Dynamic Effects of Industrial Policies Amidst Geoeconomic Tensions*

Ziran Ding† Adam Hal Spencer‡ Zinan Wang §

May, 2024

Preliminary and incomplete, please do not circulate without permission

Abstract

Policymakers use various industrial policies to achieve geopolitical and economic goals. What are the dynamic and welfare effects of these policies? How does the short-sightedness of policymakers influence their choice of instrument? What are the distributional consequences of these protectionist measures? We study these questions in a two-country open economy macro framework with firm heterogeneity, trade, and offshoring of tasks. We then calibrate the model to the context of the US and China and utilize it as a laboratory to explore the effects of four popular industrial policies: import tariff, offshoring friction, domestic production subsidy, and entry subsidy. We find that myopic policymakers are incentivized to subsidize production, yielding short-term gains and long-term losses. More forward-looking policymakers prefer to levy import tariffs; however joint losses are incurred at all time horizons when used by both countries simultaneously. Although all policy instruments reduce skill premiums of the imposing country in the short-run, some of them incur welfare losses in the long-run.

JEL Classification: F23, F41, F51, F62, L51

Keywords: Macroeconomic dynamics; Firm heterogeneity; Trade; Trade-in-tasks; Industrial policies; Welfare; Global value chains

---

*We would like to thank the seminar participants at the Bank of Lithuania and the National Bank of Ukraine. We are also grateful to Andrei Zlate, Jake Bradley, Matteo Cacciatore, Julien Martin, Wolfgang Lechthaler for their helpful conversations. The views expressed in this paper are those of the authors and do not necessarily reflect the position of the Bank of Lithuania or the Eurosystem. All errors are ours.

†Bank of Lithuania and Kaunas University of Technology, Lithuania, e-mail: zding@lb.lt

‡University of Nottingham, UK, e-mail: adam.spencer@nottingham.ac.uk

§Ma Yinchu School of Economics, Tianjin University, China e-mail: wangzn@tju.edu.cn

1 Introduction

After decades of reaping the benefits of globalization, the world has been witnessing profound backlash against globalization. Following the slow recovery after the global financial crisis, global trade and investment were further distressed by the US-China trade war. This trend was then exacerbated by the recent Covid-19 pandemic and Russia's war against Ukraine. Amid these waves of geoeconomic tension, industrial policy became a popular choice for policymakers to drive the rivalry between nations and secure each country's own interest. Take the economic conflicts between the US and China as an example. The Biden administration's "CHIPS Act" is deemed as a direct response to China's "MIC 2025" project. China's export control of gallium and germanium in July 2023 was an immediate retaliation against the export control of cutting-edge chips of the US in October 2022. The effects of these policies go well beyond national borders, affecting the global economy through channels that are often intertwined, making it difficult to understand their intended and unintended consequences. This study aims to contribute to this understanding through the lens of a micro-founded model of international trade and offshoring with macroeconomic dynamics.

We begin our analysis by extending the two-country model proposed by Zlate (2016). We embed trade-in-task (Grossman and Rossi-Hansberg, 2008) into Zlate's framework and extend the model to allow offshoring activity in both countries.[1] In our setting, both countries are endowed with high-skilled and low-skilled labor. The North is relatively more abundant in the former while the South is more abundant in the latter. The endowment differences translate into wage differences across skill classes in both countries. For simplicity, we assume each country only has one sector that supplies differentiated varieties; the production of varieties requires the input of both types of labor. As in Zlate (2016), the key model ingredients include endogenous firm entry, heterogeneous labor productivity, endogenous export, and offshoring decisions. Due to the South's abundance of low-skilled labor, more productive firms in the North find it profitable to offshore low-skilled tasks to the South. On the other hand, due to the North's abundance of high-skilled labor, more productive firms in the South find it profitable to offshore high-skill tasks to the North. As a result of each country's cost advantage, the extensive margin of North's offshoring activity depends crucially on the cost of effective low-

[1] In Zlate (2016), only firms in the North offshore their production to the South to take advantage of the cheap labor costs. Firms in the South only access the North market via export.

skilled labor while the offshoring activity of South depends on the cost of effective high-skilled labor. In contrast, the extensive margin of export depends on the combination of both types of cost of effective labor.

We then calibrate the model to the context of US and China and utilize it as a laboratory to explore the effects of four popular industrial policies: import tariff, offshoring friction, domestic production subsidy, and entry subsidy. Leveraging the dynamic structure of the model, we account for policymakers with differing horizons of interest.[2] We study the welfare gains along the entire transition path and scenarios for myopic policymakers, with horizons of one and four years. These shorter policy horizons loosely proxy for the concept of decision-making with an eye toward favorable macro indicators in the face of an upcoming election. We study several combinations of unilateral, as well as bilateral policy actions, designed to capture the idea of policy wars. Overall, our results show significant differences in the welfare predictions of policy scenarios between the short-run and the long-run.

Consider the welfare effects of unilateral single-instrument actions by the North. The strongest action at one and four-year policy horizons is the domestic production subsidy. This instrument depresses entry as it benefits incumbents, reshuffling economic resources from investment in new firms into production. The rise of production boosts firms' labor demand for both high-skilled and low-skilled labor and pushes up wages, translating into higher consumption in the North. A 1% temporary rise in the production subsidy gives 0.2% and 0.04% Northern gains in welfare at one and four-year horizons, respectively. An additional benefit of such policy is the short-run reduction in the wage inequality in the North, although it is at the cost of a deterioration in the South's wage inequality. Over time, due to adverse incentives it creates for entry, a long-run decline in the overall measure of Northern firms gives welfare losses along the whole transition.

In contrast, the North's import tariff and entry subsidy incentivize more long-run firm creation, giving lifetime welfare gains at the expense of short-run consumption losses. The underlying mechanisms of these two instruments are somewhat different. Tariff hikes increase the cost of effective low-skill and high-skill labor in the North relative to the South, inflicting a substantial loss on the North's business profits. The short-run consumption loss would have been much more significant without tariff revenue rebates. Although the entry subsidy spurs

[2]For a similar approach, see Akcigit, Ates and Impullitti (2018) and Milicevic, Defever, Impullitti and Spencer (2022).

firm entry in the North, its positive impact on low-skilled wages is mild, implying that the subsidy could only be funded by a lump-sum transfer from the consumers.

An increase in the offshoring friction faced by the North can be interpreted as a reshoring policy, which reduces the North's reliance on the South's low-skilled tasks and can possibly improve the North's supply chain resilience. This policy incurs welfare loss both in the short run and over time. On impact, reshoring low-skill tasks back to the North forbids firms in the North from taking advantage of low-skilled labor in the South, hurting the prospective profits of firms and depressing firm entry. What is worse, although reshoring boosts demand for low-skilled labor in the North and increases its wages, its impact is balanced out by the drop in high-skilled wages in the North, generating a mild drop in consumption. Over time, the depressed firm entry translates into fewer varieties in the North, generating welfare losses along the whole transition.

