and find that producer dynamics magnify the impact responses of the skill premium and the employment ratio shaped by the asymmetric SAM and CSC. Turning off the producer dynamics attenuates the downward aggregate demand pressure; no endogenous selection into export dampens the micro-level reallocation of market shares toward the less-efficient firms by eliminating the extensive margin of adjustments, and the absence of endogenous entry implies the reduction in real income no longer translates in a reduction of investment in firm creation.

Policy-wise, an important implication of our paper is that protectionism does not have the effects of lowering both the wage gap and employment gap as claimed by policy makers. Our results suggest that protectionism helps with wage inequality but worsens employment inequality between high- and low-skilled workers.

Related Literature Our paper is closely related to the burgeoning literature which studies the macroeconomic effects of protectionism; see, for example, Herrendorf and Teixeira (2005), Durling and Prusa (2006), Bown and Crowley (2007), Vandenbussche and Zanardi (2010), Lu et al. (2013), Bond et al. (2013), and more recently Barattieri et al. (2021), Bown et al. (2021)), Imura (2022), Barattieri and Cacciatore (2023). While most papers along this line of research study the aggregate effect, very few has been devoted to the distributional outcomes. One exception is Furceri et al. (2020). Exploiting an annual unbalanced panel of 151 countries covering 1963 through 2014, the authors find tariff increases lead to a short-run increase in inequality, as measured by the Gini coefficient. Compared with their paper, we focus on the inequality across workers with different skill levels, and, to the best of our knowledge, this is the first paper to bring direct evidence on the effects of temporary trade barriers on the skill premium and the employment ratio between high-skilled and low-skilled workers. Moreover, we develop a two-country dynamic general equilibrium model to dissect the underlying mechanisms which drive the distributional patterns. Our analysis thus add new insights that complement this line of literature.

Another strand of literature studies the 2018-2019 trade war, for which Fajgelbaum and Khandelwal (2022) provide a comprehensive review. Among these papers, there are several that study distributional issues. Waugh (2019) examines the consumption patterns across US counties. The author finds that relative to a county in the lower quartile of the retaliatory tariff distribution, a county in the upper quartile experiences a 3.8 percentage point decline in automobile sales which serves as a proxy for consumption expenditures. Fajgelbaum et al. (2020) embed their estimated trade elasticities in a general-equilibrium model of the U.S. economy to simulate real wage changes across counties. They find a large standard deviation of real wages in the tradeable sectors across counties of 0.5% which reflects specialization patterns, relative to an average decline of 1.0%. Caliendo and Parro (2021) simulate the distributional effects across US states in a framework that incorporates mobility frictions, and find that losses in real income range from about 0.1% to 0.2% across states. Weighing against this line of literature, our paper differs along three main dimensions. First, we use a different approach to deal with protectionism's endogeneity, exploiting monthly and quarterly data to identify TTB shocks. Second, instead of focusing on a specific event-2018-2019 trade war, we use almost 40 years of data in the monthly structural VAR estimation, and a sample of 36 countries over 15 years in the panel VAR exploiting TTB variation across both time and countries. Third, we focus on the distributional issues across workers with different skill levels.

There is a large literature invetigating the long-run effects of trade on the skill premium. Early works studying this issue usually employ the classic Heckscher-Ohlin (HO) trade model (Goldberg and Pavcnik (2007)). Although the HO model would make similar qualitative predictions of the effect of trade barriers on the skill premium for skill abundant countries as our model,[3] we do not think this is the relevant mechanism to explain the effects of temporary trade barriers as identified in our empirical study. There are two reasons for this. First, as pointed out by Leamer (1996), the HO model operates over a time period that is long enough to allow complete detachment of workers and capitals from their original sectors. However, the effects of temporary trade barriers being studies in this paper become significant on the skill premium shortly after they are imposed,[4] leaving no time for such mechanism to take effect. By contrast, as alluded earlier, the main elements in our model (asymmetric SAM and CSC) have been shown to have significant distributional implications at the business cycle frequency (Dolado et al. (2021)). Second, the HO model is set up under full employment conditions, thus would predict no changes in the employment ratios, which

[3]The Heckscher-Ohlin model predicts that trade would increase skill premium in the skill abundant countries, like the US. Thus, through the same channels, barriers to trade would decrease skill premium in those countries.

[4]As the results of the Monthly VAR in Section 2.1.2 show, the peak of the IRF of the skill premium is reached well within a year.

is inconsistent with our empirical finding.

Recent studies have explored other mechanisms in which international trade may affect inequality (e.g. Acemoglu (2003); Thoenig and Verdier (2003); Yeaple (2005); Matsuyama (2007); Monte (2011); Parro (2013); Burstein et al. (2013); Turnovsky and Wang (2022)). Several theoretical papers along these lines, to which our approach is more closely related, investigate the effects of international trade on the wage distribution and unemployment patterns in the presence of labor market search and matching frictions (e.g. Helpman et al. (2010); Helpman et al. (2016); Coşar et al. (2016)). While most of these papers only study the long-run effects of trade, we complement this line of literature by focusing on the short-run dynamic effects of temporary trade barriers and demonstrating how the asymmetry of search and matching frictions between high- and low-skilled workers, together with its interaction with capital-skill complementarity, generate the dynamics of skill premium and employment ratios consistent with the empirical findings.

2 Empirical analysis

In this section, we estimate the labor market effects of trade shocks by applying structural VARs. First, we use monthly and quarterly measures of temporary trade barriers for the U.S.. Second, we look at annual tariffs for a panel of thirty-six countries.

Following Bown and Crowley (2013) and Barattieri et al. (2021), our baseline measure of trade policy corresponds to the number of HS-6 products for which an antidumping investigation begins in a given month (or quarter). Our time series data is constructed by matching the initiation dates of each antidumping case recorded in the GAD database to the number of HS-6 products involved in each investigation. Figure 1 shows the number of quarterly new antidumping initiatives, which exhibits substantial variation over time. Please see the appendix for a full description of data.

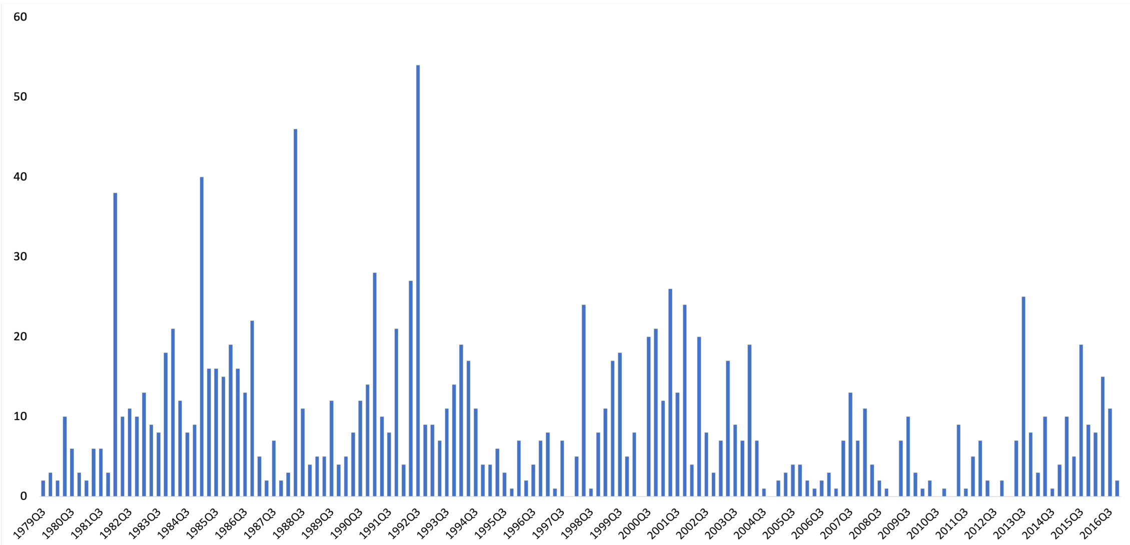

Figure 1: Antidumping initiatives

2.1 Temporary trade barriers shock

2.1.1 Empirical strategy

We estimate the following structural VAR equation

$$Y_t = \Theta + \sum_{i=1}^{p} \Phi_i Y_{t-i} + Au_t,$$

where Y_t is a vector that includes trade cost measures and labor market variables including skill premium and employment ratio of high-skilled to low-skilled workers; u_t is a vector of structural innovations that satisfy the condition of $E(u_t u_t') = I_N$; and A is a matrix that links structural and reduced-form innovations.

We use monthly data covering the period May 1979- December 2016 in our baseline specification. Quarterly data is also examined. In the spirit of a majority of research in the field, high-skilled and low-skilled are classified according to whether they have experiences of some college or not. We rely on Dolado et al. (2021) for data of hourly wage and employment, with time series of wage gap and employment ratio being extracted from the NBER extracts of the Current Population Survey (CPS) Merged Outgoing Rotation Groups. The sample includes individuals in working age 15–64 and excluding part-time workers, self-employed workers, and military employees. Wages are computed as the ratio of weekly wages and the number of weekly hours worked in each skill category, whereas employment is calculated as number of hours of work per employee per month, multiplied by the number of workers in each skill group.[5] As pointed out by Dolado et al. (2021), the wage and employment series from the CPS micro data, albeit seasonally adjusted, exhibits too much volatility at the monthly frequency. Thus, we follow their practice in using a backward-five-month moving average, which also turns out to be in line with our optimal choice of lag length in the VAR.

As in Barattieri et al. (2021), the causal effects of TTB shocks are identified by exploiting the contemporaneous exogeneity of antidumping investigations with respect to macroeconomic and labor market variables. The assumption here is that changes in antidumping initiatives do not respond to shocks in labor and macroeconomic variables within a month. Such assumption reflects the decision lags in the opening of the antidumping investigation. First, industry producers are required to file a petition. As described in Barattieri and Cacciatore (2023), producers' petitions must gather evidence about dumped imports, and each petition must represent at least 25 percent of the product's domestic total production. Then a preliminary assessment of compliance by the United States International Trade Commission (USITC) must be conducted before the antidumping investigation is opened, which induces additional time lags. Due to the fact that the opening of an investigation is immediately announced to the public, we focus on the initiations of antidumping investigations rather than their outcomes to avoid possible anticipatory effects. As in Barattieri et al. (2021), this allows us to impose short-run restrictions, computed with a Cholesky decomposition of the reduced-form residuals' covariance matrix where trade shock is ordered first.

Our benchmark SVAR consists of 7 variables: the number of antidumping initiatives, the skill premium, high-to-low skilled employment ratio, the real wage of high-skilled workers,

[5]Unfortunately, we do not have wage and employment data of workers with different skill levels for each specific HS 2-digit level industry to match with the anti-dumping initiatives data. Thus, we cannot further provide industry-level evidence in this paper.

the employment of high-skilled workers, real net exports, and the real exchange rate. It is worth noting that with the inclusion of high-skilled wage and employment in addition to the skill premium and the employment ratio, we are also able to infer the responses of wages and employment of low-skilled workers. The combination of AIC, HQ, and BIC results leads us to include five lags of each variable in the VAR. [6]

2.1.2 Benchmark results

Figure 2 displays the point estimates and 68 (darker bands) and 90 (lighter bands) percent confidence intervals for the impulse responses of the baseline SVAR model to a one-standard deviation shock to antidumping initiatives. The shock implies the average number of antidumping initiatives more than quadruples (roughly a 350% increase). Net exports fall and the exchange rate appreciates.[7]

Regarding the labor market variables, the employment ratio increases after the shock and remains persistently above trend whereas the skill premium falls shortly after the time of the shock and remains below trend. At the peaks of the IRFs, the employment ratio increases by about 0.2 percentage points while the skill premium lowers by around 0.1 percentage points. High-skilled employment decreases substantially on impact and continues to exhibit the below-trend pattern over time, while the point estimate of the high-skilled wage experiences initial decline though not statistically significant. Combining the results on the employment ratio and the level of high-skilled employment, we can further infer that low-skilled employment also decreases, which is consistent with the aggregate negative employment effects for downstream industries found by Barattieri and Cacciatore (2023) and Bown et al. (2021). To address the concern that TTBs to imports from China might be driving the results, we

[6] Setting lag equal to four and six give us lower AIC and HQ. However, a lag of five gives us the lowest BIC. Since the VAR results using either lag 4 or lag 5 generate virtually the same patterns, we decide to go with the lag of five.

[7] The data on the real exchange rate from the FRED is the Real Narrow Effective Exchange Rate for United States. To be consistent with the definition of real exchange rate in our model, we take our RER data to be the the inverse of that series. Therefore, as in line with the standard interpretation of the real exchange rate, a decrease in the value of the real exchange rate is an appreciation of the real exchange rate.

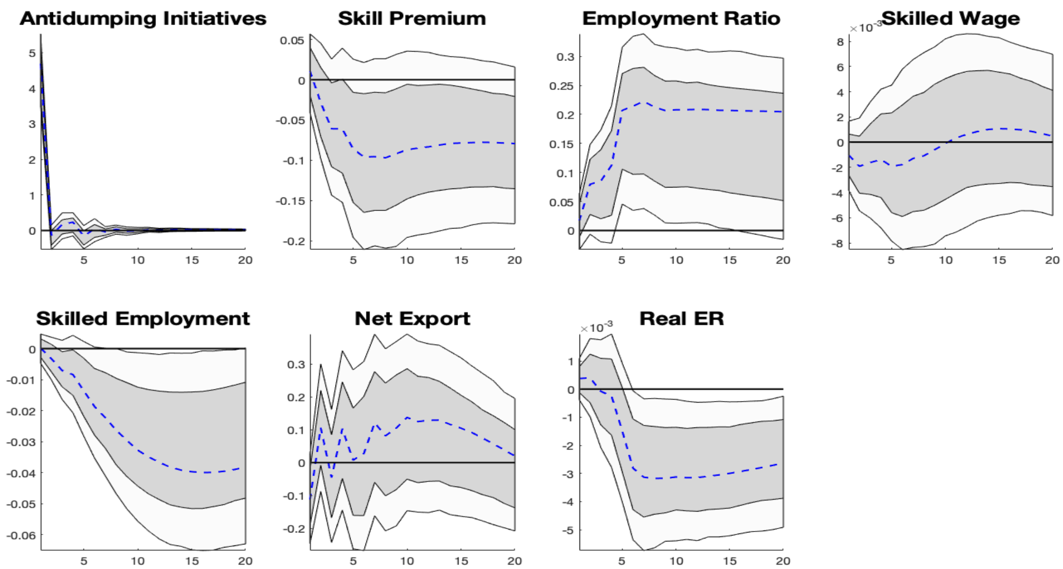

Figure 2: Monthly VAR. One-standard deviation increase in antidumping initiatives in the U.S..

performed our VAR analysis on countries that are under U.S. antidumping investigation initiatives excluding China, which shows very similar results to our benchmark. More details are relegated to Appendix B. Overall, the evidence of the relationship between increased trade tension and labor market inequality is mixed: higher temporary trade barriers help to alleviate wage inequality but worsen the employment opportunities relatively more for the low-skilled workers. To the extent that protectionist policies usually aim to protect low-wage workers' employment, the finding of low-skilled workers' employment actually being more adversely affected relative to the high-skilled could have important policy implications.

2.1.3 Quarterly data: specification and results

In our VAR specification using quarterly data from 1992Q1 to 2016Q4, we include only the number of antidumping initiatives, skill premium, employment ratio and firm entry due to the smaller number of observations. Two lags of each variable are considered. Figure 3 shows that the labor market results are consistent with the monthly estimates – skill premium declines whereas the high-to-low-skilled employment ratio displays a persistent

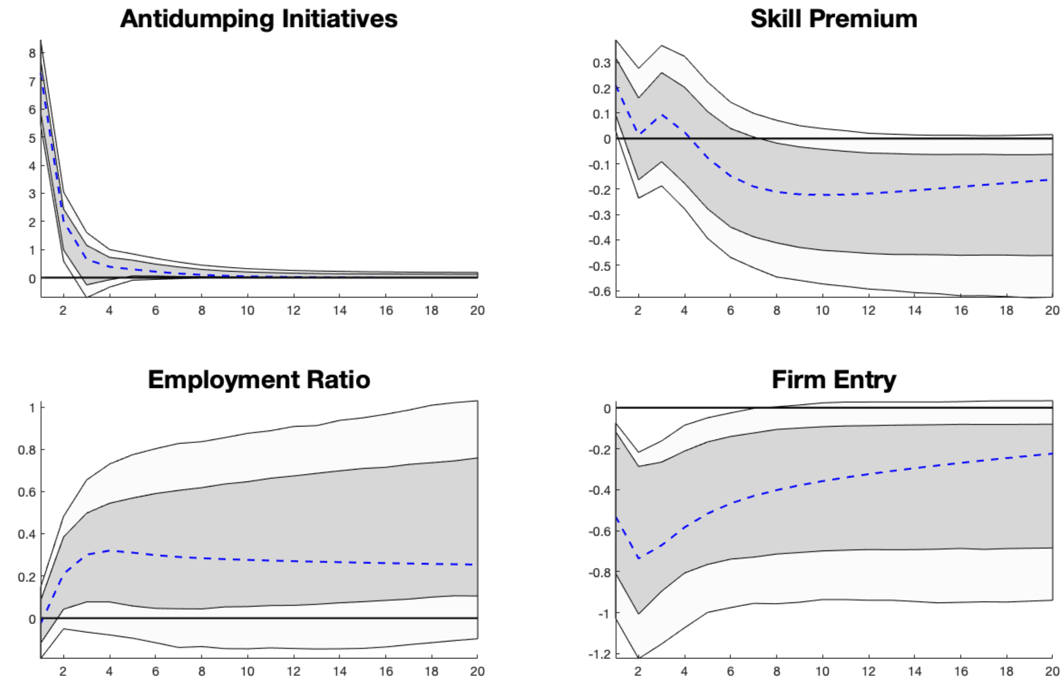

Figure 3: Quarterly VAR. One-standard deviation increase in antidumping initiatives in the U.S..

increase shortly after the TTB shock. Meanwhile, there is a significant and substantial decline in firm entry, which partially reflects the transmission channels highlighted by the model in Section 5.