As seen in recent policy episodes, a protectionist action from one government is likely to be met by a response from another. To this end, we explore the dynamics of the joint welfare effects of policy wars. Focusing on the one-year horizon, we find that levying production subsidies is the dominant strategy for both North and South. This is mainly driven by production subsidy's positive impact on labor demand and wages, increasing consumption. However, the rising labor costs in the North (South) substantially dwarf the offshoring firms in the North (South), translating into a significant drop in the low-skilled (high-skilled) wage in the South (North), hurting the South's (North's) consumption. Yet such a beggar-thy-neighbor impact is entirely outweighed by the consumption gain; therefore, when both countries make this choice, they obtain mutual welfare gains. If both countries keep this strategy, its negative impact on firm entry starts to materialize, creating losses for the South at four years, and both countries experience losses at an infinite horizon.

Our framework generally paints a dire picture with regard to the long-term effects of policy wars. Long-run welfare is jointly maximized with no policy action from either country, suggesting a laissez-faire style is the best choice. However, both governments have an incentive to levy an import tariff, regardless of the other country's action. On the one hand, the protective environment encourages firm entry. On the other hand, compared to entry subsidy, which also encourages firm entry at the cost of consumption loss, it redistributes resources from foreign exporters and domestic offshorers to the consumers. When economic conflict arises, these two aspects make import tariffs the best single instrument in policymakers' toolbox. It is worth mentioning that the usage of this instrument by both countries delivers welfare losses, regardless of time horizon. This suggests that a trade war between the North and the South, in the presence of both export and offshoring activities, is bad policy in the short-run and the long-run.

Related Literature

This paper is related to several strands of literature. The first strand focuses on the macroeconomic impact of geoeconomic fragmentation. In recent years, with the intensification of geopolitical conflicts, the global economy has gradually shown signs of geoeconomic fragmentation (Aiyar et al., 2023). As a result, a new body of literature has emerged on the macroeconomic implications of the potential decoupling between different geopolitical blocks. Among them, some of them focus on the aggregate impacts of trade and supply chain decoupling (Bolhuis et al., 2023; Attinasi et al., 2023; Javorcik et al., 2023) and find geoeconomic fragmentation could lead to a substantial losses in global GDP. Some others focus on the macroeconomic impact of technology decoupling (Góes and Bekkers, 2022; Cerdeiro et al., 2021) and find technology decoupling could amplify the welfare losses of fragmentation. We contribute to this strand of literature by presenting a dynamic quantitative analysis of various industrial policies, in a canonical international macroeconomic framework with trade and offshoring as its micro-foundation.

Our paper also relates to the strand of literature that focuses on the "trade war" between China and the United States. Existing studies have presented various aspects of the impact of the US-China trade war, such as welfare (Amiti et al., 2019, 2020), the labor market (Benguria and Saffie, 2020), the trade balance (Tu et al., 2020; Ma and Meng, 2023) and others. However, only a few articles have explored the distributional aspect. Among them, Waugh (2019), Fajgelbaum et al. (2020), and Caliendo and Parro (2022) focus on the impacts of the trade war on either consumption or wages across different counties/states in the US. Chor and Li (2021) analyzes the impact of the trade war on the intensity of economic activity across different regions in China. Our contribution to this strand of literature is twofold. First, we study the impact of tariffs on workers with different skill classes in a dynamic macro framework. Second, we compare the effects of tariffs on wages and skill premiums with other industrial policies and discuss their welfare implications.

This paper is also related to the literature on new economics of industrial policy (Juhász et al., 2023). Early research on industrial policies focused on the output, earnings, and growth rates of the industries or countries (Baldwin and Krugman, 1988; Head, 1994; Luzio and Greenstein, 1995; Irwin, 2000; Hansen et al., 2003), while more recent studies have turned to the assessment of productivity effects and cross-sectoral spillovers, among others (Aghion et al., 2015; Lane, 2022; Liu, 2019; Manelici and Pantea, 2021; Choi and Levchenko, 2021; Juhász et al., 2022). More recently, there has been a new literature that integrates industrial policy and trade policy into a unified theoretical framework to quantitatively study the synergies between the two. For example, Lashkaripour and Lugovskyy (2023) study optimal trade and industrial policies in a quantitative trade model. They find that internationally coordinated industrial policies are more effective than any unilaterally implemented policies to reduce the misallocation of resources. Ju et al. (2024) evaluate the impact of the US-China trade war and subsidies on high-tech industries on welfare through a quantitative trade model. They find that properly-implemented industrial subsidies may produce fewer distortions than the imposition of tariffs. In contrast to this literature, our paper takes the underlying steady-state distortions as given, and explores the potential gains and losses of industrial policies along the entire transition path.

Our paper also contributes to the literature on international macroeconomic models with microfoundations, which evolved following work by Melitz (2003) and Ghironi and Melitz (2005) (GM). Several studies have extended the GM framework to address several questions in international macroeconomics. These include works by Auray and Eyquem (2011), Bergin and Corsetti (2020), Cacciatore and Ghironi (2021), Corsetti et al. (2013), Hamano and Zanetti (2017), Imura and Shukayev (2019), Jiang (2023), Kim (2021), and Zlate (2016) among others. In our contribution, we enhance this literature by incorporating a two-way trade-in-tasks (as in Grossman and Rossi-Hansberg (2008)) model of offshoring production (as in Zlate (2016)) into the GM framework. We then utilize this model to examine the dynamic effects of various industrial policies.

The rest of the paper is organized as follows: Section 2 presents the two-country model. Section 3 presents the calibration. Section 4 studies the dynamics and welfare implications of each industrial policy and their possible combinations in the two-country model. Section 5 concludes. The Appendix contains our computation method and additional figures and tables.

2 The Model

Overview

Our framework consists of two countries, North (N) and South (S), all variables for the South are denoted with an asterisk. Each country has one sector, featured with heterogeneous firms producing differentiated varieties. The production of each variety requires two types of labor: high-skilled labor and low-skilled labor, both are supplied inelastically. The North has a relatively higher endowment of high-skill labor, whereas the South has a relatively higher endowment of low-skill labor. The building blocks of our exercise are trade-in-tasks as in Grossman and Rossi-Hansberg (2008), and offshoring as in Zlate (2016).

Our goal here is not to exactly model all kinds of policies, but through some combinations of various policy instruments, we can obtain a good approximation of the ongoing geoeconomic tensions. For this reason, our model is featured with the following four sets of popular policy instruments (Juhász et al., 2022): (i) ad valorem import tariffs (τ^{IM}, τ^{IM*}), (ii) iceberg friction on offshoring low-skill task (τ^{V}) faced by North, and iceberg friction on offshoring high-skill task (τ^{V*}) faced by South, (iii) domestic production subsidies (s_D, s_D^*), and (iv) entry subsidies (s_E, s_E^*).

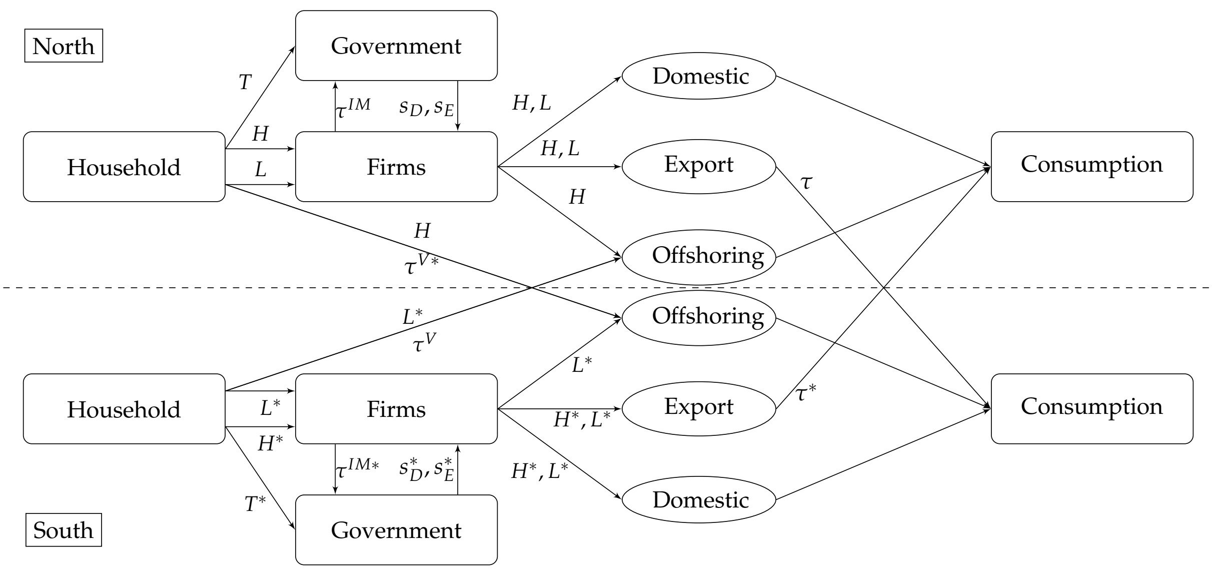

Figure 1. Model structure

2.1 Households

There are two countries – North and South. We denote the Northern endowments of high-skilled labor by H and low-skilled labor by L. The North is assumed to be more high-skilled labor abundant than the South, so that the relative skill abundance is higher for the North than for the South: $H/L > H^*/L^*$. Each economy consists of a unit mass of atomistic households and a continuum of monopolistically competitive firms with heterogeneous levels of labor productivity. As in Ghironi and Melitz (2005), all contracts are written in nominal terms. Since prices are flexible, the variables solved for are all in real terms. Here we mostly focus on presenting the model setup for the North, noting that those for the South hold analogously.

The representative household maximizes expected lifetime utility:

$$\max_{\{C_s, B_{s+1}, x_{s+1}\}_{s=t}^{\infty}} E_t \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\gamma}}{1-\gamma},$$

where $\beta \in (0,1)$ is the subjective discount factor, C_t is the aggregate consumption basket, and $\gamma > 0$ is the inverse of the inter-temporal elasticity of substitution. The budget constraint is:

$$C_t + (N_t + N_{E,t})\, \tilde{v}_t x_{t+1} + B_{N,t+1} = \left(\tilde{v}_t + \tilde{d}_t\right) N_t x_t + (1 + r_t)\, B_{N,t} + w_{h,t} H + w_{l,t} L + T_t. \quad (1)$$

The household purchases two types of assets. First, it purchases x_{t+1} shares in a mutual fund of Northern firms, which includes N_t incumbent firms producing either domestically or offshore at time t, and also $N_{E,t}$ new entrants in period t. The date t price of a claim to the future profit stream of the mutual fund of $N_t + N_{E,t}$ Northern firms is equal to the average nominal price of claims to future profits of Northern firms, $P_t \tilde{v}_t$. The mutual fund pays a total profit that is equal to the average total profits of all Northern firms that produce in that period, $P_t \tilde{d}_t N_t$. The household also receives dividends equal to the average firm profit $\tilde{d}_t$ proportional to the mass of firms N_t. The household also purchases the risk free bond issued by its own country $B_{N,t+1}$, denominated in units of the issuing country's consumption basket. The domestic risk-free bond pays interest rate r_t. Entering period t, the household has share holdings x_t in a mutual fund of N_t Northern firms whose average market value is $\tilde{v}_t$. There are two types of labor – high-skilled labor and low-skilled labor, supplied inelastically, earning real wages $w_{h,t}$ and $w_{l,t}$, while pooling income together. The household also receives transfers from the Northern government.

The consumption basket for the Northern household includes varieties produced by the Northern firms (some of which are offshoring firms), as well as goods produced by the Southern exporters, with the elasticity of substitution $\theta > 1$:

$$C_t = \left[\int_{z_{\min}}^{z_{V,t}} y_{D,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega + \int_{z_{V,t}}^{\infty} y_{V,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega + \int_{z_{X,t}^*}^{\infty} y_{X,t}^*(\omega)^{\frac{\theta-1}{\theta}} d\omega \right]^{\frac{\theta}{\theta-1}}. \tag{2}$$

Each variety $\omega \in \Omega$ is produced by a different firm. As explained below, Northern firms with productivity above the offshoring cutoff $z_{V,t}$ will offshore the low-skilled tasks to the South, whereas firms with productivity above $z_{\min}$ but below $z_{V,t}$ produce their varieties using domestic high-skilled and low-skilled labor tasks. The consumption-based price index for the North is then $P_t = \left(\int_{\omega \in \Omega_t} p_t(\omega)^{1-\theta} d\omega \right)^{1/(1-\theta)}$. Setting the consumption basket C_t as numeraire, the price index for the North is $1 = \left[\rho_t(\omega)^{1-\theta} d\omega \right]^{\frac{1}{1-\theta}}$, where $\rho_t(\omega)$ is the real price of goods of different varieties. The household's demand for each individual good variety ω is $c_t(\omega) = \rho_t^{-\theta} C_t$.

The Southern household earns real wage rate $w_{l,t}^*$ and $w_{h,t}^*$, in units of Southern consumption basket. It maximizes a similar utility function. However, the composition of the consumption basket is different. The subset of goods available for consumption in the South Ω_t^* consists of goods produced by the Southern firms (some of which are offshoring firms), as well as goods produced by the Northern exporters, which is expressed as:

$$C_t^* = \left[\int_{z_{\min}}^{z_{V,t}^*} y_{D,t}^*(\omega)^{\frac{\theta}{\theta-1}} d\omega + \int_{z_{V,t}^*}^{\infty} y_{V,t}^*(\omega)^{\frac{\theta}{\theta-1}} d\omega + \int_{z_{X,t}}^{\infty} y_{X,t}(\omega)^{\frac{\theta-1}{\theta}} d\omega \right]^{\frac{\theta}{\theta-1}}.$$

Northern household's utility maximization problem delivers the following Euler equation for bonds,

$$1 = \beta \left(1 + r_{t+1}\right) E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \right] \tag{3}$$

and the Euler equation for stocks

$$\tilde{v}_t = \beta \left(1 - \delta\right) E_t \left[\left(\frac{C_{t+1}}{C_t} \right)^{-\gamma} \left(\tilde{d}_{t+1} + \tilde{v}_{t+1} \right) \right], \tag{4}$$

where δ is firms' exogenous exit rate, which reflects the random exit shock that can hit all firms including the entrants every period. Similar equations also hold for the Southern households.