2.2 Annual tariff data

Although a large majority of antidumping initiatives end up with tariffs, they only cover a subset of imports. To account for a more comprehensive range of products that are subject to trade policy shocks, we also consider the import-weighted average of the applied tariff rate as an alternative measure of trade policy, which is only available at annual frequency, and estimate a panel VAR for a sample of thirty-six countries over the period 1995-2009.[8]

[8]Weighted mean applied tariff is the average of effectively applied rates weighted by the product import shares corresponding to each partner country. Data are classified using HS-6 or HS-8. Effectively applied tariff rates at the 6- and 8-digit product level are averaged for products in each commodity group. This rate includes preferential tariff when it exists and is normally lower than the MFN Tariff. When the effectively applied rate is unavailable, the MFN rate is used instead. Import weights were calculated using the UN

To have as many data points as possible, we include all the countries and the largest time window that we have data availability on their skill premium, employment ratio, and tariff rates in our sample. Our focus is on the labor market consequences of tariff changes, using a broad recent panel of data. The notion of temporary trade policy interventions is captured by removing a deterministic trend from the tariff data. Details of the data are relegated to Appendix A.

Our panel VAR specification includes import-weighted average of the applied tariff rate, skill premium and employment ratio, and one lag of each variable is considered. To account for possible common shocks experienced by different countries, we include the year-fixed effects. To further account for cross-country heterogeneity, we include country-fixed effects. Figure 4 displays the responses to a one-standard deviation increase in the applied tariff, which corresponds to a 1.8 percentage point increase. The skill premium declines by around 4.5 percentage point while employment ratio increases by 0.275 percentage point at the peak.

To address the potential endogeneity of import weights used in the calculation of weighted-average tariffs, we also conduct a robustness check in which we fix the import share of HS-2 products at the 1995 level using data from WITS. That way, the import weights for all the countries in our samples are fixed during the sample period. The results are shown in figure of the appendix, which are quite consistent with those shown in Figure 4 using varying import weights. In addition, we perform another estimation of the panel VAR restricting our sample to countries that are in the custom unions, which share common trade policies at the supranational level.

We acknowledge that the exercise using annual tariff data is constrained by low frequency. Nonetheless, we believe it is helpful for showing additional suggestive evidence on the labor market effects of protectionist trade policies that are in line with our monthly and quarterly analyses using anti-dumping initiatives.

Comtrade database.

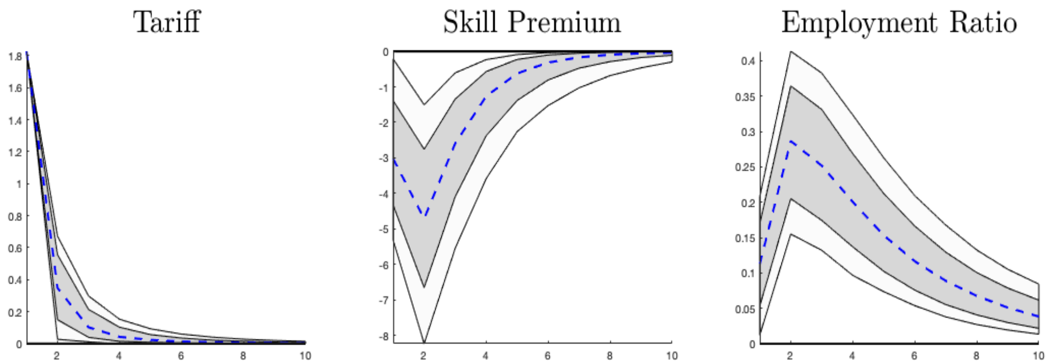

Figure 4: Panel VAR. One-standard deviation increase in detrended applied tariffs

3 Model

We model a world economy that consists of two countries, Home and Foreign. Foreign variables are denoted with asterisks. The home (foreign) country is endowed with $\bar{L}_h$ ($\bar{L}_h^*$) high-skilled labor and $\bar{L}_l$ ($\bar{L}_l^*$) low-skilled labor. We focus on presenting the model environment for the home country; that for the foreign country holds analogously.

3.1 Household preferences

Following Andolfatto (1996) and much of the subsequent literature, we assume full consumption insurance across individuals within the household. The representative household in the home economy maximizes the expected intertemporal utility function:

$$E_t \sum_{s=t}^{\infty} \beta^{s-t} \left[\frac{(C_s)^{1-\eta}}{1-\eta} - \chi_l L_{l,s} - \chi_h L_{h,s} \right]$$

where $\beta \in (0,1)$ is the subjective discount factor, $\eta > 0$ is the inverse of the inter-temporal elasticity of substitution, $L_{l,t}$ and $L_{h,t}$ are the number of employed low-skilled and high-skilled workers. $\chi_j > 0$ is the disutility of work for the type j workers, $j \in \{h, l\}$.

The consumption basket C_t is defined over a continuum Ω: $C_t = (\int_{\omega \in \Omega} c_t(\omega)^{\frac{\psi-1}{\psi}} d\omega)^{\frac{\psi}{\psi-1}}$, where $\psi > 1$ is the symmetric elasticity of substitution across goods. At any period t, only a subset of goods $\Omega_t \subset \Omega$ is available. Let $p_t(\omega)$ be the Home nominal price for the good $\omega \in \Omega_t$. The consumption-based price index for the Home economy is then given by $P_t = (\int_{\omega\in\Omega_t} p_t(\omega)^{1-\psi} d\omega)^{\frac{1}{1-\psi}}$.

3.2 Firms and the labor market

In each country there is a continuum of monopolistically competitive firms, each producing a differentiated variety that can be sold domestically and abroad. Firms are heterogeneous since they produce with different technologies indexed by relative productivity z. As in Ghironi and Melitz (2005), the number of firms serving the domestic and export market is endogenous. Prior to entry, firms are identical and face a sunk entry cost $f_{E,t}$ ($\tilde{f}^*_{E,t}$) in units of the home (foreign) consumption basket. Upon entry, Home and Foreign firms draw their productivity level from a common Pareto distribution with lower bound z_{min} and shape parameter $\vartheta > \psi - 1 : G(z) = 1 - (z_{min}/z)^{\vartheta}$. This relative productivity level remains fixed thereafter. Every period, since there are no fixed production costs, all firms produce until they are hit with an exit shock which happens at the end of the period with probability δ. Exporting is costly, and involves both a melting-iceberg trade cost τ_t (τ^*_t) as well as a fixed cost $f_{X,t}$ ($f^*_{X,t}$) measured in units of the home (foreign) consumption basket.

Production requires capital, low-skilled labor and high-skilled labor:

$$y_t(z) = f(k_t(z), l_{h,t}(z), l_{l,t}(z)) = Z_t z \left[\phi \left[\lambda (k_t(z))^{\gamma} + (1-\lambda)(l_{h,t}(z))^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)(l_{l,t}(z))^{\alpha}\right]^{\frac{1}{\alpha}},$$

where Z_t is the aggregate productivity. Following Krusell et al. (2000), our production function is a nested CES composite of three factors of production. At the first level, capital, $k_t(z)$, and high-skilled labor, $l_{h,t}(z)$, are combined via a CES technology having an elasticity of substitution $(1-\gamma)^{-1}$. At the second level, this composite input is combined with low-skilled labor, $l_{l,t}(z)$, also using a CES technology having an elasticity of substitution $(1-\alpha)^{-1}$ between low-skilled labor, this composite input, and its components. We assume capital-skill complementarity (CSC, henceforth), i.e. $\alpha > \gamma$, which implies that capital is more complementary with high-skilled labor than it is with low-skilled labor, as assumed by Krusell et al. (2000) and broadly supported by empirical evidence.

To hire a new worker, a firm needs to post a vacancy, requiring different skills and incurring a real cost κ. The probability of filling a vacancy depends on a constant return to scale matching technology, which converts aggregate job seekers $S_{j,t}$ and aggregate vacancies $V_{j,t}$ into aggregate matches $M_{j,t} \equiv M_{j,t}(V_{j,t}, S_{j,t}) = \xi_j (V_{j,t})^{\varepsilon} (S_{j,t})^{1-\varepsilon}$, $j \in \{h, l\}$. ξ_j is the matching efficiency parameter for type j unemployed workers.

Thus, the transition rate for vacancies of type j is $\nu_{j,t} \equiv M_{j,t}/V_{j,t}$, while the rate at which job seekers of type j meet vacancies is $\mu_{j,t} \equiv M_{j,t}/S_{j,t}$. For an individual firm with productivity z, the inflow of new hires in t is therefore $\nu_{j,t} v_{j,t}(z)$, where $v_{j,t}(z)$ is the total number of vacancies posted for skill type j by an incumbent with productivity z.

The timing of hiring and firing proceeds as follows. At the beginning of each period, a fraction of σ_j of last period's workers of type j are exogenously separated from each firm. Aggregate shocks are then realized, after which firms post vacancies and aggregate job seekers $S_{j,t} \equiv \bar{L}_j - (1-\sigma_j)(1-\delta)L_{j,t-1}$ searches for vacancies. Once the hiring round has taken place, both newly created ($M_{j,t}$) and continuing matches ($(1-\sigma_j)(1-\delta)L_{j,t-1}$) receive wages within the period, i.e. $L_{j,t} = M_{j,t} + (1-\sigma_j)(1-\delta)L_{j,t-1}$. The aggregate unemployment is $\bar{L}_j - L_{j,t}$. Figure 5 summarizes the timeline of key events in one period.

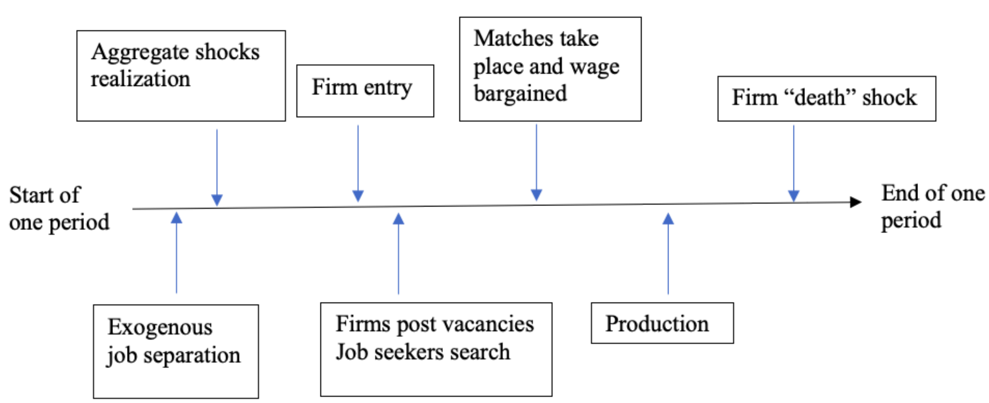

Figure 5: **Timeline of key events in the model**

The law of motion of employment of type j workers for (surviving) firm with productivity

z is thus given by

$$l_{j,t}(z) = (1-\sigma_j)l_{j,t-1}(z) + \nu_{j,t}v_{j,t}(z) \tag{1}$$

3.3 Cost minimization

Following Cacciatore (2014), we assume firms take wages as given when choosing employment and capital.[9] In each period, an incumbent firm with productivity z chooses the employment level, $l_{j,t}(z)$, vacancies to be posted, $v_{j,t}(z)$, for $j \in h, l$, and capital, $k_t(z)$, to minimize the expected discounted sum of current and future costs:

$$\min E_t \sum_{s=t}^{\infty} \beta_{t,s}(1-\delta)^{(s-t)} \left[l_{h,s}(z)w_{h,s}(z) + l_{l,s}(z)w_{l,s}(z) + \kappa v_{h,s}(z) + \kappa v_{l,s}(z) + r_s k_s(z)\right],$$

subject to:

$$y_t(z) = Z_t z \left[\phi \left[\lambda \left(k_t(z)\right)^{\gamma} + (1-\lambda)\left(l_{h,t}(z)\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(l_{l,t}(z)\right)^{\alpha}\right]^{\frac{1}{\alpha}} \tag{2}$$

$$l_{h,t}(z) = (1-\sigma_h)l_{h,t-1}(z) + \nu_{h,t}v_{h,t}(z) \tag{3}$$

$$l_{l,t}(z) = (1-\sigma_l)l_{l,t-1}(z) + \nu_{l,t}v_{l,t}(z) \tag{4}$$

where $\beta_{t,s} \equiv \beta^{s-t}(\frac{C_s}{C_t})^{-\eta}$ is the stochastic discount factor of the households, who are assumed to own domestic firms.

The first-order conditions for vacancies and employment imply the following job creation equations:

$$\frac{\kappa}{\nu_{h,t}} = (1-\sigma_h)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{h,t+1}}\right] + \varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{h,t}(z)} - w_{h,t}(z) \tag{5}$$

$$\frac{\kappa}{\nu_{l,t}} = (1-\sigma_l)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{l,t+1}}\right] + \varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{l,t}(z)} - w_{l,t}(z) \tag{6}$$

[9] As argued in Cacciatore (2014), we choose to ignore the feedback effect of firms' employment and capital decisions on wages for two reasons. One is computational convenience. The other, as shown by Krause and Lubik (2007), is that intra-firm bargaining does not significantly affect aggregate dynamics.

where $F(z) \equiv \left[\phi\left[\lambda\left(k(z)\right)^{\gamma}+(1-\lambda)\left(l_h(z)\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}}+(1-\phi)\left(l_l(z)\right)^{\alpha}\right]^{\frac{1}{\alpha}}$, and $\varphi_t(z)$ is the Lagrange multiplier attached to the constraint (2), corresponding to the real marginal cost of production. The above two conditions equate the marginal cost to the marginal benefit of posting a vacancy for the two skill types respectively.

The first-order condition for capital is:

$$r_t = \varphi_t(z) z Z_t \frac{\partial F(z)}{\partial k_t(z)}, \tag{7}$$

which equates the rental rate of capital to its marginal revenue product.

3.4 Wage determination

Following most of the labor search literature, we assume that the wage schedule is the solution of an individual Nash bargaining process that splits the surplus of the match between the firm and the worker. The equilibrium sharing rule resulting from the bargaining between a type j worker and a producer with productivity z can be written as $\zeta_j S^F_{j,t}(z) = (1-\zeta_j) S^W_{j,t}(z)$, where $\zeta_j \in (0,1)$ represents the type j worker's bargaining share, $S^F_{j,t}(z)$ is firm surplus, and $S^W_{j,t}(z)$ is worker surplus.

In the Appendix, we show that worker's surplus, firm's surplus and the bargained wage are all symmetric across the firm's productivity z, i.e. $S^F_{j,t}(z) = S^F_{j,t}$, $S^W_{j,t}(z) = S^W_{j,t}$ and $w_{j,t}(z) = w_{j,t}$. In particular, the bargained wage $w_{j,t}$ is a weighted average between the marginal revenue product of the worker and the worker's outside option $\bar{\omega}_{j,t}$:

$$w_{j,t} = \zeta_j \varphi_t(z) z Z_t \frac{\partial F(z)}{\partial l_{j,t}(z)} + (1-\zeta_j)\bar{\omega}_{j,t} \tag{8}$$

The worker's outside option is given by the utility gain from leisure in terms of consumption, $\chi_j / C_t^{-\eta}$, an unemployment benefit from the government, $\varkappa_j$, and the expected discounted value of searching for other jobs in the next period:

$$\bar{\omega}_{j,t} = b_{j,t} + E_t[\beta_{t,t+1}\mu_{j,t+1}S^W_{j,t+1}] \tag{9}$$

where $b_{j,t} \equiv \chi_j / C_t^{-\eta} + \varkappa_j$.

In the Appendix, we also show that the symmetry of $S^F_{j,t}(z)$, $S^W_{j,t}(z)$ and $w_{j,t}(z)$ across z further indicates that $\varphi_t(z)z$ is symmetric across z, which means the real marginal cost $\varphi_t(z)$ is symmetric across producers up to firm-specific productivity differentials, i.e. $\varphi_t(z) = \frac{\varphi_t}{z}$.