2.2 Firms

Firm entry in the North (South) requires an entry cost that is equal to f_E (f_E^*) effective labor units, which is equal to $\frac{f_E}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$ units of the Northern consumption basket. Part of the entry cost is subsidized by Northern government with the rate equal to s_E. After paying the sunk entry cost, each firm is randomly assigned an idiosyncratic productivity z which is drawn from a Pareto distribution over the interval $[z_{\min}, \infty)$. This productivity stays the same for the firm's entire term of operation. Southern firms draw productivity levels from an identical distribution over the same interval. Therefore, there are $N_{E,t}$ new firms entering the market every period and start producing in the next period. With all firms including the new entrants being subject to a random death shock with probability δ at the end of every period, the law of motion for the mass of firms is $N_{t+1} = (1-\delta)(N_t + N_{E,t})$. Similar to Ghironi and Melitz (2005), the sunk entry cost together with the time to build assumption is crucial in generating endogenously persistent dynamics in our model.

Every period, the new entrants form expectation of their post-entry firm value $\tilde{v}_t$, which is a function of the stochastic discount factor, the probability of exit δ and the expected monopolistic stream of profits $\tilde{d}_t$. Equation (4) yields the expected post-entry value of the average firm:

$$\tilde{v}_t = E_t \sum_{s=t+1}^{\infty} [\beta(1-\delta)]^{s-t} \left(\frac{C_s}{C_t}\right)^{-\gamma} \tilde{d}_s \tag{5}$$

As a result, every period, potential entrants make their decision of entering or not by comparing the sunk entry cost that they need to pay upfront before entry with the expected profits after entry. In equilibrium, firm entry takes place until the expected value of the average firm value is equal to the sunk entry cost : $\tilde{v}_t = (1-s_E)\frac{f_E}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$, which is $(1-s_E)f_E$ times the cost of effective labor.

Firms' Production Location and Market Decisions

The structure of firms' offshoring decisions is based on Zlate (2016), with the main difference being that there are two types of labor in our setting. There is one final-good sector.[3] Firms are all final-good producers with heterogeneity in their productivities, each producing a different variety of the final goods. Production of the final good requires two tasks – y_h and y_l. Task y_h

[3] In the same spirit as Melitz (2003), the model is best thought of as that of the tradable sector, part of which turns out to be non-traded in equilibrium.

uses high skilled labor only and task y_l uses low skilled labor only. The production function is assumed to take the following form: $y_t(z) = [y_{h,t}(z)]^{\alpha} [y_{l,t}(z)]^{1-\alpha}$.[4]

The high and low-skilled endowments of each country are set up to deliver a cost relationship, where some firms in the North have incentive to offshore the low-skilled task to the South, to utilize the associated cost advantage. Similarly, some firms in the South have incentive to offshore the high-skilled tasks to the North. Each task is subject to its source country's aggregate productivity. Each firm has a different relative productivity z, with which it transforms the two tasks into the final output. The productivity differences across firms translate into differences in the unit cost of production. Every period, firms choose to produce each task either domestically or offshore.

Production Location Strategies for Firms in the North

For a firm in the North, if it decides to produce both tasks domestically, then $y_{h,t}(z) = zZ_t h_t(z)$ and $y_{l,t}(z) = zZ_t l_t(z)$. If the firm instead decides to offshore the low-skilled task, $y_{h,t}(z) = zZ_t h_t(z)$ but $y_{l,t}(z) = zZ_t^* l_t^*(z)$. Offshoring the low-skilled task to the South incurs an iceberg cost τ^V, which is reflected on the cost side of firm's profit maximization problem. Therefore, the output of producing both tasks domestically is $y_{D,t}(z) = zZ_t [h_t(z)]^{\alpha} [l_t(z)]^{1-\alpha}$. In contrast, keeping the high-skilled task produced in-house and offshoring the low-skilled tasks generates output $y_{V,t}(z) = z [Z_t h_t(z)]^{\alpha} [Z_t^* l_t^*(z)]^{1-\alpha}$.

Cost minimization pins down the number of high-skilled and low-skilled workers each firm hires to produce one unit of output, depending on the wages, firms' relative productivity z and aggregate productivities Z_t and Z_t^*. For the firms in the North, the marginal costs of production for the two strategies then follow — $mc_{D,t}(z) = \frac{1-s_D}{Z_t z} \left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha} \left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$ for domestically producing firms, where s_D stands for the production subsidy received from the Northern government. The marginal cost of offshoring firms is given by $mc_{V,t}(z) = \frac{1}{z} \left(\frac{(1+\tau^{IM})\tau^V Q_t w_{l,t}^*}{Z_t^*(1-\alpha)}\right)^{1-\alpha} \left(\frac{w_{h,t}}{Z_t \alpha}\right)^{\alpha}$, where $w_{l,t}$ is the real wage for low-skilled labor and $w_{h,t}$ is the real wage for high-skilled labor. Similarly, $w_{l,t}^*$ is the real wage for the Southern low-skilled labor. The monopolistically competitive firms maximize profits for the two different production

[4]In Antras and Helpman (2004), the output of a firm z is a Cobb-Douglas function of two inputs that use domestic and foreign inputs respectively, $y_{V,t} = \left[\frac{Z_t z l_t}{\alpha}\right]^{\alpha} \left[\frac{Z_t^* z l_t^*}{1-\alpha}\right]^{1-\alpha}$.

strategies:

$$\max_{\rho_{D(z)}} d_{D,t}(z) = \rho_{D,t}(z)y_{D,t}(z) - mc_{D,t}(z)y_{D,t}(z) \tag{6}$$

$$\max_{\rho_{V(z)}} d_{V,t}(z) = \rho_{V,t}(z)y_{V,t}(z) - mc_{V,t}(z)y_{V,t}(z) - f_V \frac{Q_t}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha} \tag{7}$$

where $\rho_D(z)$ and $\rho_V(z)$ are the real prices of the two production strategies. Offshoring firms also need to pay the fixed offshoring cost f_V units of Southern effective labor, which is associated with building and running maintenance of the factories and facilities offshore. Following Zlate (2016), we assume that Northern offshoring firms hire workers from Southern labor market to cover these fixed offshoring costs. Therefore, the fixed offshoring cost is $f_V \frac{Q_t}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha}$ units of the Northern consumption basket. It can be interpreted as a friction (e.g., a non-tariff trade barrier) or productivity disadvantage (less control and monitoring over the products) due to distance.

The demand for variety produced by firm z using the two production strategies are $y_{D,t}(z) = \rho_{D,t}(z)^{-\theta}C_t$ and $y_{V,t}(z) = \rho_{V,t}(z)^{-\theta}C_t$. Prices are at a markup over marginal costs, with pricing conditions: $\rho_{D,t}(z) = \frac{\theta}{\theta-1}mc_{D,t}(z)$ and $\rho_{V,t}(z) = \frac{\theta}{\theta-1}mc_{V,t}(z)$. Profits are $d_{D,t}(z) = \frac{1}{\theta}\rho_{D,t}(z)^{1-\theta}C_t$ for domestic production and $d_{V,t}(z) = \frac{1}{\theta}\rho_{V,t}(z)^{1-\theta}C_t - f_V \frac{Q_t}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha}$ for offshoring the low-skilled task.