3.5 Profit maximization and export decisions

Firms set flexible prices that reflect the same proportional markup $\psi/(\psi - 1)$ over marginal cost. Let $p_{D,t}(z)$ and $p_{X,t}(z)$ denote the nominal domestic and export prices of a Home firm. Prices, in real terms relative to the price index in the destination market, are then given by: $\rho_{D,t}(z) \equiv \frac{p_{D,t}(z)}{P_t} = \frac{\psi}{\psi-1}\varphi_t(z)$, $\rho_{X,t}(z) \equiv \frac{p_{X,t}(z)}{P_t^*} = Q_t^{-1}\tau_t\rho_{D,t}(z)$, where $Q_t \equiv \frac{\epsilon_t P_t^*}{P_t}$ is the consumption-based real exchange rate (units of Home consumption per units of Foreign; ϵ_t is the nominal exchange rate, units of home currency per unit of foreign).

Firms with low productivity levels may choose not to export in any given period due to the presence of the fixed export cost. Profits from domestic sales $d_{D,t}(z)$ and potential export sales $d_{X,t}(z)$ are expressed in real terms in units of the consumption basket in the firm's location: $d_{D,t}(z) = (1/\psi)\,\rho_{D,t}^{1-\psi}(z)\,Y_t$, $d_{X,t}(z) = (Q_t/\psi)\,\rho_{X,t}^{1-\psi}(z)\,Y_t^* - f_{X,t}$, where Y_t and Y_t^* denote the aggregate demand for the composite goods in Home and Foreign, respectively.

A firm will export if and only if the expected profit from exporting is non-negative. This will be the case so long as productivity z is above a cutoff level $z_{X,t}$ such that: $z_{X,t} = inf\{z : d_{x,t}(z) > 0\}$. Firms with productivity levels between z_{min} and the export cutoff level $z_{X,t}$ produce only for their domestic market in period t.

3.6 Firm averages

Since the real marginal cost of production satisfies $\varphi_t(z) = \frac{\varphi_t}{z}$, the ratio of any two firms' output and revenues depends only on the ratio of their productivity levels. Therefore, as in Melitz (2003), Ghironi and Melitz (2005) and Cacciatore (2014), all the information about the distribution of productivity levels $G(z)$ that are relevant for all macroeconomic variables can be summarized by means of "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:

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

where $\tilde{z}_D$ and $\tilde{z}_{X,t}$ are based on weights proportional to relative firm output shares. The model can then be restated in terms of average (representative) firms. In particular, $\tilde{\rho}_{D,t} \equiv \rho_{D,t}\left(\tilde{z}_D\right)$ represents the average real price of Home firms in their domestic market, and $\tilde{\rho}_{X,t} \equiv \rho_{X,t}\left(\tilde{z}_X\right)$ represents the average real price of Home exporters in the export market. $\tilde{d}_{D,t} \equiv d_{D,t}\left(\tilde{z}_D\right)$ is the average domestic profit, and $\tilde{d}_{X,t} \equiv d_{X,t}\left(\tilde{z}_X\right)$ is the average export profit. Thus, the average total profit of Home firms is given by $\tilde{d}_t = \tilde{d}_{D,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{d}_{X,t}$. The average stock of type j workers is $\tilde{l}_{j,t} = \tilde{l}_{D,j,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{l}_{X,j,t}$, where $\tilde{l}_{D,j,t}$ and $\tilde{l}_{X,j,t}$ denote, respectively, the number of type j workers serving domestic and export market for the representative domestic producer and the representative exporter. The average stock of physical capital is $\tilde{k}_t = \tilde{k}_{D,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{k}_{X,t}$, where $\tilde{k}_{D,t}$ and $\tilde{k}_{X,t}$ are defined similarly as the case for labor.

3.7 Firm entry and exit

In every period there is an unbounded mass of prospective entrants in both countries. As in Ghironi and Melitz (2005) and Cacciatore (2014), these entrants are forward looking, and form rational expectations about their future expected profits in every period as well as the probability δ of incurring the exit-inducing shock. Entrants at time t start producing only from $t+1$, which introduces a one-period time-to-build lag in the model and is a plausible assumption given the quarterly calibration we will conduct. The expected post-entry value of prospective entrants in period t, $\tilde{e}_t$, is thus given by the present discounted value of the expected stream of per-period profits: $\tilde{e}_t = E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^{s-t} (\frac{C_s}{C_t})^{-\eta} \tilde{d}_s$. Due to the time-to-build assumption, the number of home-producing firms during period $t+1$ is given by $N_{D,t+1} = (1-\delta)(N_{D,t} + N_{E,t})$.

Prior to entry, firms face a sunk entry cost $f_{E,t}$ units of the consumption basket: $f_{E,t} \equiv f_{r,t} + \kappa \tilde{v}_{E,h,t} + \kappa \tilde{v}_{E,l,t} + w_{h,t}\tilde{l}_{h,t} + w_{l,t}\tilde{l}_{l,t}$, where the first term, $f_{r,t}$, represents the real costs of regulation associated with market entry, and the second and the third terms are the real cost of recruiting workers to start production and $\tilde{v}_{E,j,t} \equiv \tilde{l}_{j,t}/\nu_{j,t}$. The fourth and the fifth terms are the wages paid to the matched workers.

Firm entry takes place until the expected value of the average firm is equal to the sunk entry cost, leading to the free-entry condition $\tilde{e}_t = f_{E,t}$. This condition holds so long as the mass of entrants, $N_{E,t}$, is strictly positive.[10] We note that firm entries interact with labor market frictions in our model as in Cacciatore (2014)-changes in the labor market tightness lead to variations in the cost of hiring workers, affecting the profitability of market entry; firm entries, in turn, by changing the degree of competition, affects the labor demand and the bargained wages. Additionally, endogenous selection into exports alters the average productivity of the firms as in Melitz (2003), which affects the households' real income and aggregate demand, translating into changes in labor demand and bargained wages; labor market conditions, in turn, affect the profitability of the firms and the export productivity cut-off.

[10]We verify that this condition holds in our exercises.

3.8 Household budget constraint

We assume financial autarky, so there is no internationally traded asset. Following Ghironi and Melitz (2005), we assume the representative household can invest in shares in a mutual fund of domestic firms and it serves as the mechanism through which the household savings are made available to finance the new firms' entry. We denote x_t as the share in the mutual fund of domestic firms held by the representative household entering period t. The mutual fund pays a total real dividend in each period that is equal to the average total profit of all domestic firms that produce in that period, $\tilde{d}_t N_{D,t}$. During period t, the representative household buys x_{t+1} shares in a mutual fund of $N_{D,t} + N_{E,t}$ firms. Only a fraction $1 - \delta$ of these firms will produce and pay dividends at time $t + 1$. As the household does not know which firm will be hit by the death shock, it finances the the continuing operation of all incumbents and all new entrants during period t. 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 domestic firms, $\tilde{e}_t$.

In addition to shares in the mutual fund, the household can also invest in domestic risk-free bonds. Let B_t be the bond holdings in units of consumption of the household entering period t. It receives gross interest income $\left(1 + r_t^b\right) B_t$, where r_t^b is the consumption-based interest rate on holdings of bonds between $t - 1$ and t (known with certainty as of $t - 1$). During period t, the household purchases bonds B_{t+1} to be carried into next period.

The household accumulates physical capital, K_t, and rents it out to firms in a competitive capital market at a rental rate r_t. Investment in physical capital, I_t, consists of the same composite of all available varieties as the consumption basket. It has to cover depreciation at rate δ^k and convex capital adjustment costs, the latter being governed by parameter ω. The law of motion for physical capital is:

$$K_{t+1} = I_t + (1 - \delta^k)K_t - \frac{\omega}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t. \tag{10}$$

Employed high-skilled and low-skilled members of the household receives labor income at real wage rate $w_{h,t}$ and $w_{l,t}$ respectively, while unemployed members get time invariant unemployment benefit $\varkappa_h$ and $\varkappa_l$. The representative household's period budget constraint is :

$$\begin{aligned} C_t + I_t + T_t + (N_{D,t} + N_{E,t})\,\tilde{e}_t x_{t+1} + B_{t+1} =& w_{h,t} L_{h,t} + \varkappa_h(\bar{L}_h - L_{h,t}) + w_{l,t} L_{l,t} + \varkappa_l(\bar{L}_l - L_{l,t}) \\ & + r_t K_t + \left(\tilde{e}_t + \tilde{d}_t\right) N_{D,t} x_t + \left(1 + r_t^b\right) B_t, \end{aligned} \tag{11}$$

where T_t is lump-sum taxes from the government. The representative household maximizes its expected intertemporal utility subject to (10) and (11).

The Euler equation for bond holdings, share holdings and physical capital are, respectively:

$$(C_t)^{-\eta} = \beta(1 + r_{t+1}^b) E_t[(C_{t+1})^{-\eta}],$$

$$\tilde{e}_t = E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\eta}(1-\delta)\beta\left(\tilde{e}_{t+1} + \tilde{d}_{t+1}\right)\right],$$

$$(C_t)^{-\eta}\left[1 + \omega\left(\frac{K_{t+1}}{K_t} - 1\right)\right] = \beta E_t\left\{(C_{t+1})^{-\eta}\left[r_{t+1} + (1-\delta^k) + \frac{\omega}{2}\left[\left(\frac{K_{t+2}}{K_{t+1}}\right)^2 - 1\right]\right]\right\}.$$

3.9 Equilibrium

Aggregate employment for the high-skilled and low-skilled workers are, respectively, $L_{h,t} = (N_{D,t} + N_{E,t})\tilde{l}_{h,t}$ and $L_{l,t} = (N_{D,t} + N_{E,t})\tilde{l}_{l,t}$, while aggregate capital stock is given by $K_t = N_{D,t}\tilde{k}_t$. The equilibrium price index at Home satisfies $N_{D,t}\left(\tilde{\rho}_{D,t}\right)^{1-\psi} + N_{X,t}^*\left(\tilde{\rho}_{X,t}^*\right)^{1-\psi} = 1$. In equilibrium, bonds are in zero net supply, which implies $B_{t+1} = 0$, while shares in the mutual fund $x_{t+1} = 1$ in all periods. Assuming that the government runs a balanced budget in every period, it implies $T_t = \varkappa_h U_{h,t} + \varkappa_l U_{l,t}$.

The aggregate demand for the composite goods is given by $Y_t = C_t + I_t + N_{E,t}f_{r,t} + N_{X,t}f_{X,t} + \kappa(V_{h,t} + V_{l,t})$. Goods market clearing for the variety produced by the representative producing firm serving the domestic market requires:

$$[\tilde{\rho}_{D,t}]^{-\psi} Y_t = Z_t \left(\frac{\vartheta}{\vartheta - (\psi - 1)}\right)^{\frac{1}{\psi-1}} z_{\min} \left[\phi \left[\lambda \left(\tilde{k}_{D,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}_{D,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}_{D,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}},$$

while goods market clearing for the variety produced by the representative exporter requires:

$$\tau_t [\tilde{\rho}_{X,t}]^{-\psi} Y_t^* = Z_t \tilde{z}_{X,t} \left[\phi \left[\lambda \left(\tilde{k}_{X,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}_{X,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}_{X,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}}.$$

Finally, to close the model, observe that financial autarky implies balanced trade: $Q_t N_{X,t}(\tilde{\rho}_{X,t})^{1-\psi} Y_t^* = N_{X,t}^*(\tilde{\rho}_{X,t}^*)^{1-\psi} Y_t$. Similar conditions hold in the Foreign, and Appendix C summarizes the full equilibrium conditions of the model.

4 Calibration

We interpret periods as quarters and set the discount factor $\beta = 0.99$ and the (inverse) intertemporal elasticity $\eta = 2$ -both standard choices for quarterly business cycle models. Following Ghironi and Melitz (2005), we set the size of the exogenous firm exit shock $\delta = 0.025$, elasticity of substitution across product varieties $\psi = 3.8$ and melting-iceberg trade cost $\tau = 1.3$. We calibrate shape parameter of productivity distribution $\vartheta = 3.4$, and normalize the lower bound of productivity $z_{min} = 1$. We follow Cacciatore (2014) and assume that the entry cost due to market regulation, f_r, to be approximately 5 months of per capita output, which implies $f_r = 6$. Following Ghironi and Melitz (2005), we calibrate fixed export cost $f_X = 0.0571$ such that the proportion of exporting plants matches the number reported in Bernard et al. (2003) (21 percent). Consistent with Dolado et al. (2021), we set capital adjustment costs $\omega = 4$ and depreciation rate of capital stock $\delta^k = 0.01$. We assume symmetry in the matching elasticity ε and vacancy posting costs κ. We calibrate

$\varepsilon = 0.4000$ following Cacciatore (2014), and set $\kappa = 0.1300$ to be consistent with Dolado et al. (2021).

Following Dolado et al. (2021), the asymmetry in SAM frictions is captured by three set of skill-specific parameters: the separation rate, bargaining power and matching efficiencies of high-skilled and low-skilled workers. We set the separation rate $\sigma_h = 0.0245$ and $\sigma_l = 0.0562$ in line with Fallick et al. (2004), and the bargaining power $\zeta_h = 0.6955$ and $\zeta_l = 0.3740$ which are consistent with Dolado et al. (2021). We calibrate the matching efficiency $\xi_h = 0.5500$ and $\xi_l = 0.3587$ to target the market tightness for high-skilled as 1.4 and that for low-skilled as 2.13, which matches the estimates in Wolcott et al. (2018) and the average value between 1979 and 2007 in the CPS data, respectively (Dolado et al. (2021)). We set the population weights $\bar{L}_h = 0.23$ and $\bar{L}_l = 0.77$, consistent with Dolado et al. (2021). Following Cacciatore (2014), we calibrate the unemployment benefits $\varkappa_h = \varkappa_l = 1.3440$ to target the the replacement rate, which is the ratio of unemployment benefits to average wages, as 0.54 as reported by OECD (2004). We choose the disutility of labor $\chi_h = 0.1834$ and $\chi_l = 0.0951$ to target the unemployment rate for high-skilled as 0.028 and that for low-skilled as 0.078 (Dolado et al. (2021)).

There is heterogeneity across different skill types of workers not only from the labor market, but also in their different role in production, as captured by CSC. We set the elasticities of substitution in the production function based on the estimates in Krusell et al. (2000), namely, $\alpha = 0.4$ and $\gamma = -0.4902$. These correspond to high-skilled workers being a complement to capital, while the composite factor they form is a substitute for low-skilled workers. We calibrate the share parameters of production $\phi = 0.2743$ and $\lambda = 0.8018$ to target high-skilled labor share of income as 0.2 and low-skilled labor share of income as 0.45, which are close to the average of the emerging market and developing economies around 2000, documented by Dao et al. (2017).

All parameters for the foreign country are symmetric to the home country. Our calibration implies a steady-state level of skill premium as 1.4114 and the ratio of job-finding rate between high- and low-skilled as 1.2963, which are similar to those in Dolado et al. (2021). The calibration is summarized in Table 1.

Table 1: **Benchmark Calibration**

Parameter	Meaning	Value	Source/target
Externally calibrated			
β	discount factor	0.9900	Dolado et al. (2021)
η	(inverse) intertemporal elasticity	2.0000	Dolado et al. (2021)
σ_h	seperation rate, H	0.0245	Fallick et al. (2004)
σ_l	seperation rate, L	0.0562	Fallick et al. (2004)
ε	matching elasticity	0.4000	Cacciatore (2014)
κ	vacancy posting costs	0.1300	Dolado et al. (2021)
ζ_h	bargaining power, H	0.6955	Dolado et al. (2021)
ζ_l	bargaining power, L	0.3740	Dolado et al. (2021)
α	substitution between (l_h, k) and l_l	0.4000	Krusell et al. (2000)
γ	substitution between l_h and k	-0.4902	Krusell et al. (2000)
$\bar{L}_h$	population weight, H	0.2300	Dolado et al. (2021)
$\bar{L}_l$	population weight, L	0.7700	Dolado et al. (2021)
ω	capital adjustment costs	4.0000	Dolado et al. (2021)
δ^k	depreciation rate of capital stock	0.0100	Dolado et al. (2021)
δ	exogenous firm exit shock	0.0250	Ghironi and Melitz (2005)
ψ	elasticity of substitution between varieties	3.8000	Ghironi and Melitz (2005)
ϑ	shape parameter of productivity distribution	3.4000	Ghironi and Melitz (2005)
τ	melting-iceberg trade cost	1.3000	Ghironi and Melitz (2005)
z_{min}	lower bound of productivity	1.0000	normalization
Internally calibrated			
f_r	regulation entry cost	6.0000	approximately 5 months of per capita output
ϕ	share parameters of production	0.2743	low-skilled labor share of income=0.45
λ	share parameters of production	0.8018	high-skilled labor share of income=0.2
f_X	fixed export cost	0.0571	the proportion of exporting plants=21 pct.
ξ_h	matching efficiency, H	0.5500	market tightness for high-skilled=1.4
ξ_l	matching efficiency, L	0.3587	market tightness for low-skilled=2.13
χ_h	disutility of labor, H	0.1834	unemployment rate for high-skilled=0.028
χ_l	disutility of labor, L	0.0951	unemployment rate for low-skilled=0.078
$\varkappa_h$	unemployment benefits, H	1.3440	the replacement rate=0.54
$\varkappa_l$	unemployment benefits, L	1.3440	the replacement rate=0.54

5 Theoretical results

We use changes in the Foreign iceberg trade cost τ^* to reflect changes in the Home trade barriers, and parameterize the stochastic process of τ^* to mimic the persistence of the tariff shock identified in the panel VAR. This approximately requires setting the quarterly persistence of the shock equal to 0.5. We set the standard deviation of innovations equal to

0.13 to simulate a 10% temporary increase in τ^*. We solve for the dynamics in response to exogenous temporary increase in Home trade barriers by log-linearizing the model around the deterministic steady state under different scenarios and parameterizations.

5.1 The effects of temporary increase in Home trade barriers

Figure 6 shows the impulse responses of key variables under the benchmark scenario to a temporary increase in τ^* at time 1, assuming that the economy was at the deterministic steady state at time 0.

The GDP response depends on the relative importance of two margins of adjustment. One is the tendency for an increase in the domestic demand for Home goods due to the expenditure switching effect, which stems from the increase in the average price of imported goods. The other is the countervailing force of the decline in the aggregate real income (expenditure reduction) and decline in foreign demand for domestic export. As both consumption and investment in physical capital and firm entry require the composite good which combines the Home and Foreign varieties, the increase in the price of imports make them more costly, reducing households' real income. The appreciation of the real exchange rate raises the price of exports, cutting the foreign demand for domestic exports. Moreover, the contraction of exporting firms along the extensive margin (i.e., number of exporting firms) results in market share being reallocated toward relatively less productive non-exporting firms, which tends to reduce the households' real income, further dampening aggregate demand. Overall, the simulation results show that the downward pressure in aggregate demand dominates, causing a contraction in GDP, consumption, investment in physical capital, firm entries and the levels of wages and employments for both types of workers. These simulated aggregate macroeconomic effects are broadly consistent with the empirical evidence provided by Barattieri et al. (2021).

The last two panels in the third row of Figure 6 show the impulse responses of the skill premium and the employment ratio under the benchmark scenario. The results are consistent with those identified in the VAR; skill premium declines while the employment ratio between and high-skilled and low-skilled labor increases in the short run.

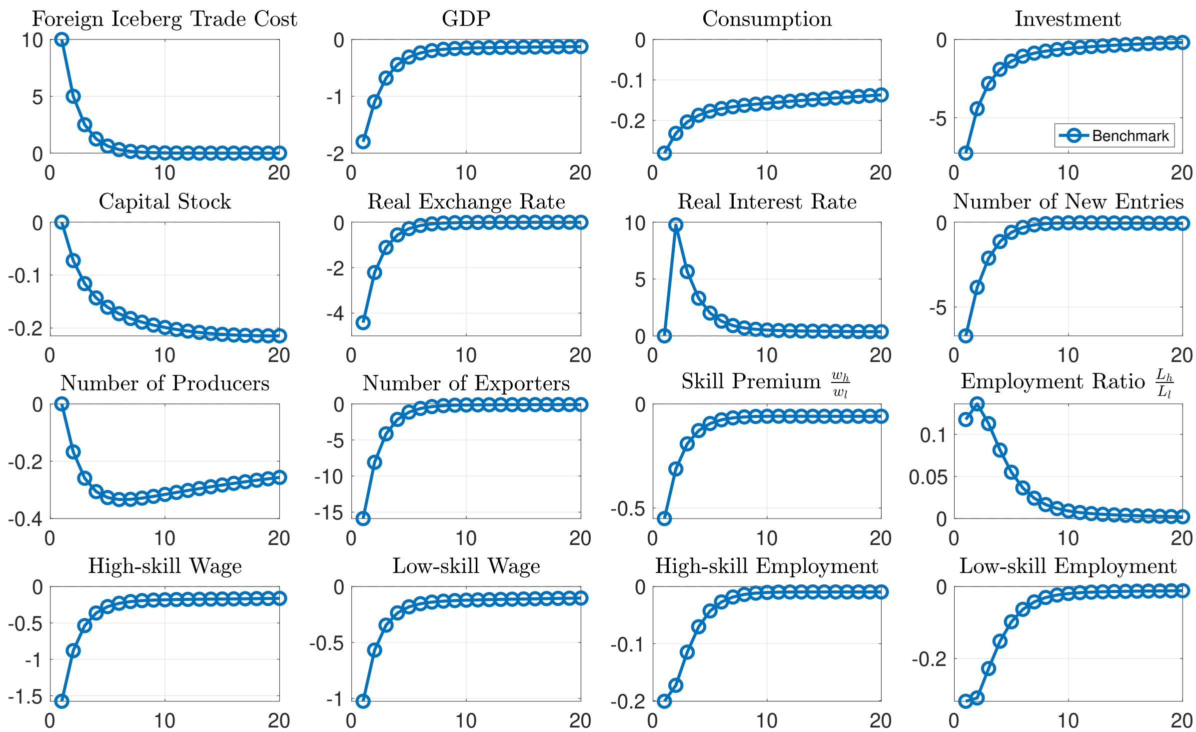

Figure 6: **Responses to a temporary increase in Home trade barriers, benchmark scenario. Responses show percentage deviations from the steady state.**

5.2 Dissecting the mechanism

We focus on primarily dissecting the mechanism for the dynamic responses of the skill premium, as the mechanisms embedded also have implications for the dynamics of the aggregate employment ratio, and we briefly discuss these implications at the end of Section 5.2.2. Three elements in our model play a key role in shaping the distributional patterns of the tariff shocks – asymmetric SAM, CSC and producer dynamics. We first discuss the roles of asymmetric SAM and CSC, as these two elements affect the outcomes qualitatively.

To demonstrate how asymmetric SAM and CSC qualitatively shape the short-run dynamics of the skill premium and the employment ratio, we compute the IRFs under three different scenarios where we make the SAM symmetric by setting the matching efficiencies, bargaining powers and job separation rates across the two types of labor to be equal at the average of the benchmark values, and/or reduce the strength of capital-skill complementarity by change the value of the parameters of α and γ to 0.25 and -0.35, respectively. Figure 7 shows the impulse responses of the skill premium and the employment ratio under the three different scenarios in addition to the benchmark result, and the dynamics differ sharply from the benchmark case.

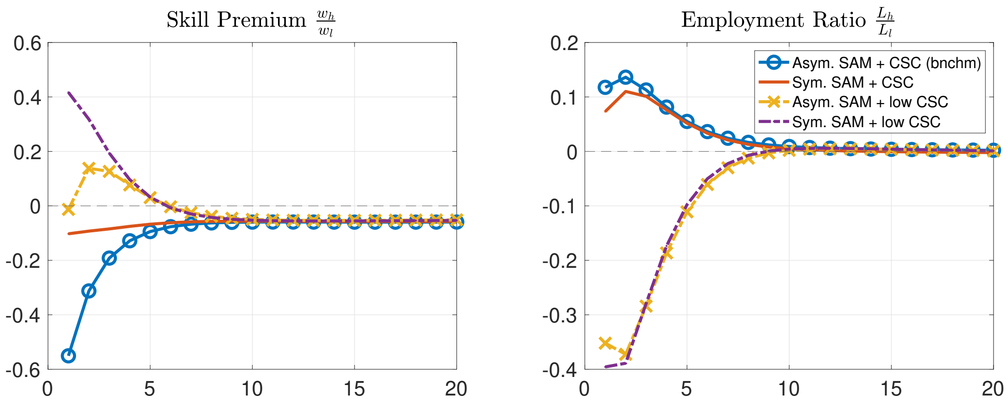

Figure 7: **Responses to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**

To dig deeper into the reasons why different scenarios lead to vastly different dynamics of the skill premium, we decompose the dynamics of the skill premium into different channels through which the trade shocks propagate. To do this, we log-linearize the wage bargaining equation (8), and using "hats" to denote the log deviation of a variable from its steady state, i.e., $\hat{f}_t = \log f_t - \log f$, we can express the log deviation of the real wage of each skill type, j, as

$$\begin{aligned}\hat{w}_{j,t} &= \underbrace{\frac{\zeta_j F_{l_j}\varphi}{w_j}}_{\alpha^j_\varphi}\hat{\varphi}_t + \underbrace{\frac{\zeta_j F_{l_j}\varphi}{w_j}}_{\alpha^j_{F_l}}\hat{F}_{l_j,t} + \underbrace{\frac{1}{w_j}[(1-\zeta_j)\chi_j\eta c^\eta + \zeta_j\kappa\beta\theta_j\eta]}_{\alpha^j_c}\hat{c}_t + \underbrace{(-\eta\zeta_j\kappa\beta\theta_j)}_{\alpha^j_{c+1}}\hat{c}_{t+1} + \underbrace{\zeta_j\kappa\beta\theta_j}_{\alpha^j_{\theta+1}}\hat{\theta}_{j,t+1} \\ &= \alpha^j_\varphi\hat{\varphi}_t + \alpha^j_{F_l}\hat{F}_{l_j,t} + \alpha^j_c\hat{c}_t + \alpha^j_{c+1}\hat{c}_{t+1} + \alpha^j_{\theta+1}\hat{\theta}_{j,t+1}\end{aligned}$$

where $F_{l_j} \equiv \frac{\partial\tilde{F}}{\partial\tilde{l}_j}$ and $\theta_j \equiv \frac{\mu_j}{\nu_j}$ is the labor market tightness for skill type j.

Using the above equation we can express the log deviation of skill premium as

$$\hat{w}_{h,t} - \hat{w}_{l,t} = (\alpha^h_\varphi - \alpha^l_\varphi)\hat{\varphi}_t + [\alpha^h_{F_l}\hat{F}_{l_h,t} - \alpha^l_{F_l}\hat{F}_{l_l,t}] + (\alpha^h_c - \alpha^l_c)\hat{c}_t + (\alpha^h_{c_{+1}} - \alpha^l_{c_{+1}})\hat{c}_{t+1} + [\alpha^h_{\theta_{+1}}\hat{\theta}_{h,t+1} - \alpha^l_{\theta_{+1}}\hat{\theta}_{l,t+1}]$$

which decomposes the dynamics of the skill premium into five channels through which the trade shock takes effect. In particular, the channel of the aggregate demand pressure, as captured by the real marginal cost/revenue $\hat{\varphi}_t$, and the channel of the skill-specific marginal products of labor $\hat{F}_{l_j,t}$ affect labor demand and the firm's surplus. Meanwhile, the channels of differing wealth effects, as captured by $\hat{c}_t$ and $\hat{c}_{t+1}$, and labor market tightness $\hat{\theta}_{j,t+1}$ affect labor supply and workers' surplus. We plot the contributions of each of the five channels along side with the IRF of the skill premium for the four scenarios separately, as shown by Figure 8.[11]

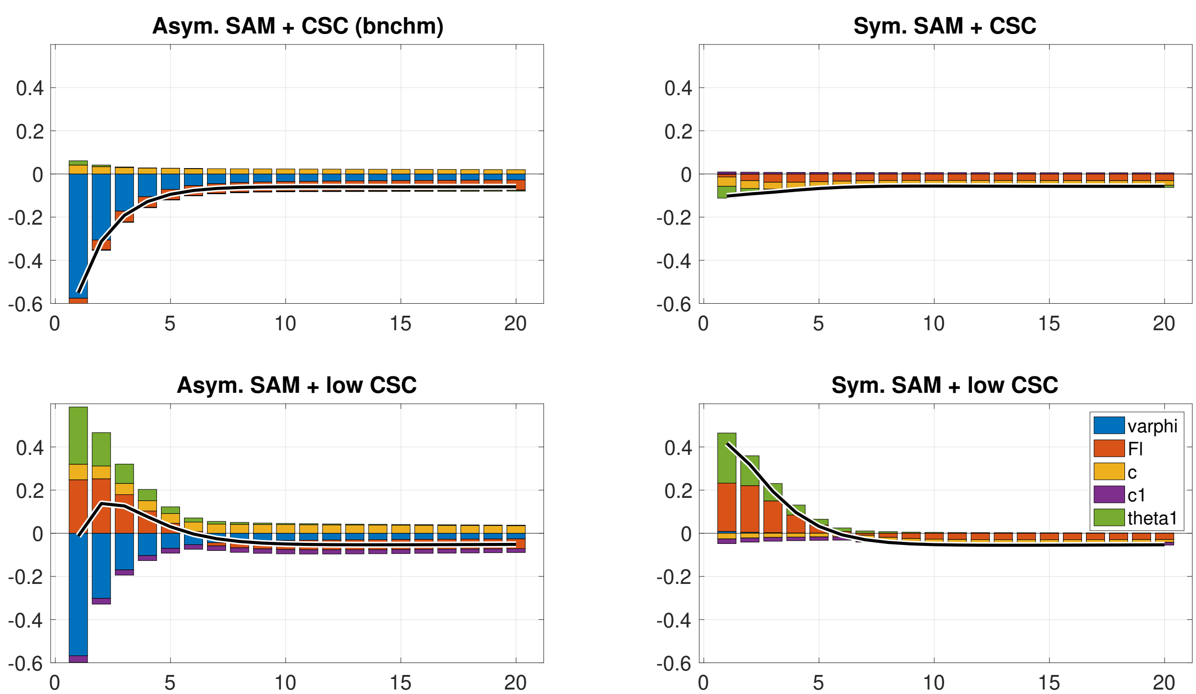

Figure 8: **Responses of the skill premium to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**

[11]See Figure 18-21 in the appendix for the responses of the level of wages under different scenarios.

5.2.1 The role of asymmetric SAM

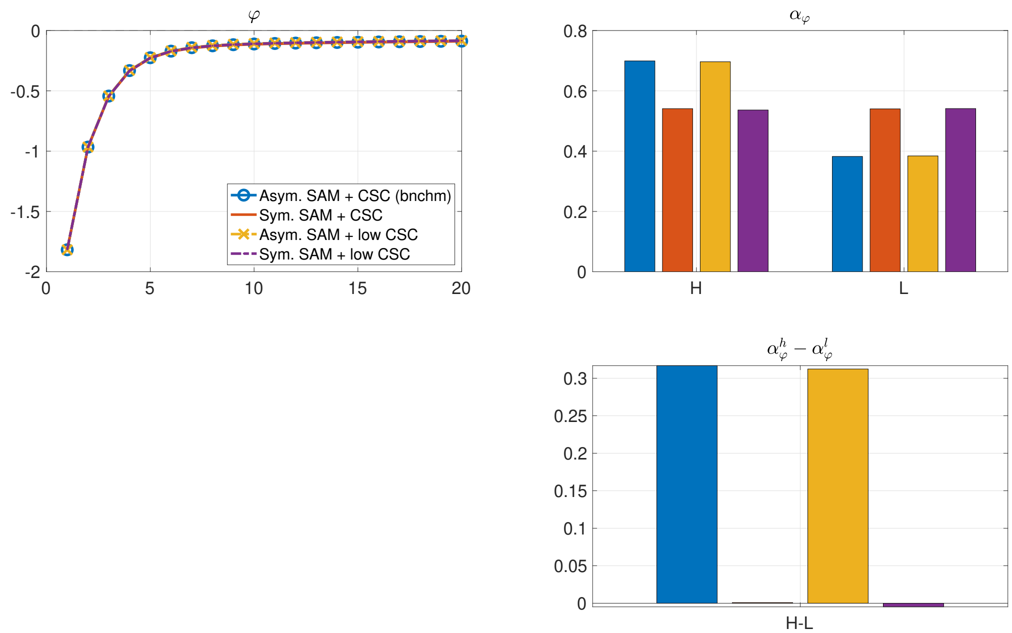

Figure 9: **IRFs of φ and Comparison of α_φ^k and $(\alpha_\varphi^h - \alpha_\varphi^l)$ across different scenarios**

Comparing the left two panels with the right two ones in Figure 8, we see that eliminating the asymmetry of SAM removes the negative contribution of the marginal cost channel, which leads to significant changes in the dynamics of the skill premium. The intuition of this role of asymmetric SAM in the dynamics of the skill premium is as follows. As shown in Figure 18, the dynamics of the skill premium under the benchmark scenario is mostly driven by the marginal cost channel which reflects the changes in the aggregate demand pressure. To investigate how the contribution of this channel changes across different scenarios, in Figure 9, we plot the IRFs of the marginal cost φ and the associated coefficients α_φ^j and $(\alpha_\varphi^h - \alpha_\varphi^l)$ across the four scenarios. Marginal cost drops driven by the downward pressure in aggregate demand, and its dynamics remain the same across the four scenarios. However, the coefficient $(\alpha_\varphi^h - \alpha_\varphi^l) \equiv \frac{\zeta_h F_{l_h} \varphi}{w_h} - \frac{\zeta_l F_{l_l} \varphi}{w_l}$, which is affected by the difference in the bargaining powers of the two types of labor (ζ_j), is drastically different between the asymmetric SAM and symmetric SAM scenarios. Larger bargaining power of the skilled labor implies their wages will take a larger hit when there is downward demand pressure as a larger fraction of their wages is tied to the marginal revenue product of labor. Under symmetric SAM which implies symmetric bargaining power, the downward demand pressure translates into equal reduction to the wages for the two types of labor, which effectively eliminate the negative contribution through the marginal cost channel to the skill premium, as can be seen in Figure 8.