The offshoring cutoff $z_{V,t}$ is pinned down by equalizing profits of the two strategies for firms' production: $z_{V,t} = \{z | d_{D,t}(z_{V,t}) = d_{V,t}(z_{V,t})\}$. It indicates that at this productivity level $z_{V,t}$, producing both tasks domestically and offshoring the low-skilled task generate the same profit. Every period, a firm compares, based on its productivity level, whether the strategy of producing both tasks domestically or that of offshoring the low-skilled task yields higher profits. The cutoff is time-varying; it is responsive to changes in the labor cost of two types of labor across the two countries as well as the iceberg trade cost. The set of offshoring firms fluctuates over time with changes in the profitability of offshoring. A lowering of the trade cost or the wage cost of the low-skilled workers abroad increases the profitability of offshoring and thus lowers the offshoring cutoff, incentivizing more firms to offshore.

Consistent with the implications of Zlate (2016), firms with productivity level above the cutoff productivity self select into offshoring since the benefit of offshoring outweighs the cost. In order to ensure the existence of the offshoring cutoff, the slope of offshoring profit function must exceed the slope of domestic profit function. This gives the following condition:

$$\tau^V(1+\tau^{IM})\,(1-s_D)^{\frac{1}{\alpha-1}}\,TOL_l < 1 \tag{8}$$

where $TOL_l = \frac{Q_t w^*_{l,t}/Z^*_t}{w_{l,t}/Z_t}$ stands for the ratio between the cost of effective low-skill labor in the South and the North expressed in the same currency. This condition states that effective low-skill wage in the South must be sufficiently lower than in the North, so that the North still finds it profitable to offshore these tasks abroad in the midst of all the geoeconomic tensions.

Production Location Strategies for Firms in the South

Similarly, for a firm in the South, if it decides to produce both tasks domestically, then $y^*_{D,t}(z) = zZ^*_t\,[h^*_t(z)]^{\alpha}\,[l^*_t(z)]^{1-\alpha}$. The South offshoring firms share a very similar production with North offshoring firms, the only difference comes from the fact that now the offshoring of high-skilled task to the North will incur iceberg cost τ^{V*}, which is reflected on the cost side of firm's profit maximization problem. The corresponding marginal costs of production for the two strategies then follow — $mc^*_{D,t}(z) = \frac{1-s^*_D}{Z^*_t z}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$ for domestically producing firms. The marginal cost of offshoring firms is $mc^*_{V,t}(z) = \frac{1}{z}\left(\frac{w^*_{l,t}}{Z^*_t(1-\alpha)}\right)^{1-\alpha}\left(\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{h,t}}{Z_t\alpha}\right)^{\alpha}$. The monopolistically competitive firms set optimal prices to maximize profits for the two different production strategies:

$$\max_{\rho^*_{D(z)}} d^*_{D,t}(z) = \rho^*_{D,t}(z)y^*_{D,t}(z) - mc^*_{D,t}(z)y^*_{D,t}(z)$$
$$\max_{\rho^*_{V(z)}} d^*_{V,t}(z) = \rho^*_{V,t}(z)y^*_{V,t}(z) - mc^*_{V,t}(z)y^*_{V,t}(z) - f^*_V\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$$

The corresponding condition to ensure the existence of the offshoring cutoff is the following:

$$(\tau^{V*})^{-1}(1+\tau^{IM*})^{-1}(1-s^*_D)^{\frac{1}{\alpha}}\,TOL_h > 1 \tag{9}$$

where $TOL_h = \frac{Q_t w^*_{h,t}/Z^*_t}{w_{h,t}/Z_t}$ stands for the ratio between the cost of effective high-skill labor in the South and the North expressed in the same currency. This condition states that effective high-skill wage in the North must be sufficiently lower than in the South, so that the South still finds it profitable to offshore these tasks abroad in the midst of all the geoeconomic tensions. We will set the high-skilled and low-skilled endowment of labor of each country such that both condition (8) and condition (9) are satisfied.

Exporting

Firms in the North and the South not only serve their domestic market, but can also choose to serve the foreign market through exports, as in Ghironi and Melitz (2005). In the North, the firm with productivity level z produces goods for exporting using domestic low-skilled and high-skilled labor $l_{X,t}(z)$ and $h_{X,t}(z)$, generating output $y_{X,t}(z) = zZ_t\,[h_{X,t}(z)]^{\alpha}\,[l_{X,t}(z)]^{1-\alpha}$. The Southern exporters produce output in a similar fashion, $y^*_{X,t}(z) = zZ^*_t\,[h^*_{X,t}(z)]^{\alpha}\,[l^*_{X,t}(z)]^{1-\alpha}$. Profit maximization implies that the price of exports for a firm with productivity level z is $\rho_{X,t}(z) = \frac{\theta}{\theta-1}\frac{\tau Q_t^{-1}}{zZ_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$. Notice that $\rho_{X,t}(z)$ is the dock export price, i.e. it does not include Southern import tariff. The profit function is thus given by: $d_{X,t}(z) = \frac{1}{\theta}(1+\tau^{IM*})^{-\theta}\rho_{X,t}(z)^{1-\theta}C^*_t Q_t - \frac{f_X}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$, where C^*_t is aggregate consumption in the South, τ^{IM*} is the ad-valorem tariff imposed by South on North exporters' sales. In terms of a firm's export decisions, a firm will export if and only if the export profit it would earn is nonnegative, giving export cutoff for firms of $z_{X,t} = \inf\{z | d_{X,t}(z) > 0\}$. Firms with productivity level above the export cutoff $z_{X,t}$ choose to export whereas firms with productivity level below $z_{X,t}$ choose to serve the domestic market only.

2.3 Averages

The model is isomorphic to a framework with three representative firms in the North: one produces both tasks domestically. A second offshores the low-skilled task and only produces the high-skilled task in the North (both serving the domestic market). A third produces both tasks domestically and engages in exporting.

Average Productivities

Firms' productivities are drawn from the Pareto distribution over the interval $[z_{\min}, \infty)$, where the common distribution is $G(z)$ with density $g(z)$. Every period in the North, there are $N_{D,t}$ firms, whose idiosyncratic productivities are below the offshoring cutoff $z_{\min} < z_t < z_{V,t}$, that produce both tasks domestically. Then there are $N_{V,t}$ firms with productivity levels above the cutoff $z_t > z_{V,t}$ that choose to offshore. We denote average productivity of domestically producing firms as $\tilde{z}_{D,t}$ and that of offshoring firms as $\tilde{z}_{V,t}$. The average productivity levels follow as:

$$\tilde{z}_{D,t} = \left[\frac{1}{G\left(z_{V,t}\right)} \int_{z_{\min}}^{z_{V,t}} z^{\theta-1} g(z) dz\right]^{\frac{1}{\theta-1}} \quad \text{and} \quad \tilde{z}_{V,t} = \left[\frac{1}{1-G\left(z_{V,t}\right)} \int_{z_{V,t}}^{\infty} z^{\theta-1} g(z) dz\right]^{\frac{1}{\theta-1}}.$$

With the assumption that the Pareto distribution of the productivity has p.d.f. $g(z) = kz_{\min}^{k}/z^{k+1}$ and c.d.f. $G(z) = 1 - (z_{\min}/z)^{k}$, the average productivity levels $z_{D,t}$ and $z_{V,t}$ can both be expressed as functions of the offshoring productivity cutoff $z_{V,t}$:

$$\tilde{z}_{D,t} = \nu z_{\min} z_{V,t} \left[\frac{z_{V,t}^{k-(\theta-1)} - z_{\min}^{k-(\theta-1)}}{z_{V,t}^{k} - z_{\min}^{k}}\right]^{\frac{1}{\theta-1}} \quad \text{and} \quad \tilde{z}_{V,t} = \nu z_{V,t}$$

where $\nu = \left[\frac{k}{k-(\theta-1)}\right]^{\frac{1}{\theta-1}}$, $k > \theta - 1$, and the cutoff is $z_{V,t} = z_{\min}\left(N_t/N_{V,t}\right)^{1/k}$.