5.2.2 The role of CSC

By comparing the top two panels with the bottom two ones in Figure 8, it can be seen that lowering the strength of CSC leads to significantly positive contributions from the labor market tightness channel and the marginal product of labor channel and it reverses the decreases in the skill premium. The following two subsections analyze the effects of CSC on these two channels respectively.

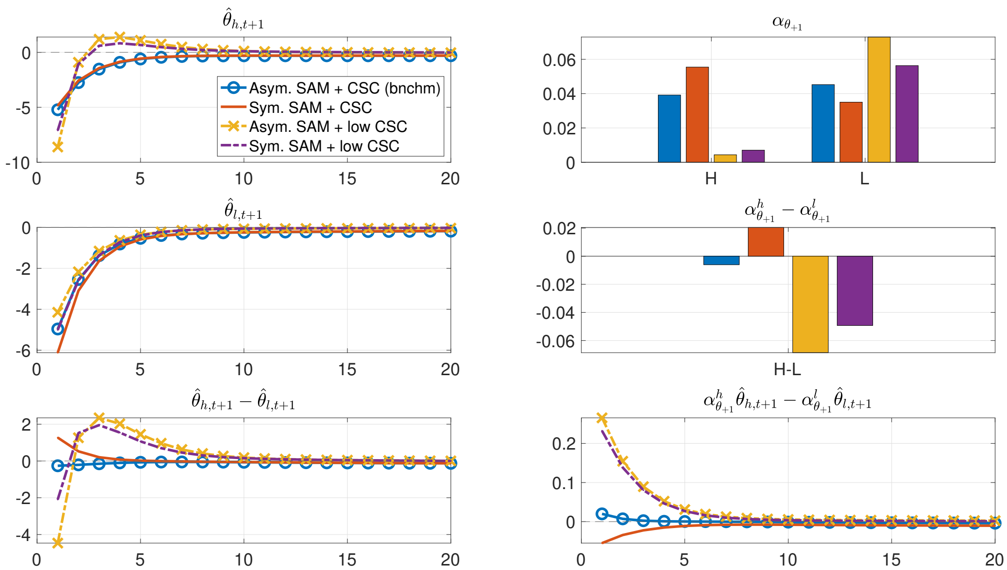

Figure 10: **Components of the labor market tightness channel across different scenarios**

(1) The effects on the labor market tightness channel

Figure 10 shows different components of the labor market tightness channel, $\alpha^h_{\theta_{+1}}\hat{\theta}_{h,t+1} - \alpha^l_{\theta_{+1}}\hat{\theta}_{l,t+1}$, across the four scenarios. The significant increase of the labor market tightness channel under the counterfactual low CSC scenario are mainly caused by the changes in the difference between the coefficients, i.e. $(\alpha^h_{\theta_{+1}} - \alpha^l_{\theta_{+1}})$. [12]

The intuition for the effects of CSC on the difference between the coefficients, $(\alpha^h_{\theta_{+1}} - \alpha^l_{\theta_{+1}})$, is as follows. When there is downward aggregate demand pressure, firms reduce vacancy posting for both high-skilled and low-skilled labor, thus labor market tightness drops for both markets, worsening the outside options which tends to reduce the wages for both types of labor. The effects on the skill premium hinges on the relative strength of these two reduction forces, which is tied to relative weights, i.e., the coefficients on the labor market tightness term, $\alpha^j_{\theta_{+1}} \equiv \zeta_j \kappa \beta \theta_j$, and they are, by definition, in proportion to the steady-state levels of labor market tightness, θ_j. Comparing with the benchmark scenario, this coefficient for the high-skilled labor becomes lower relative to that for the low-skilled under lower CSC. The reason is that lower CSC reduces the steady-state marginal product of labor of the high-skilled relative to the low-skilled labor, thus relatively reducing the marginal benefit of creating high-skilled job vacancies, which in turn relatively decreases the steady-state labor market tightness of the high-skilled. This reduces the difference in weights tied to the labor market tightness terms. As the drop in the labor market tightness of the high-skilled labor is weighted less heavily, which means their wages get hurt less, the contribution to the skill premium through the labor market tightness channel becomes significantly positive in response to the trade shock under lower CSC. [13]

(2) The effects on the marginal product of labor channel

Figure 11 shows the the different components of the marginal product of labor channel, $\alpha^h_{F_l} \hat{F}_{l_h,t} - \alpha^l_{F_l} \hat{F}_{l_l,t}$, across the four scenarios. The significant positive contribution to the skill premium through marginal product of labor channel under lower CSC is driven by the large

[12] This can be seen by comparing the dynamics of the labor market tightness channel with and without the changes in the difference between the coefficients (bottom right panel versus bottom left panel).

[13] The relatively large increase in the flow value of unemployment of the skilled labor caused by the increase in the steady-state consumption under lower CSC also plays a role in the reduction in the relative labor market tightness, as higher flow value of unemployment tends to increase the wages, which reduce the marginal benefit of job vacancies. However, this relatively large increase in the flow value of unemployment is tied to the higher value of disutility of labor for the skilled labor, which may or may not be empirically robust, so we do not view this effect through the relative changes in the flow value of unemployment as a robust implication of lower CSC.

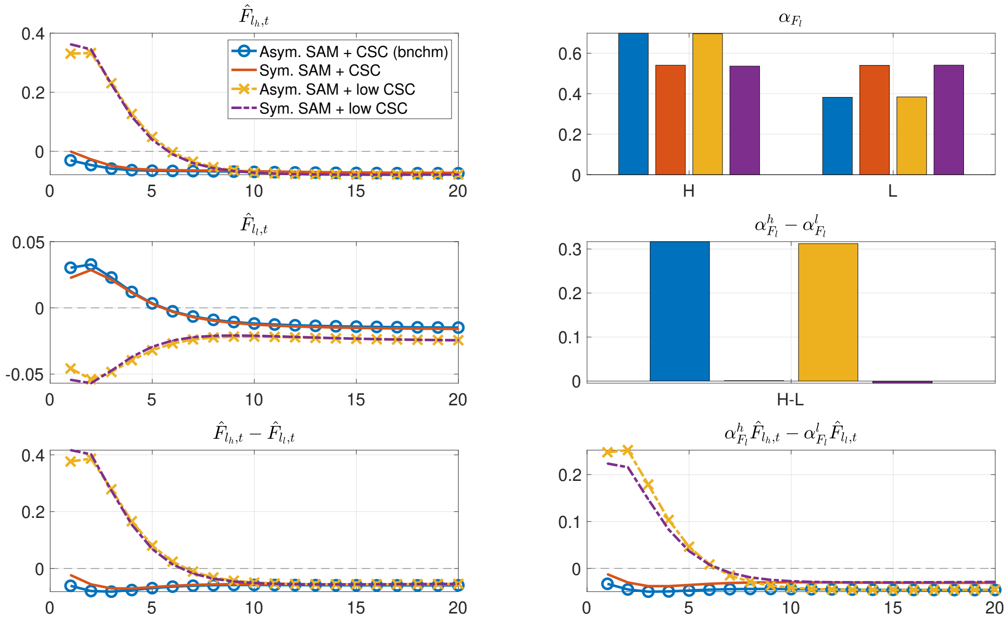

Figure 11: **Components of the marginal product of labor channel across different scenarios**

increase in the difference between the log changes of the marginal product of labor for the two types of labor, $\hat{F}_{l_h,t} - \hat{F}_{l_l,t}$, as can be seen from the bottom left panel of Figure 11. $\hat{F}_{l_h,t} - \hat{F}_{l_l,t}$ is equal to the log change of the ratio of the marginal product of labor between the high-skilled and the low-skilled. Based on the log-linearization of the expression for the ratio of the marginal product of labor as in equation (A.6), we conduct a similar component analysis for the IRFs of of it (see Figure 22 in the appendix), and find that the increase in the log change of the ratio of the marginal product of labor under lower CSC, in turn, is driven by the positive contribution through the average high-skilled employment channel, which is caused by the larger drop in the average high-skilled employment. The reason is that, as mentioned, lower CSC implies the drop of labor market tightness hurts the high-skilled workers less, so they are less willing to accept lower wage and thus tend to reduce their labor supply. This results in a larger drop in the average high-skilled employment, and it in turn drives up the change in the ratio of the marginal product of labor between the two types of labor and leads to a positive contribution to the skill premium through the marginal product of labor channel. Together with the positive contribution from the labor market tightness channel under lower CSC, it reverses the negative effect caused by the marginal cost channel. Thus, to generate the decline of the skill premium consistent with the empirical evidence, the model requires a sufficiently high degree of capital-skill complementarity.

(3) Implications for the employment ratio

The larger drop in the average high-skilled employment driven by weaker high-skilled labor supply under lower CSC scenario also translates into a larger drop in the aggregate high-skilled employment, L_h, which in turn leads to a reduction in the aggregate employment ratio upon impact and it contrasts sharply with the dynamics in the benchmark CSC scenario (see Figure 23 and 24 in the appendix, which are the component analysis of L_h based on the log-linearization equation (A.7)). Thus, in our benchmark model the sufficiently high degree of CSC based on the estimate from Krusell et al. (2000) is also necessary to generate the dynamic responses of the employment ratio consistent with the empirical evidence.

5.2.3 The role of producer dynamics

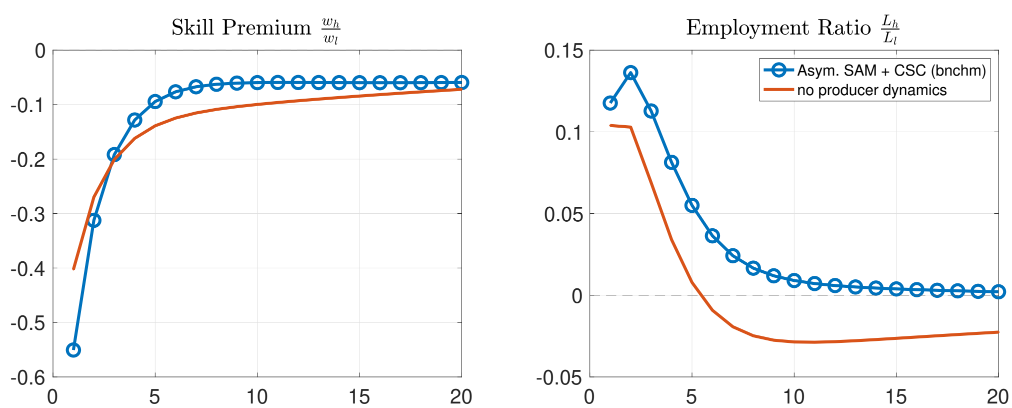

Figure 12: **Responses to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**

Figure 12 shows the IRFs of the skill premium and the employment ratio under the benchmark scenario and the one with no producer dynamics (by making the number of domestic firms, exporting firms and new entries constant for both Home and Foreign). Turning off the producer dynamics attenuates the distributional consequences upon impact, especially

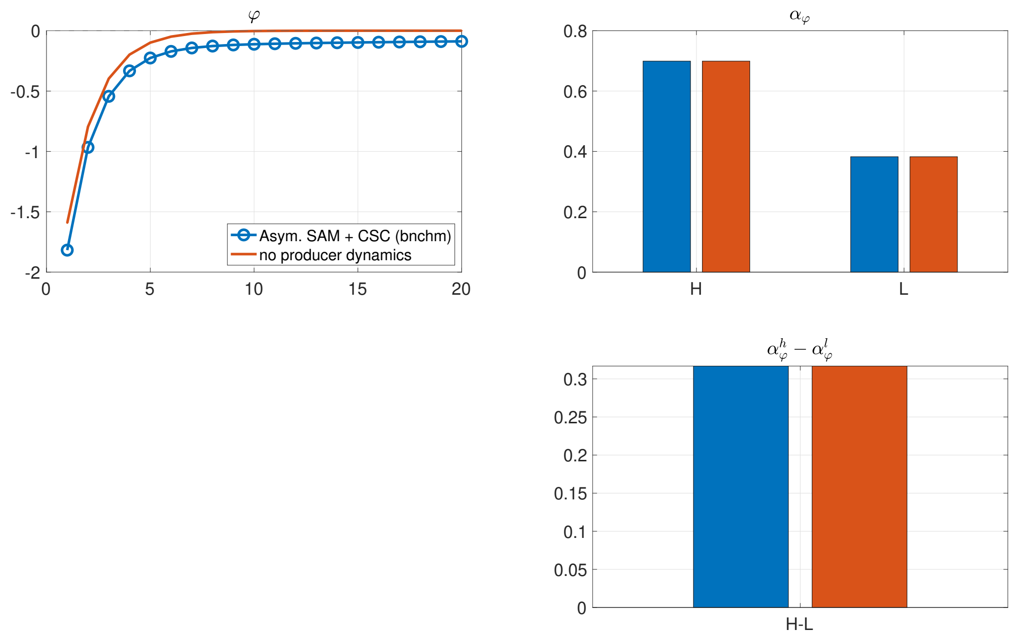

Figure 13: **IRFs of φ and Comparison of α_φ^k and $(\alpha_\varphi^h - \alpha_\varphi^l)$ across the benchmark and no producer dynamics scenarios**

for the skill premium, as can be seen by Figure 12. This is mainly because the absence of endogenous selection into export tends to dampen the micro-level reallocation of market shares toward the less-efficient firms by eliminating the extensive margin of adjustments, and the absence of endogenous producer entry implies the reduction in real income no longer translates in a reduction of investment in firm creation, both of which tend to mitigate downward aggregate demand pressure. Figure 13 plots the IRFs of the marginal cost/revenue φ and the associated coefficients α_φ^k and $(\alpha_\varphi^h - \alpha_\varphi^l)$ across the two scenarios. As the figure shows, there is a dampened decline of the marginal revenue φ when producer dynamics is eliminated, and this partially accounts for the smaller drop in the skill premium upon impact.

Over time, however, producer dynamics generate a dampened decrease in the skill premium, along with a persistent increase in employment ratio, compared to the model without producer dynamics. These suggest that the decrease in firm entry and export in response to the trade barrier shock gradually leads to worsened labor market inequality. The results may have important policy implications: the entry and export margins of firms under protectionism over time exacerbates worker inequality as protectionism discourages firm entry and selection into exporting over time, both of which exert downward pressure on labor demand, with a larger adverse effect on the low-skilled workers though.

6 Conclusion

This paper explores how protectionism manifested by heightened temporary trade barriers affects the wage ratio and the employment ratio of high-skilled workers to low-skilled workers. We first examine the distributional effects of protectionism using vector autoregressions. Our country-level analysis using temporary trade barriers at the monthly and quarterly frequency, as well as our panel estimation using applied tariffs data at the annual frequency all suggest that protectionism reduces the skill premium but increases the employment ratio in the short run.

To map our empirical evidence, we build a two-country dynamic general equilibrium model that incorporates asymmetric search-and-matching (SAM) frictions, capital-skill complementary (CSC) in production, as well as producer dynamics. The model generates impulse responses that are in line with our VAR evidence.

We then conducted a number of counterfactual exercises that illustrate the channels through which the trade barrier shock affects inequality between high-and-low- skilled workers. Our findings show that both asymmetric SAM and CSC play vital roles in shaping the dynamic responses of the skill premium. In particular, asymmetric SAM generates a large negative contribution to the skill premium through the aggregate demand channel – skilled-workers' relatively larger bargaining power implies that they are exposed to a larger wage hit when presented with the downward aggregate demand pressure caused by the trade barrier shock. Lowering the degree of CSC tends to lead to a counterfactual increase in skill premium and a decrease in employment ratio, partially through inducing a larger drop in the average high-skilled employment, which levels up the ratio of high-to-low- skilled marginal product of labor. Lastly, our analysis of producer dynamics (firm entry and selection into exporting) suggests that allowing for the adjustment of the extensive margins of firms magnify the impact responses of the skill premium and the employment ratio through amplifying the downward aggregate demand pressure.

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Appendices

A Data description

A.1 Monthly and Quarterly Data

Antidumping Initiatives The data is from the Global Antidumping Database (GAD), which was initiated as the Temporary Trade Barriers Database (Bown (2011)). Following Barattieri et al. (2021), we construct the antidumping initiatives as the total number of HS-6 products affected by new antidumping investigations in a given quarter or month.

Skill Premium, Skilled Wage, Employment Ratio, and Skilled Employment We rely on Dolado et al. (2021) for data of hourly wage and employment, with time series of wage gap and employment ratio being extracted from the NBER extracts of the Current Population Survey (CPS) Merged Outgoing Rotation Groups. The sample includes individuals in working age 15–64 and excluding part-time workers, self-employed workers, and military employees. Wages are computed as the ratio of weekly wages and the number of weekly hours worked in each skill category, whereas employment is calculated as number of hours of work per employee per month, multiplied by the number of workers in each skill group. The data is originally obtained in monthly frequency. We transform it to quarterly frequency for our quarterly analysis.

Net Export Data on net exports is from OECD statistics, Monthly International Merchandise Trade (IMTS).

Real Exchange Rate Data on real exchange rate is the series of Real Narrow Effective Exchange Rate for United States from FRED. https://fred.stlouisfed.org/series/RNUSBIS.

Firm Entry We use Timely Indicators of Entrepreneurship from OECD.Stat as the measurement for firm entry. Link to data: https://stats.oecd.org/index.aspx?queryid=74181

A.2 Panel Data

Tariffs We use the Tariff rate, Applied, Weighted mean, Manufactured products (%) series from the World Bank World Development Indicators for each country and year. We also use HS-2 product-level tariff rates from the WITS when calculating fixed import weights. We detrend tariffs for each country using HP filter.

Skill Premium We obtain annual data on wages and employment for high-skilled and low-skilled workers from the World Input-Output database(WIOD)'s Socio Economic Accounts for all of the countries in our sample from 1995 to 2009. They use the 1997 International Standard Classification of Education (ISCED) classification to define workers with three different skill levels – low, medium and high skilled labor. Since we follow the general practices adopted in the literature that define the high-and-low-skilled workers by whether they attended college or not, we convert their low- and medium- skilled labor (people without a tertiary education) to low-skilled labor in our context and keep the high-skilled group as in the data. To obtain high-skilled hourly wage, we divide total high-skilled labour compensation by hours worked by high-skilled persons engaged. In a similar fashion, low-skilled hourly wage is calculated by combining the low-skilled and medium-skilled hourly wage in the data. Finally, we calculate the skill premium as the ratio of high-skilled hourly wage over low-skilled hourly wage. The original dataset can be found here: https://web.archive.org/web/20211102093655/http://www.wiod.org/database/seas13

Employment Ratio Using the same dataset described above, we calculate the employment ratio by dividing the total hours worked by high-skilled persons engaged over the total hours worked by low-skilled persons at the annual frequency. High-skilled employment is measured by total hours worked by persons engaged (millions) multiplied by the share in total hours worked by high-skilled workers. Similarly, low-skilled employment is measured by total hours worked by persons engaged (millions) multiplied by share in total hours worked by both the low-skilled and medium skilled workers.

Country List: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, India, Indonesia, Ireland, Italy, Japan, South Korea, Republic of Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Turkey, the United States.

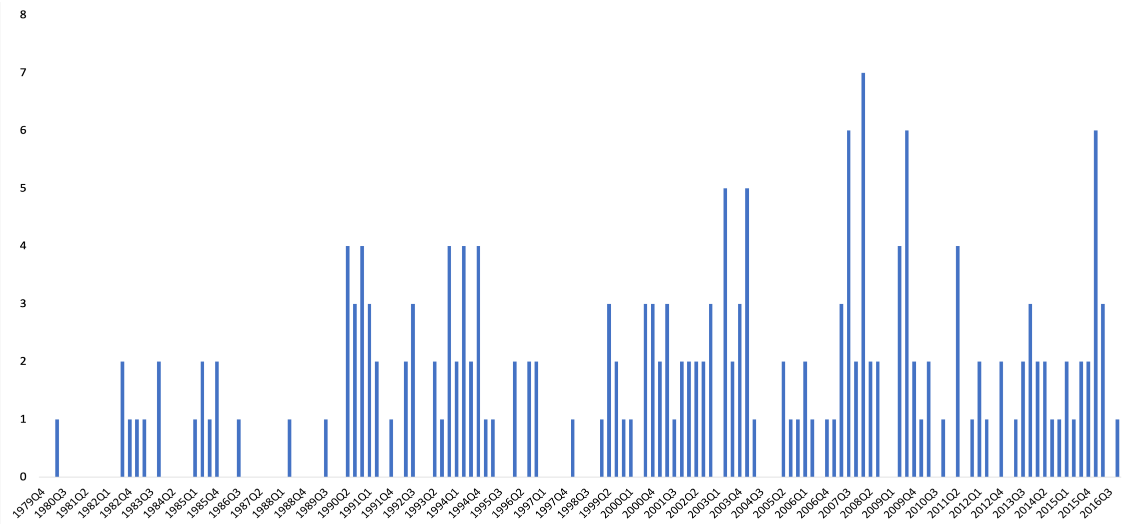

Figure 14: Antidumping initiatives against China at quarterly frequency

B VAR Robustness Checks

China shock, monthly VAR

Our VAR analysis incorporating all countries under the antidumping investigations from the U.S. raises the concern that China plays a substantially larger role by the end of the sample, which might affect our results. Fig. 14 illustrates that there is indeed a moderate increase in the number of antidumping initiatives against China on average in the second half of our sample period, particularly after China's accession into the WTO in 2001. We address the China shock concern by running our VAR on all the countries excluding China in our data. Fig. 15 plots the VAR responses of antidumping duties on countries excluding China together with other variables of interest. The results are very similar to the benchmark ones, suggesting that changes in the focus of the countries against which antidumping investigations are initiated do not interfere with our results.

Panel VAR robustness checks

To provide robustness checks to our panel VAR analysis using tariff data, we first re-estimate the panel using applied tariff data with fixed import weights. More specifically, we calculate the import shares of HS 2-digit level products in the initial year, which is 1995, for each country that the U.S. reports imports from. Since there is quite some variation of product codes from year to year for each exporting partner of the U.S., we match the product codes for every year after 1995 with those in 1995 so as to use the import weights in 1995. Then, we are able to generate the applied tariff rates fixing import shares at 1995 level, thus accounting

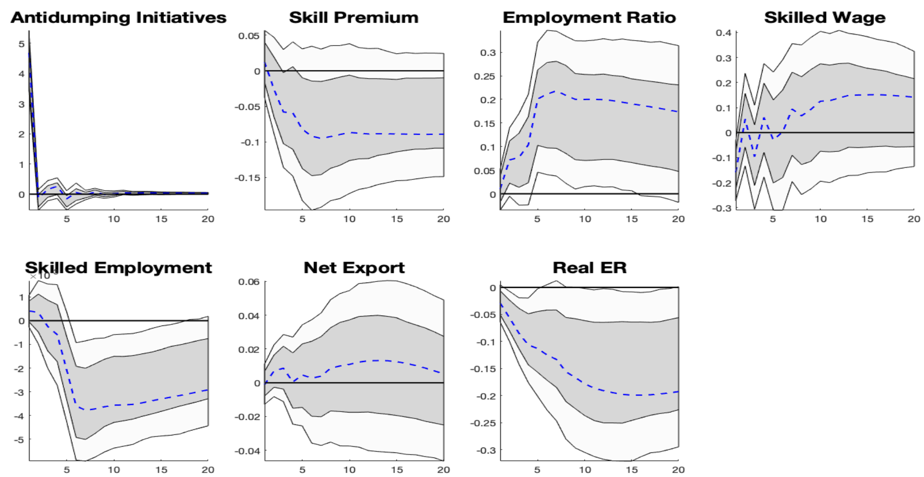

Figure 15: Monthly VAR. One-standard deviation increase in antidumping initiatives on countries excluding China

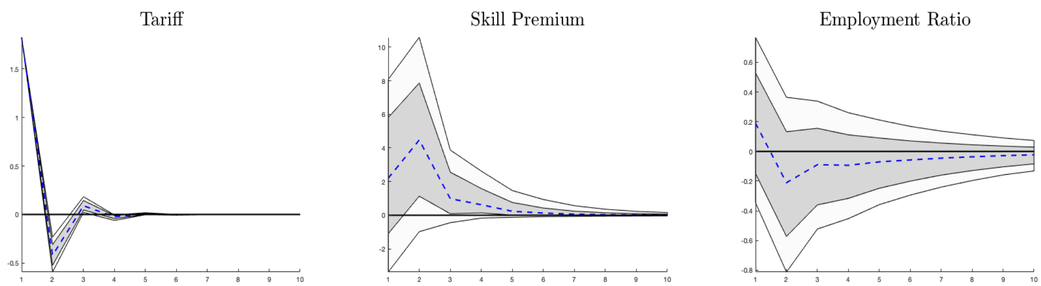

Figure 16: Panel VAR. One-standard deviation increase in detrendeded applied tariffs with import weights being fixed at the 1995 level.

for endogeneity of the import weights. Figure 16 shows the corresponding VAR results. It is worth noting that with an initial jump on impact, tariff experiences a decline in the second period, while skill premium increases and employment ratio decreases. Qualitatively, these are consistent with the panel VAR results without pre-fixed import weights as in figure 4. Figure 17 shows the responses of variables using the same tariff data but restricting the sample to countries in the customs union. The results are very similar to those in figure 16. These two robustness checks show that our panel VAR results hold under alternative specifications.

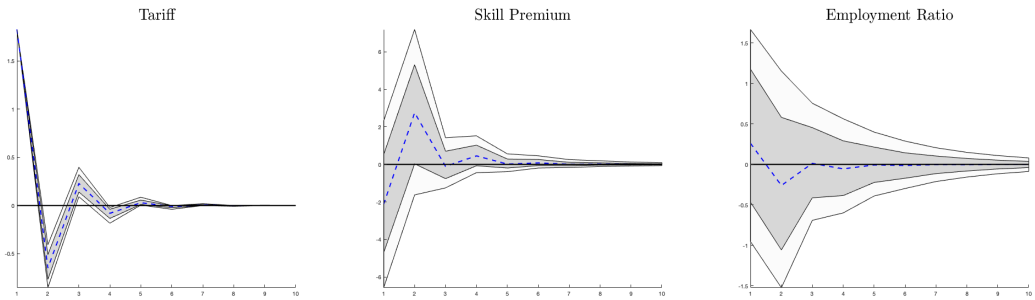

Figure 17: Panel VAR. One-standard deviation increase in detrendeded applied tariffs. Only custom union member countries are included.

C Model summary

Below summarizes the equilibrium conditions of the model.

- average high-skilled employment

  $\tilde{l}_{h,t} = \tilde{l}_{D,h,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{l}_{X,h,t}$

  $\tilde{l}^*_{h,t} = \tilde{l}^*_{D,h,t} + \frac{N^*_{X,t}}{N^*_{D,t}}\tilde{l}^*_{X,h,t}$

- average low-skilled employment

  $\tilde{l}_{l,t} = \tilde{l}_{D,l,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{l}_{X,l,t}$

  $\tilde{l}^*_{l,t} = \tilde{l}^*_{D,l,t} + \frac{N^*_{X,t}}{N^*_{D,t}}\tilde{l}^*_{X,l,t}$

- average capital stock

  $\tilde{k}_t = \tilde{k}_{D,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{k}_{X,t}$

  $\tilde{k}^*_t = \tilde{k}^*_{D,t} + \frac{N^*_{X,t}}{N^*_{D,t}}\tilde{k}^*_{X,t}$

- flow value of unemployment for high-skilled workers

  $b_{h,t} = \chi_h / C_t^{-\eta} + \varkappa_h$

  $b^*_{h,t} = \chi_h / C_t^{*-\eta} + \varkappa^*_h$

- flow value of unemployment for low-skilled workers

  $b_{l,t} = \chi_l / C_t^{-\eta} + \varkappa_l$

  $b^*_{l,t} = \chi_l / C_t^{*-\eta} + \varkappa^*_l$

- symmetry conditions for labor ratios

  $\frac{\tilde{l}_{D,h,t}}{\tilde{l}_{D,l,t}} = \frac{\tilde{l}_{X,h,t}}{\tilde{l}_{X,l,t}}$

$$\frac{\tilde{l}^*_{D,h,t}}{\tilde{l}^*_{D,l,t}} = \frac{\tilde{l}^*_{X,h,t}}{\tilde{l}^*_{X,l,t}}$$

- symmetry conditions for capital-labor ratios

$$\frac{\tilde{l}_{D,h,t}}{\tilde{k}_{D,t}} = \frac{\tilde{l}_{X,h,t}}{\tilde{k}_{X,t}}$$

$$\frac{\tilde{l}^*_{D,h,t}}{\tilde{k}^*_{D,t}} = \frac{\tilde{l}^*_{X,h,t}}{\tilde{k}^*_{X,t}}$$

- high-skilled job creation

$$\frac{\kappa}{\nu_{h,t}} = (1-\zeta_h)\varphi_t Z_t \frac{\partial \tilde{F}}{\partial \tilde{l}_{h,t}} + (1-\sigma_h)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{h,t+1}}\right] - \zeta_h E_t[\beta_{t,t+1}\mu_{h,t+1}\frac{\kappa}{\nu_{h,t+1}}] - (1-\zeta_h)b_{h,t}$$

$$\frac{\kappa}{\nu^*_{h,t}} = (1-\zeta_h)\varphi^*_t Z^*_t \frac{\partial \tilde{F}^*}{\partial \tilde{l}^*_{h,t}} + (1-\sigma_h)(1-\delta)E_t\left[\beta^*_{t,t+1}\frac{\kappa}{\nu^*_{h,t+1}}\right] - \zeta_h E_t[\beta^*_{t,t+1}\mu^*_{h,t+1}\frac{\kappa}{\nu^*_{h,t+1}}] - (1-\zeta_h)b^*_{h,t}$$

- low-skilled job creation

$$\frac{\kappa}{\nu_{l,t}} = (1-\zeta_l)\varphi_t Z_t \frac{\partial \tilde{F}}{\partial \tilde{l}_{l,t}} + (1-\sigma_l)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{l,t+1}}\right] - \zeta_l E_t[\beta_{t,t+1}\mu_{l,t+1}\frac{\kappa}{\nu_{l,t+1}}] - (1-\zeta_l)b_{l,t}$$

$$\frac{\kappa}{\nu^*_{l,t}} = (1-\zeta_l)\varphi^*_t Z^*_t \frac{\partial \tilde{F}^*}{\partial \tilde{l}^*_{l,t}} + (1-\sigma_l)(1-\delta)E_t\left[\beta^*_{t,t+1}\frac{\kappa}{\nu^*_{l,t+1}}\right] - \zeta_l E_t[\beta^*_{t,t+1}\mu^*_{l,t+1}\frac{\kappa}{\nu^*_{l,t+1}}] - (1-\zeta_l)b^*_{l,t}$$

- bargained wage for high-skilled workers

$$w_{h,t} = \zeta_h\varphi_t Z_t \frac{\partial \tilde{F}}{\partial \tilde{l}_{h,t}} + (1-\zeta_h)(b_{h,t} + E_t[\beta_{t,t+1}\mu_{h,t+1}\frac{\zeta_h}{1-\zeta_h}\frac{\kappa}{\nu_{h,t+1}}])$$

$$w^*_{h,t} = \zeta_h\varphi^*_t Z^*_t \frac{\partial \tilde{F}^*}{\partial \tilde{l}^*_{h,t}} + (1-\zeta_h)(b^*_{h,t} + E_t[\beta^*_{t,t+1}\mu^*_{h,t+1}\frac{\zeta_h}{1-\zeta_h}\frac{\kappa}{\nu^*_{h,t+1}}])$$

- bargained wage for low-skilled workers

$$w_{l,t} = \zeta_l\varphi_t Z_t \frac{\partial \tilde{F}}{\partial \tilde{l}_{l,t}} + (1-\zeta_l)(b_{l,t} + E_t[\beta_{t,t+1}\mu_{l,t+1}\frac{\zeta_l}{1-\zeta_l}\frac{\kappa}{\nu_{l,t+1}}])$$

$$w^*_{l,t} = \zeta_l\varphi^*_t Z^*_t \frac{\partial \tilde{F}^*}{\partial \tilde{l}^*_{l,t}} + (1-\zeta_l)(b^*_{l,t} + E_t[\beta^*_{t,t+1}\mu^*_{l,t+1}\frac{\zeta_l}{1-\zeta_l}\frac{\kappa}{\nu^*_{l,t+1}}])$$

- demand for capital

$$r_t = \varphi_t Z_t \frac{\partial \tilde{F}}{\partial \tilde{k}_t}$$

$$r^*_t = \varphi^*_t Z^*_t \frac{\partial \tilde{F}^*}{\partial \tilde{k}^*_t}$$

- Euler equations for bond holdings

$$(C_t)^{-\eta} = \beta(1 + r^b_{t+1})E_t[(C_{t+1})^{-\eta}]$$

$$(C^*_t)^{-\eta} = \beta(1 + r^{b*}_{t+1})E_t[(C^*_{t+1})^{-\eta}]$$

- Euler equations for share holdings

$$\tilde{e}_t = E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\eta}(1-\delta)\beta\left(\tilde{e}_{t+1} + \tilde{d}_{t+1}\right)\right]$$

$$\tilde{e}_t^* = E_t \left[\left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\eta} (1-\delta)\beta \left(\tilde{e}_{t+1}^* + \tilde{d}_{t+1}^* \right) \right]$$