Similarly, in the South, the average productivity for the firms which produces both tasks domestically and the average productivity for those which offshore the high-skilled task to the North are:

$$\tilde{z}^{*}_{D,t} = \nu z_{\min} z^{*}_{V,t} \left[\frac{{z^{*}_{V,t}}^{k-(\theta-1)} - z_{\min}^{k-(\theta-1)}}{{z^{*}_{V,t}}^{k} - z_{\min}^{k}}\right]^{\frac{1}{\theta-1}} \quad \text{and} \quad \tilde{z}^{*}_{V,t} = \nu z^{*}_{V,t}$$

where $z^{*}_{V,t}$ is the offshoring productivity cutoff for firms in the South.

The average productivity of exporting firms in the North and the South are:

$$\tilde{z}_{X,t} = \nu z_{\min}\left(\frac{N_t}{N_{X,t}}\right)^{1/k} \quad \text{and} \quad \tilde{z}^{*}_{X,t} = \nu z^{*}_{\min}\left(\frac{N^{*}_t}{N^{*}_{X,t}}\right)^{1/k}$$

Average Price Indices

The average price indices for the North and the South follow as

$$\begin{aligned} 1 &= N_{D,t}\left(\tilde{\rho}_{D,t}\right)^{1-\theta} + N_{V,t}\left(\tilde{\rho}_{V,t}\right)^{1-\theta} + N^{*}_{X,t}\left((1+\tau^{IM})\tilde{\rho}^{*}_{X,t}\right)^{1-\theta} \\ 1 &= N^{*}_{D,t}\left(\tilde{\rho}^{*}_{D,t}\right)^{1-\theta} + N^{*}_{V,t}\left(\tilde{\rho}^{*}_{V,t}\right)^{1-\theta} + N_{X,t}\left((1+\tau^{IM*})\tilde{\rho}_{X,t}\right)^{1-\theta}. \end{aligned}$$

Average Profits

The total profits of firms in the two countries are $N_t\tilde{d}_t = N_{D,t}\tilde{d}_{D,t} + N_{V,t}\tilde{d}_{V,t} + N_{X,t}\tilde{d}_{X,t}$ and $N^{*}_t\tilde{d}^{*}_t = N^{*}_{D,t}\tilde{d}^{*}_{D,t} + N^{*}_{V,t}\tilde{d}^{*}_{V,t} + N^{*}_{X,t}\tilde{d}^{*}_{X,t}$. The linkages between the average profit of offshoring and that of domestically producing both tasks are:

$$\tilde{d}_{V,t} = \frac{k}{k-(\theta-1)}\left(\frac{z_{V,t}}{\tilde{z}_{D,t}}\right)^{\theta-1}\tilde{d}_{D,t} + \frac{\theta-1}{k-(\theta-1)} f_V \frac{Q_t}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha}$$
$$\tilde{d}_{V,t}^* = \frac{k}{k-(\theta-1)}\left(\frac{z_{V,t}^*}{\tilde{z}_{D,t}^*}\right)^{\theta-1}\tilde{d}_{D,t}^* + \frac{\theta-1}{k-(\theta-1)} f_V^* \frac{Q_t^{-1}}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}.$$

From the above relationships, it can be noted that the average profit of offshoring firms is higher than that of domestically-producing firms, because firms above the productivity cutoff self select into offshoring.

Exploiting the property that the firm at the productivity cutoff $z_{X,t}$ obtains zero profits from exporting, the average profits from exports can be expressed as:

$$\tilde{d}_{X,t} = \frac{\theta-1}{k-(\theta-1)}\frac{f_X}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$$
$$\tilde{d}_{X,t}^* = \frac{\theta-1}{k-(\theta-1)}\frac{f_X^*}{Z_t}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha}.$$

2.4 Closing the Model

There are labor market clearing conditions for both high-skilled and low-skilled labor, governments in both countries balance their budgets, aggregate accounting across households and balance of international payments. A full summary of the model equations is in Table A.1.

Labor Market

Here we explicitly set out the high-skilled labor market clearing conditions, noting that those for the low-skilled will be implicitly implied by all other equilibrium conditions in the model. Denote $\tilde{h}_{D,t}$ as the amount of high-skilled labor used by the representative domestically producing firms that serve the domestic market, $\tilde{h}_{V,t}$ as that used by the representative offshoring firms, and $\tilde{h}_{X,t}$ by the representative exporter. The high-skilled labor market clearing conditions for the two countries then are:

$$\begin{aligned} H =& N_{D,t}\tilde{h}_{D,t} + N_{X,t}\tilde{h}_{X,t} + N_{V,t}\tilde{h}_{V,t} + N_{V,t}^*\tilde{h}_{V,t}^*\tau^{V*} \\ &+ \left(N_{E,t}\frac{f_E}{Z_t} + N_{X,t}\frac{f_X}{Z_t} + N_{V,t}^*\frac{f_V^*}{Z_t}\right)\left(\frac{\alpha w_{l,t}}{(1-\alpha)w_{h,t}}\right)^{1-\alpha} \\ H^* =& N_{D,t}^*\tilde{h}_{D,t}^* + N_{X,t}^*\tilde{h}_{X,t}^* + \left(N_{E,t}^*\frac{f_E^*}{Z_t^*} + N_{X,t}^*\frac{f_X^*}{Z_t^*} + N_{V,t}\frac{f_V}{Z_t^*}\right)\left(\frac{\alpha w_{l,t}^*}{(1-\alpha)w_{h,t}^*}\right)^{1-\alpha} \end{aligned}$$

Northern high-skilled labor is used for production by domestically-producing firms (serving either the domestic or export market), Northern offshoring firms and Southern offshoring firms, as well as for sunk entry costs, fixed exporting costs and fixed offshoring costs.[5] In contrast, the Southern high-skilled labor is used for production by only the domestically producing firms and for sunk entry costs, fixed exporting costs and fixed offshoring costs. Similarly, the low-skilled labor market clearing conditions for the two countries are:

$$\begin{aligned} L_t =& N_{D,t}\tilde{l}_{D,t} + N_{X,t}\tilde{l}_{X,t} + \left(N_{E,t}\frac{f_E}{Z_t} + N_{X,t}\frac{f_X}{Z_t} + N^*_{V,t}\frac{f^*_V}{Z_t}\right)\left(\frac{(1-\alpha)w_{h,t}}{\alpha w_{l,t}}\right)^{\alpha} \\ L^*_t =& N^*_{D,t}\tilde{l}^*_{D,t} + N^*_{X,t}\tilde{l}^*_{X,t} + N_{V,t}\tilde{l}_{V,t}\tau^V + N^*_{V,t}\tilde{l}^*_{V,t} \\ &+ \left(N^*_{E,t}\frac{f^*_E}{Z^*_t} + N^*_{X,t}\frac{f^*_X}{Z^*_t} + N_{V,t}\frac{f_V}{Z^*_t}\right)\left(\frac{(1-\alpha)w^*_{h,t}}{\alpha w^*_{l,t}}\right)^{\alpha}. \end{aligned}$$

Government

The Northern government keeps a balanced budget for each period:

$$\begin{aligned} &\tau^V\tau^{IM}N_{V,t}w^*_{l,t}\tilde{l}_{V,t}Q_t + \tau^{IM}N^*_{X,t}\tilde{\rho}^*_{X,t}[(1+\tau^{IM})\tilde{\rho}^*_{X,t}]^{-\theta}C_t \\ &= s_E N_{E,t}\frac{f_E}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha} + s_D N_{D,t}\tilde{\rho}^{-\theta}_{D,t}C_t\frac{1}{Z_t\tilde{z}_D}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha} + T_t, \end{aligned} \tag{10}$$

which states that the sum of ad valorem tariffs must be equal to the sum of entry subsidy, production subsidy and transfer to the households in each period. Similarly, the balanced budget for the Southern government is given by:

$$\begin{aligned} &\tau^{V*}\tau^{IM*}N^*_{V,t}w_{h,t}\tilde{h}^*_{V,t}Q_t^{-1} + \tau^{IM*}N_{X,t}\tilde{\rho}_{X,t}[(1+\tau^{IM*})\tilde{\rho}_{X,t}]^{-\theta}C^*_t \\ &= s^*_E N^*_{E,t}\frac{f^*_E}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha} + s^*_D N^*_{D,t}\tilde{\rho}^{*-\theta}_{D,t}C^*_t\frac{1}{Z^*_t\tilde{z}^*_D}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha} + T^*_t. \end{aligned} \tag{11}$$

Aggregate Accounting

Aggregating the budget constraint (1) across Northern households and imposing the equilibrium conditions of bonds and shares ($B_{t+1} = B_t = 0$ and $x_{t+1} = x_t = 1$) yields the aggregate accounting equation $C_t = w_{l,t}L + w_{h,t}H + T_t + N_t\tilde{d}_t - N_{E,t}\tilde{v}_t$. A similar equation holds in the South. Consumption in each period must equal labor income plus government transfer plus investment income net of the cost of investing in new firms.

[5]With a slight abuse of notation, we define the South's demand of high-skill labor from North as $\tilde{h}^*_{V,t}$. A similar definition is also made for North's demand of low-skill labor from South.

Balance of Payments

The balance of international payments (expressed in units of the Northern consumption basket) requires that the trade balance equals the net aggregate fixed offshoring cost:

$$TB_t = N_{V,t} f_V \frac{Q_t}{Z_t^*} \left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha} \left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha} - N_{V,t}^* f_V^* \frac{1}{Z_t} \left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha} \left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}.$$

The trade balance, TB_t, is given by the value of regular exports and the value offshoring exports of high-skilled tasks minus the value of offshoring imports of low-skilled tasks and the value of regular imports:

$$\begin{aligned} TB_t \equiv & \underbrace{N_{X,t} \tilde{\rho}_{X,t} \left((1+\tau^{IM*})\tilde{\rho}_{X,t}\right)^{-\theta} C_t^* Q_t}_{\text{Regular exports}} + \underbrace{\tau^{V*} N_{V,t}^* w_{h,t} \tilde{h}_{V,t}^*}_{\text{Offshoring exports}} \\ & - \underbrace{\tau^V N_{V,t} w_{l,t}^* \tilde{l}_{V,t} Q_t}_{\text{Offshoring imports}} - \underbrace{N_{X,t}^* \tilde{\rho}_{X,t}^* \left((1+\tau^{IM})\tilde{\rho}_{X,t}^*\right)^{-\theta} C_t}_{\text{Regular imports}}. \end{aligned} \tag{12}$$

Model Summary

The equations listed above constitute a system of 57 equations in 57 endogenous variables: C_t, r_t, $\tilde{v}_t$, $\tilde{d}_t$, $w_{l,t}$, $w_{h,t}$, N_t, $N_{E,t}$, $N_{D,t}$, $N_{V,t}$, $N_{X,t}$, $\tilde{\rho}_{D,t}$, $\tilde{\rho}_{V,t}$, $\tilde{\rho}_{X,t}$, T_t, $\tilde{d}_{D,t}$, $\tilde{d}_{V,t}$, $\tilde{d}_{X,t}$, $\tilde{z}_{D,t}$, $z_{V,t}$, $\tilde{z}_{V,t}$, $\tilde{z}_{X,t}$, $\tilde{h}_{D,t}$, $\tilde{h}_{V,t}$, $\tilde{h}_{X,t}$, $\tilde{l}_{D,t}$, $\tilde{l}_{V,t}$, $\tilde{l}_{X,t}$, their Southern counterparts and the real exchange rate Q_t. We list all the model equations in Appendix A and describe our computation methods in detail in Appendix B.

3 Calibration

We take one period in the model to be a quarter. All parameters are listed in Table 1. We take several parameters directly from Ghironi and Melitz (2005), which include the (inverse) intertemporal elasticity $\gamma = 2$, elasticity of substitution between varieties $\theta = 3.8$, the shape parameter of productivity distribution $k = 3.4$ and physical iceberg cost $\tau = 1.3$. Also as in Ghironi and Melitz (2005), we set the quarterly discount factor $\beta = 0.99$, a value consistent with real interest rates in recent years, as well as the exogenous death rate $\delta = 0.025$ and persistence of TFP $\zeta_Z = 0.9$. These latter two values are consistent with yearly exit rates reported in U.S. firm data around of 10% (see Tian (2018)) and the persistence of TFP typically used in DSGE studies, respectively. We set the production function parameter α to be 0.4, which implies the wage share of high skilled workers to be 40%. An important source of asymmetry across N and S in the calibration is the relative endowments of the two labor factors, which we take from Lechthaler and Mileva (2021) to reflect the context of US and China.

The set of parameters $\{f_X, f_X^*, f_V, f_V^*\}$ are calibrated inside the model, using simulated method of moments (SMM), to target fractions of exporting and offshoring firms, of around 10% and 0.3%, respectively in each country. This procedure gives values of $f_X = f_X^* = 0.25$ and $f_V = 0.191$ and $f_V^* = 0.04$. Note that these are close to the steady-state values obtained in Zlate (2016). The sunk cost of entry in the North f_E is chosen to normalize the high-skilled wage in the North to unity; we then take the counterpart in the South to be identical $f_E^* = f_E$.

Lastly, the four policy instruments in each country (tariff, offshoring friction, production subsidy and entry subsidy) are assumed to follow an AR(1) process with persistence $\zeta = 0.56$ as in Barattieri, Cacciatore and Ghironi (2021). We set the steady-state values of these instruments to reflect no government intervention. Finally, note that we solve for the transition of the model to a first-order approximation about the steady state associated with the parameterization in Table 1.