- Euler equations for physical capital

$$(C_t)^{-\eta} \left[1 + \omega \left(\frac{K_{t+1}}{K_t} - 1 \right) \right] = \beta E_t \left\{ (C_{t+1})^{-\eta} \left[r_{t+1} + (1-\delta^k) + \frac{\omega}{2} \left[\left(\frac{K_{t+2}}{K_{t+1}} \right)^2 - 1 \right] \right] \right\}$$

$$(C_t^*)^{-\eta} \left[1 + \omega \left(\frac{K_{t+1}^*}{K_t^*} - 1 \right) \right] = \beta E_t \left\{ (C_{t+1}^*)^{-\eta} \left[r_{t+1}^* + (1-\delta^k) + \frac{\omega}{2} \left[\left(\frac{K_{t+2}^*}{K_{t+1}^*} \right)^2 - 1 \right] \right] \right\}$$

- law of motion for capital

$$K_{t+1} = I_t + (1-\delta^k)K_t - \frac{\omega}{2} \left(\frac{K_{t+1}}{K_t} - 1 \right)^2 K_t$$

$$K_{t+1}^* = I_t^* + (1-\delta^k)K_t^* - \frac{\omega}{2} \left(\frac{K_{t+1}^*}{K_t^*} - 1 \right)^2 K_t^*$$

- average real prices

$$\tilde{\rho}_{D,t} = \frac{\psi}{\psi-1}\varphi_t (\left(\frac{\vartheta}{\vartheta-(\psi-1)} \right)^{\frac{1}{\psi-1}} z_{\min})^{-1}$$

$$\tilde{\rho}_{X,t} = Q_t^{-1}\tau_t \frac{\psi}{\psi-1}\varphi_t \left(\tilde{z}_{X,t} \right)^{-1}$$

$$\tilde{\rho}_{D,t}^* = \frac{\psi}{\psi-1}\varphi_t^* (\left(\frac{\vartheta}{\vartheta-(\psi-1)} \right)^{\frac{1}{\psi-1}} z_{\min})^{-1}$$

$$\tilde{\rho}_{X,t}^* = Q_t\tau_t^* \frac{\psi}{\psi-1}\varphi_t^* \left(\tilde{z}_{X,t}^* \right)^{-1}$$

- aggregate demand for the composite goods

$$Y_t = C_t + I_t + N_{E,t}f_{r,t} + N_{X,t}f_{X,t} + \kappa(V_{h,t} + V_{l,t})$$

$$Y_t^* = C_t^* + I_t^* + N_{E,t}^*f_{r,t}^* + N_{X,t}^*f_{X,t}^* + \kappa(V_{h,t}^* + V_{l,t}^*)$$

- profits/dividends

$$\tilde{d}_{D,t} = \frac{1}{\psi} \left[\tilde{\rho}_{D,t} \right]^{1-\psi} Y_t$$

$$\tilde{d}_{X,t} = \frac{Q_t}{\psi} \left[\tilde{\rho}_{X,t} \right]^{1-\psi} Y_t^* - f_{X,t}$$

$$\tilde{d}_{D,t}^* = \frac{1}{\psi} \left[\tilde{\rho}_{D,t}^* \right]^{1-\psi} Y_t^*$$

$$\tilde{d}_{X,t}^* = \frac{Q_t^{-1}}{\psi} \left[\tilde{\rho}_{X,t}^* \right]^{1-\psi} Y_t - f_{X,t}^*$$

$$\tilde{d}_t = \tilde{d}_{D,t} + \frac{N_{X,t}}{N_{D,t}}\tilde{d}_{X,t}$$

$$\tilde{d}_t^* = \tilde{d}_{D,t}^* + \frac{N_{X,t}^*}{N_{D,t}^*}\tilde{d}_{X,t}^*$$

- price indexes

$$N_{D,t} \left(\tilde{\rho}_{D,t} \right)^{1-\psi} + N_{X,t}^* \left(\tilde{\rho}_{X,t}^* \right)^{1-\psi} = 1$$

$$N_{D,t}^* \left(\tilde{\rho}_{D,t}^* \right)^{1-\psi} + N_{X,t} \left(\tilde{\rho}_{X,t} \right)^{1-\psi} = 1$$

- free entry

$$\tilde{e}_t = f_{r,t} + \kappa\tilde{l}_{h,t}/\nu_{h,t} + \kappa\tilde{l}_{l,t}/\nu_{l,t} + w_{h,t}\tilde{l}_{h,t} + w_{l,t}\tilde{l}_{l,t}$$

$$\tilde{e}_t^* = f_{r,t}^* + \kappa\tilde{l}_{h,t}^*/\nu_{h,t}^* + \kappa\tilde{l}_{l,t}^*/\nu_{l,t}^* + w_{h,t}^*\tilde{l}_{h,t}^* + w_{l,t}^*\tilde{l}_{l,t}^*$$

- zero-profit export cutoffs

$$\tilde{d}_{X,t} = f_{X,t}\tfrac{\psi-1}{\vartheta-(\psi-1)}$$

$$\tilde{d}_{X,t}^* = f_{X,t}^*\tfrac{\psi-1}{\vartheta-(\psi-1)}$$

- share of exporting firms

$$\tfrac{N_{X,t}}{N_{D,t}} = (z_{\min})^{\vartheta}\left(\tilde{z}_{X,t}\right)^{-\vartheta}\left[\tfrac{\vartheta}{\vartheta-(\psi-1)}\right]^{\vartheta/(\psi-1)}$$

$$\tfrac{N_{X,t}^*}{N_{D,t}^*} = (z_{\min})^{\vartheta}\left(\tilde{z}_{X,t}^*\right)^{-\vartheta}\left[\tfrac{\vartheta}{\vartheta-(\psi-1)}\right]^{\vartheta/(\psi-1)}$$

- number of firms

$$N_{D,t} = (1-\delta)\left(N_{D,t-1} + N_{E,t-1}\right)$$

$$N_{D,t}^* = (1-\delta)\left(N_{D,t-1}^* + N_{E,t-1}^*\right)$$

- aggregate high-skilled job seekers

$$S_{h,t} = \bar{L}_h - (1-\sigma_h)(1-\delta)L_{h,t-1}$$

$$S_{h,t}^* = \bar{L}_h^* - (1-\sigma_h)(1-\delta)L_{h,t-1}^*$$

- aggregate low-skilled job seekers

$$S_{l,t} = \bar{L}_l - (1-\sigma_l)(1-\delta)L_{l,t-1}$$

$$S_{l,t}^* = \bar{L}_l^* - (1-\sigma_l)(1-\delta)L_{l,t-1}^*$$

- transition rate for vacancies for high-skilled workers

$$\nu_{h,t} = \xi_h(S_{h,t}/V_{h,t})^{1-\varepsilon}$$

$$\nu_{h,t}^* = \xi_h^*(S_{h,t}^*/V_{h,t}^*)^{1-\varepsilon}$$

- transition rate for vacancies for low-skilled workers

$$\nu_{l,t} = \xi_l(S_{l,t}/V_{l,t})^{1-\varepsilon}$$

$$\nu_{l,t}^* = \xi_l^*(S_{l,t}^*/V_{l,t}^*)^{1-\varepsilon}$$

- job-finding rate for high-skilled workers

$$\mu_{h,t} = \xi_h(S_{h,t}/V_{h,t})^{-\varepsilon}$$

$$\mu_{h,t}^* = \xi_h^*(S_{h,t}^*/V_{h,t}^*)^{-\varepsilon}$$

- job-finding rate for low-skilled workers

$\mu_{l,t} = \xi_l (S_{l,t}/V_{l,t})^{-\varepsilon}$

$\mu^*_{l,t} = \xi^*_l (S^*_{l,t}/V^*_{l,t})^{-\varepsilon}$

- goods market clearing for the representative domestic firm

$$[\tilde{\rho}_{D,t}]^{-\psi} Y_t = Z_t \left(\frac{\vartheta}{\vartheta-(\psi-1)}\right)^{\frac{1}{\psi-1}} z_{\min} \left[\phi \left[\lambda \left(\tilde{k}_{D,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}_{D,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}_{D,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}}$$

$$\left[\tilde{\rho}^*_{D,t}\right]^{-\psi} Y^*_t = Z^*_t \left(\frac{\vartheta}{\vartheta-(\psi-1)}\right)^{\frac{1}{\psi-1}} z_{\min} \left[\phi \left[\lambda \left(\tilde{k}^*_{D,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}^*_{D,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}^*_{D,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}}$$

- goods market clearing for the representative exporter

$$\tau_t \left[\tilde{\rho}_{X,t}\right]^{-\psi} Y^*_t = Z_t \tilde{z}_{X,t} \left[\phi \left[\lambda \left(\tilde{k}_{X,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}_{X,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}_{X,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}}$$

$$\tau^*_t \left[\tilde{\rho}^*_{X,t}\right]^{-\psi} Y_t = Z^*_t \tilde{z}^*_{X,t} \left[\phi \left[\lambda \left(\tilde{k}^*_{X,t}\right)^{\gamma} + (1-\lambda)\left(\tilde{l}^*_{X,h,t}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\left(\tilde{l}^*_{X,l,t}\right)^{\alpha}\right]^{\frac{1}{\alpha}}$$

- aggregate accounting

$L_{h,t} = (N_{D,t} + N_{E,t})\tilde{l}_{h,t}$

$L^*_{h,t} = (N^*_{D,t} + N^*_{E,t})\tilde{l}^*_{h,t}$

$L_{l,t} = (N_{D,t} + N_{E,t})\tilde{l}_{l,t}$

$L^*_{l,t} = (N^*_{D,t} + N^*_{E,t})\tilde{l}^*_{l,t}$

$K_t = N_{D,t}\tilde{k}_t$

$K^*_t = N_{D,t}\tilde{k}^*_t$

- low of motion for aggregate high-skilled employment

$L_{h,t} = \nu_{h,t} V_{h,t} + (1-\sigma_h)(1-\delta)L_{h,t-1}$

$L^*_{h,t} = \nu^*_{h,t} V^*_{h,t} + (1-\sigma_h)(1-\delta)L^*_{h,t-1}$

- low of motion for aggregate low-skilled employment

$L_{l,t} = \nu_{l,t} V_{l,t} + (1-\sigma_l)(1-\delta)L_{l,t-1}$

$L^*_{l,t} = \nu^*_{l,t} V^*_{l,t} + (1-\sigma_l)(1-\delta)L^*_{l,t-1}$

- balanced trade

$Q_t N_{X,t} (\tilde{\rho}_{X,t})^{1-\psi} Y^*_t = N^*_{X,t} (\tilde{\rho}^*_{X,t})^{1-\psi} Y_t$

- The above equations constitute a system of 81 equations in 81 endogenous variables: $\tilde{l}_{D,h,t}$, $\tilde{l}_{D,l,t}$, $\tilde{l}_{X,h,t}$, $\tilde{l}_{X,l,t}$, $\tilde{k}_{D,t}$, $\tilde{k}_{X,t}$, $\tilde{l}_{h,t}$, $\nu_{h,t}$, $\tilde{l}_{l,t}$, $\nu_{l,t}$, φ_t, C_t, $\mu_{h,t}$, $b_{h,t}$, $\mu_{l,t}$, $b_{l,t}$, r_t, $\tilde{k}_t$, r^b_t, $\tilde{e}_t$, $\tilde{d}_t$, K_t, I_t, $\tilde{\rho}_{D,t}$, $\tilde{\rho}_{X,t}$, $\tilde{z}_{X,t}$, Y_t, $N_{E,t}$, $N_{X,t}$, $V_{h,t}$, $V_{l,t}$, $\tilde{d}_{D,t}$, $\tilde{d}_{X,t}$, $N_{D,t}$, $w_{h,t}$, $w_{l,t}$, $L_{h,t}$, $L_{l,t}$, $S_{h,t}$, $S_{l,t}$, their Foreign counterparts and the real exchange rate Q_t. Additionally, there are eight exogenous variables, the aggregate productivities Z_t and Z^*_t, and the the policy variables $f_{r,t}$, $f^*_{r,t}$, $f_{X,t}$, $f^*_{X,t}$, τ_t, τ^*_t.

D Nash wage bargaining

We assume wage is the solution of an individual Nash bargaining between a firm and a worker. The equilibrium sharing rule resulting from the bargaining between a type j worker and a producer with productivity z can be written as $\zeta_j S^F_{j,t}(z) = (1-\zeta_j)S^W_{j,t}(z)$, where $\zeta_j \in (0,1)$ represents the type j worker's bargaining share, $S^F_{j,t}(z)$ is firm surplus, and $S^W_{j,t}(z)$ is worker surplus. The surplus of the match to the firm corresponds to the value of the job to the firm, which is given by the marginal revenue product of the match, plus its expected savings from posting the job next period, net of the wage bill:

$$S^F_{j,t}(z) = \varphi_t(z) z Z_t \frac{\partial F(z)}{\partial l_{j,t}(z)} - w_{j,t}(z) + (1-\sigma_j)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{j,t+1}}\right] = \frac{\kappa}{\nu_{j,t}} \tag{A.1}$$

Equation (A.1) implies the surplus to the firm is symmetric across z, i.e. $S^F_{j,t}(z) = S^F_{j,t}$. The sharing rule further implies the surplus to the worker is also symmetric across z, i.e. $S^W_{j,t}(z) = \frac{\zeta_j}{1-\zeta_j} S^F_{j,t}(z) = \frac{\zeta_j}{1-\zeta_j}\frac{\kappa}{\nu_{j,t}} = S^W_{j,t}$. Meanwhile, the surplus to the worker can be expressed as the current wage net of the worker's outside option $\bar{\omega}_{j,t}$, plus the expected discounted continuation value of the match for the worker, $S^W_{j,t+1} = \frac{\zeta_j}{1-\zeta_j}\frac{\kappa}{\nu_{j,t+1}}$:

$$S^W_{j,t} = w_{j,t}(z) - \bar{\omega}_{j,t} + (1-\sigma_j)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\zeta_j}{1-\zeta_j}\frac{\kappa}{\nu_{j,t+1}}\right] \tag{A.2}$$

where the worker's outside option is equal to the flow value of unemployment, $b_{j,t} \equiv \chi_j / C_t^{-\eta} + \varkappa_j$, plus the value of searching for other jobs in the next period:

$$\bar{\omega}_{j,t} = b_{j,t} + E_t[\beta_{t,t+1}\mu_{j,t+1}\frac{\zeta_j}{1-\zeta_j}\frac{\kappa}{\nu_{j,t+1}}] \tag{A.3}$$

Equation (A.2) and (A.3) imply worker's wage is symmetric across z, i.e. $w_{j,t}(z) = w_{j,t}$. Plug (A.1) and (A.2) into the sharing rule, we obtain the expression for the bargained wage:

$$w_{j,t} = \zeta_j \varphi_t(z) z Z_t \frac{\partial F(z)}{\partial l_{j,t}(z)} + (1-\zeta_j)\bar{\omega}_{j,t} \tag{A.4}$$

which shows that the bargained wage is a weighted average between the marginal revenue product of the worker and the worker's outside option.

Plugging (A.4) into (A.1), the job creation equation can be expressed as:

$$\frac{\kappa}{\nu_{j,t}} = (1-\zeta_j)\varphi_t(z) z Z_t \frac{\partial F(z)}{\partial l_{j,t}(z)} + (1-\sigma_j)(1-\delta)E_t\left[\beta_{t,t+1}\frac{\kappa}{\nu_{j,t+1}}\right] - \zeta_j E_t[\beta_{t,t+1}\mu_{j,t+1}\frac{\kappa}{\nu_{j,t+1}}] - (1-\zeta_j)b_{j,t} \tag{A.5}$$

E Proof of $\varphi_t(z)z$ symmetric across z

(A.4) implies $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{h,t}(z)}$ and $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{l,t}(z)}$ are both symmetric across z. (7) implies $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial k_t(z)}$ is also symmetric across z. The above results further lead to the fact that the ratio of $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{h,t}(z)}$ to $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial k_t(z)}$ and the ratio of $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial k_t(z)}$ to $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{l,t}(z)}$ are both symmetric across z, which means $\frac{1-\lambda}{\lambda}\left(\frac{l_{h,t}(z)}{k_t(z)}\right)^{(\gamma-1)}$ and $\frac{\phi\lambda}{1-\phi}\left[\lambda + (1-\lambda)\left(\frac{l_{h,t}(z)}{k_t(z)}\right)^{\gamma}\right]^{\frac{\alpha-\gamma}{\gamma}}\left(\frac{l_{l,t}(z)}{k_t(z)}\right)^{1-\alpha}$ are symmetric across z. Therefore, $\frac{l_{h,t}(z)}{k_t(z)}$ and $\frac{l_{l,t}(z)}{k_t(z)}$ are both symmetric across z, which further implies $\frac{l_{h,t}(z)}{l_{l,t}(z)}$ is symmetric across z.

Meanwhile, we have $\frac{\partial F(z)}{\partial l_{l,t}(z)} = (1-\phi)[\frac{F(z)}{l_{l,t}(z)}]^{1-\alpha}$ and $\frac{F(z)}{l_{l,t}(z)} = \left[\phi\left[\lambda\left(\frac{k_t(z)}{l_{l,t}(z)}\right)^{\gamma} + (1-\lambda)\left(\frac{l_{h,t}(z)}{l_{l,t}(z)}\right)^{\gamma}\right]^{\frac{\alpha}{\gamma}} + (1-\phi)\right]^{\frac{1}{\alpha}}$. Thus, $\frac{\partial F(z)}{\partial l_{l,t}(z)}$ is symmetric across z. Combining this result with the fact that $\varphi_t(z)zZ_t\frac{\partial F(z)}{\partial l_{l,t}(z)}$ is also symmetric across z, it implies $\varphi_t(z)z$ is symmetric across z. This concludes the proof.

F More log linearization results

The ratio of the marginal product of labor between high-skilled and low-skilled labor is:

$$\text{ratio-Fl}_t \equiv \frac{\frac{\partial \tilde{F}}{\partial \tilde{l}_{h,t}}}{\frac{\partial \tilde{F}}{\partial \tilde{l}_{l,t}}} = \frac{\phi(1-\lambda)}{1-\phi}[\lambda(\frac{k_t}{l_{h,t}})^{\gamma} + (1-\lambda)]^{\frac{\alpha-\gamma}{\gamma}}(\frac{l_{l,t}}{l_{h,t}})^{1-\alpha}$$

Log linearize the above equation, we get:

$$\hat{\text{ratio-Fl}}_t = \frac{(\alpha-\gamma)\lambda(\frac{k}{l_h})^\gamma}{\lambda(\frac{k}{l_h})^\gamma + (1-\gamma)}\hat{k}_t + (1-\alpha)\hat{l}_{l,t} - \frac{(1-\gamma)\lambda(\frac{k}{l_h})^\gamma + (1-\alpha)(1-\lambda)}{\lambda(\frac{k}{l_h})^\gamma + (1-\lambda)}\hat{l}_{h,t} \qquad \text{(A.6)}$$

By linearizing the equation of the definition of the aggregate employment of skill type k, i.e. $L_{k,t} = (N_{D,t} + N_{E,t})\tilde{l}_{k,t}$, we get:

$$\hat{L}_{k,t} = \frac{N_D}{N_D + N_E}\hat{N}_{D,t} + \frac{N_E}{N_D + N_E}\hat{N}_{E,t} + \hat{l}_{k,t} \qquad \text{(A.7)}$$

G More figures

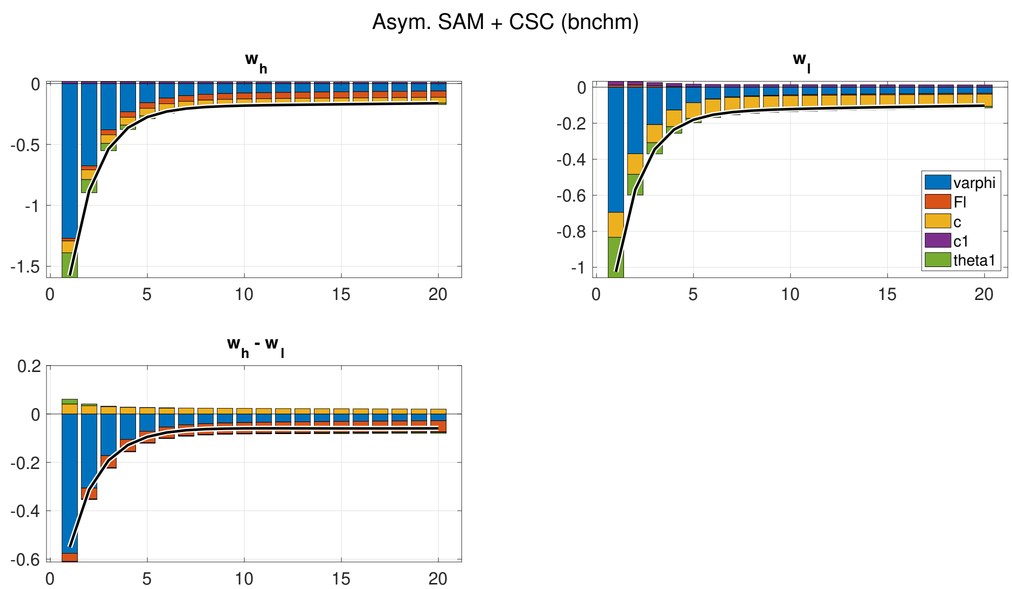

Figure 18: **Responses to a temporary increase in Home trade barriers, Asym. SAM + CSC scenario (benchamrk). Responses show percentage deviations from the steady state.**

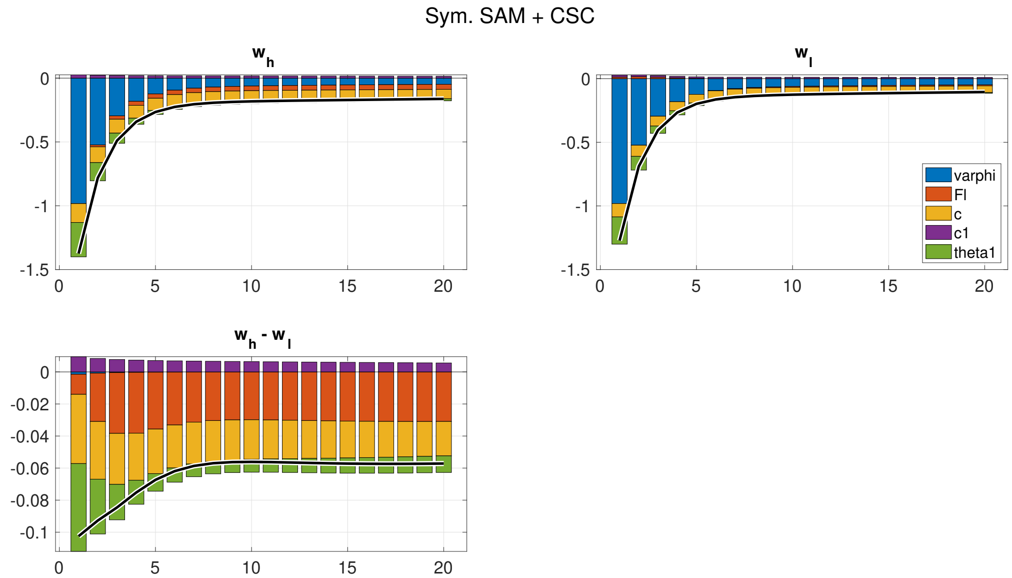

Figure 19: **Responses to a temporary increase in Home trade barriers, Sym. SAM + CSC scenario. Responses show percentage deviations from the steady state.**

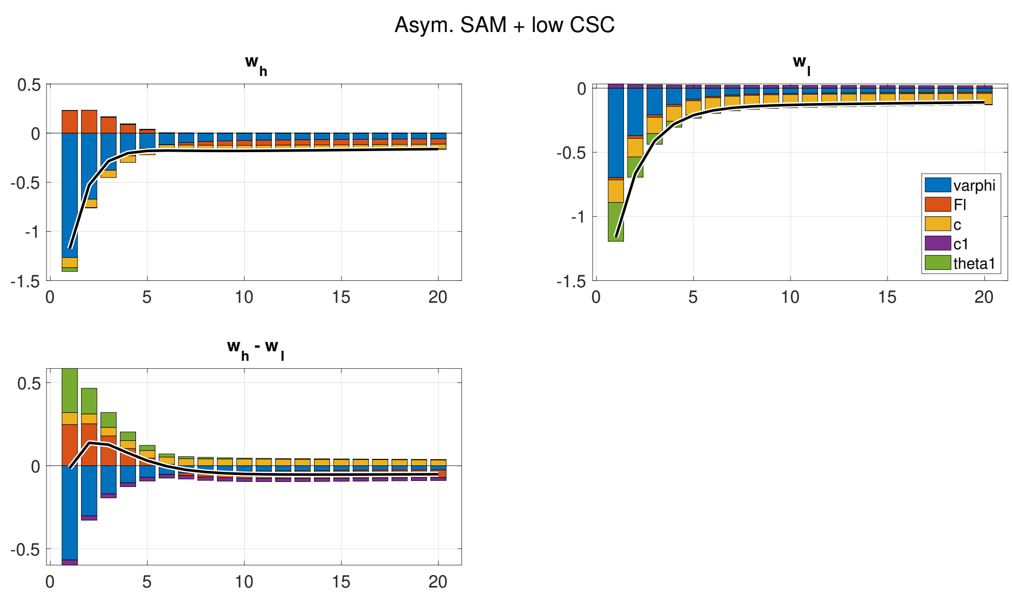

Figure 20: **Responses to a temporary increase in Home trade barriers, Asym. SAM + low CSC scenario. Responses show percentage deviations from the steady state.**

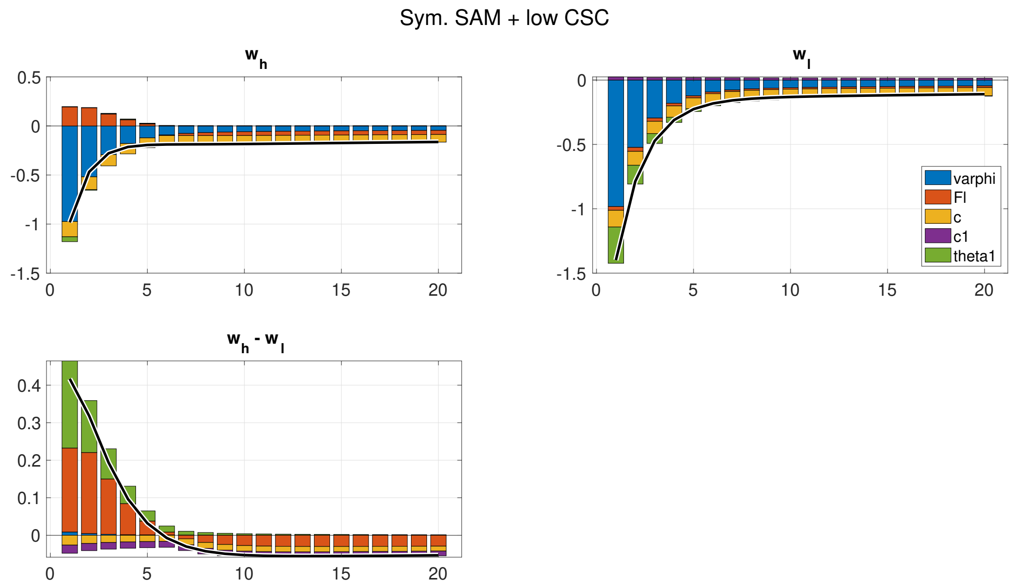

Figure 21: **Responses to a temporary increase in Home trade barriers, Sym. SAM + low CSC scenario. Responses show percentage deviations from the steady state.**

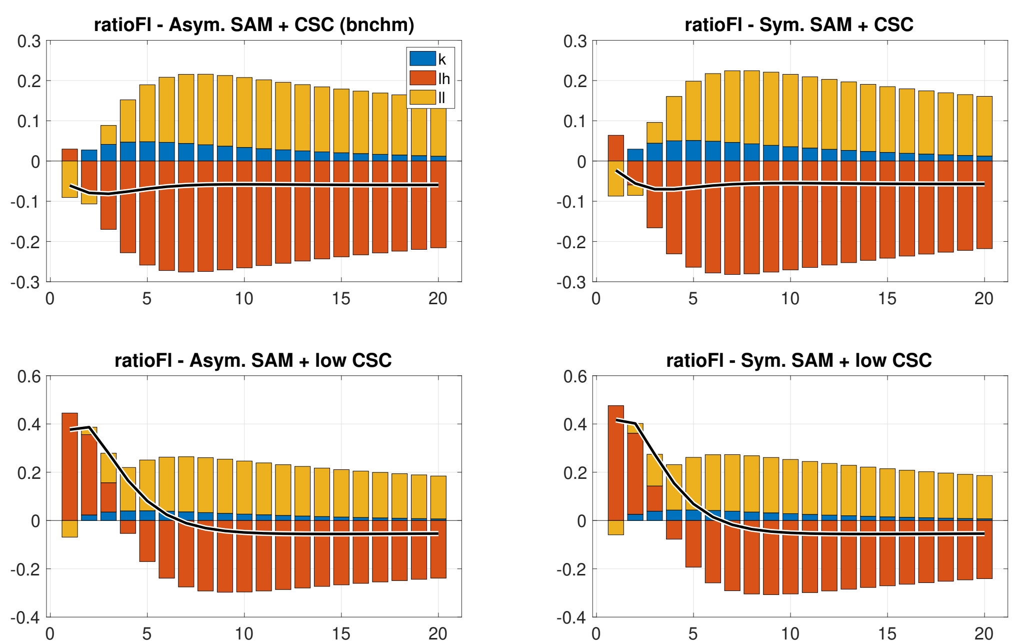

Figure 22: **Responses to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**

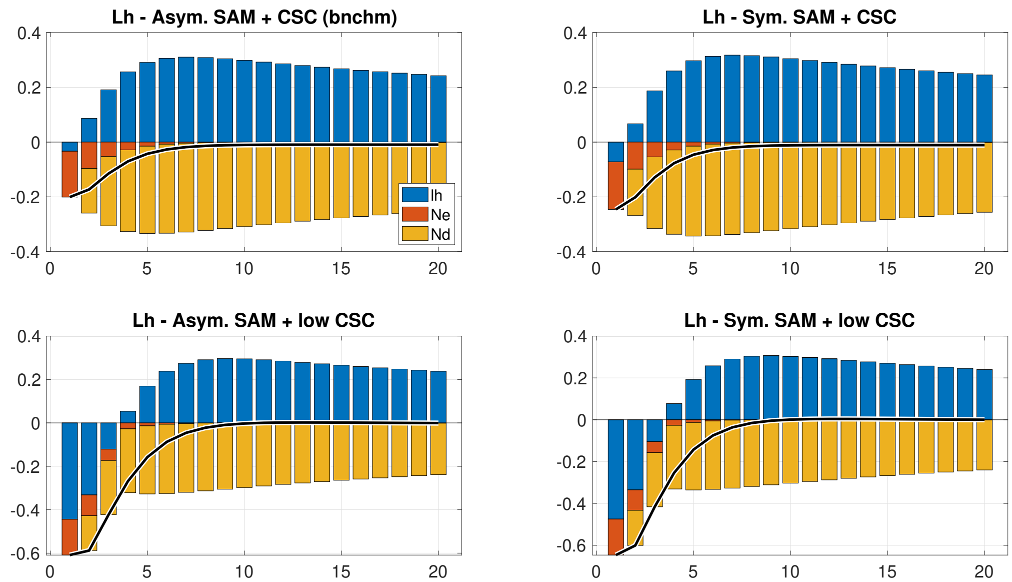

Figure 23: **Responses to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**

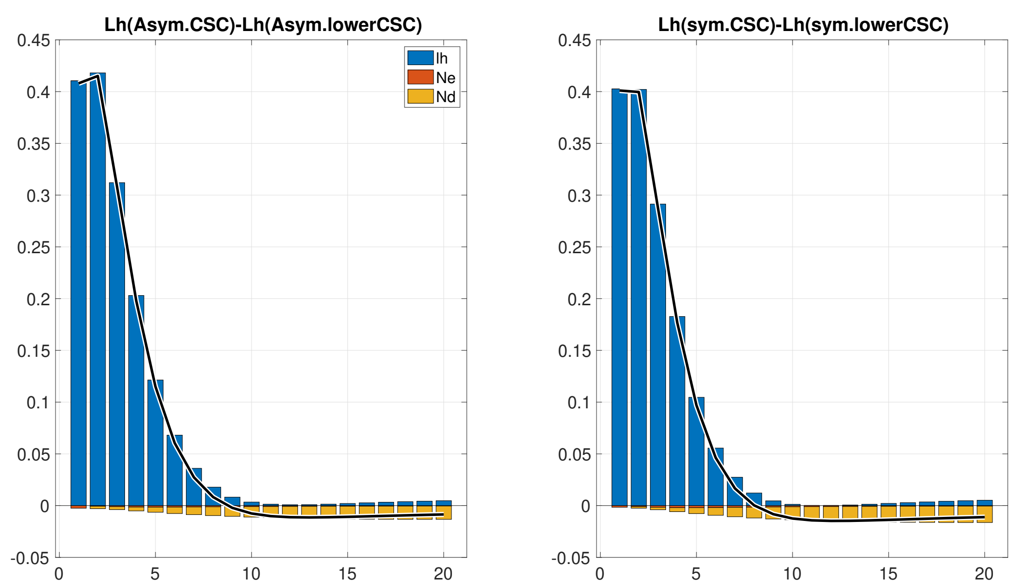

Figure 24: **Responses to a temporary increase in Home trade barriers, different scenarios. Responses show percentage deviations from the steady state.**