Parameter	Meaning	Value	Source/target
β	discount factor	0.9900	Ghironi and Melitz (2005)
γ	(inverse) intertemporal elasticity	2.0000	Ghironi and Melitz (2005)
θ	elasticity of substitution between varieties	3.8000	Ghironi and Melitz (2005)
k	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
δ	exogenous firm exit shock	0.0250	Ghironi and Melitz (2005)
α	skill intensity in production	0.4000	wage share of high-skilled
Z	steady state aggregate productivity	1.0000	normalization
ζ_Z	persistence of TFP process	0.9000	Ghironi and Melitz (2005)
ζ	persistence of policy process	0.5600	Barattieri, Cacciatore and Ghironi (2021)
H	endowment of high-skilled labor in North	0.2220	Lechthaler and Mileva (2021)
L	endowment of low-skilled labor in North	0.7780	Lechthaler and Mileva (2021)
H^*	endowment of high-skilled labor in South	0.0955	Lechthaler and Mileva (2021)
L^*	endowment of low-skilled labor in South	0.9045	Lechthaler and Mileva (2021)
f_V	fixed cost of offshoring in North	0.1910	fraction of offshoring firms N (SMM)
f_X	fixed cost of exporting in North	0.2500	fraction of exporting firms N (SMM)
f_V^*	fixed cost of offshoring in South	0.0400	fraction of offshoring firms S (SMM)
f_X^*	fixed cost of exporting in South	0.2500	fraction of exporting firms S (SMM)
f_E	sunk entry cost	15.289	normalization of high-skilled wage N
τ^{IM}	import tariff	0.0000	no steady state intervention
τ^V	iceberg friction on offshoring	1.0000	no steady state intervention
s_E	entry subsidy	0.0000	no steady state intervention
s_D	domestic production subsidy	0.0000	no steady state intervention

Table 1. Benchmark calibration

4 Industrial Policies Amidst Geoeconomic Tensions

In this section, we investigate the dynamic and welfare impacts of various industrial policies. We begin by looking at the impulse responses of the model, following a one-time shock of each industrial policy. We then explore the model's behavior when the policymaker explores all the possible combinations of industrial policies. Finally, we discuss the welfare implications of unilateral policy actions, as well as bilateral policy actions between the two countries, spanning over different time horizons.

4.1 Individual industrial policies

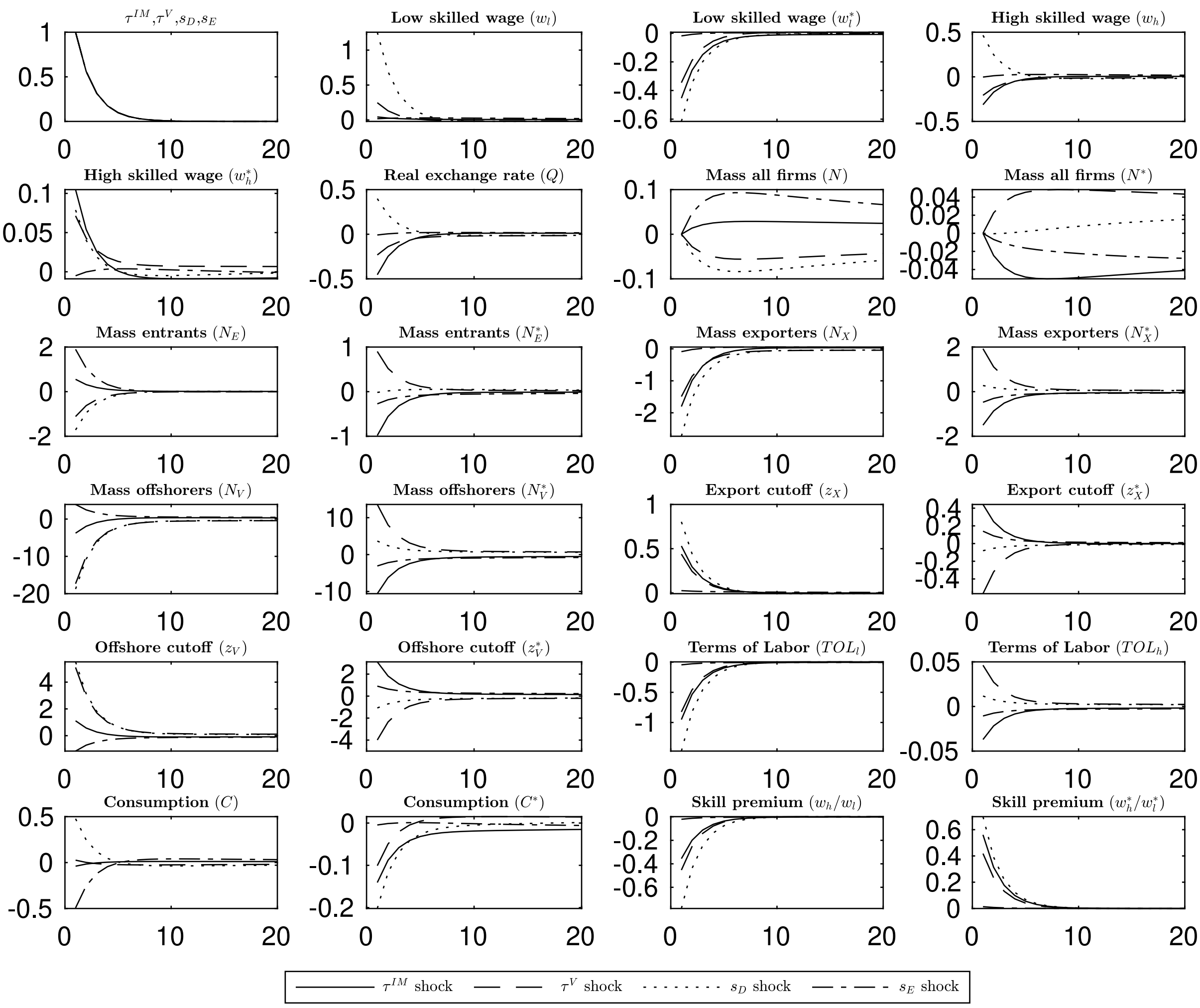

Figure 2. Impulse responses of North and South variables to 1% of individual industrial policy shocks in the North. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

North increases import tariff τ^{IM}(—)

The increase in the North's tariff makes the imported Southern varieties more costly to the Northern consumers, thus reducing their the demand for imported goods. It in turn implies a rise in the export cutoff (z_X^*) and a drop in the number of exporters (N_X^*) in the South. In the meantime, the real exchange rate (Q) appreciates (fall) in response to the decline in the demand for imported Southern goods, which renders the Northern exporters less competitive, thus also leading to a rise in the export cutoff (z_X) and a drop in the number of exporters (N_X) in the North.

Higher tariff also raises the cost for importing low-skilled task from the South faced by the Northern offshoring firms. As a result, the offshoring cutoff (z_V) rises and the number of offshoring firms (N_V) drops in the North. This subsequently reduces the demand for Southern low-skilled labor and imposes downward adjustment pressure on their wage (w_l^*). As these low-skilled labor previously employed by Northern offshoring firms being reabsorbed into domestic firms, they raise the marginal product of the high-skilled labor and thus their wage (w_h^*), which implies a rise in the skill premium of the South. Meanwhile, the appreciation of the real exchange rate implies that the terms of labor for high-skilled (TOL_h) appreciates (fall). It raises the cost of offshoring high-skilled task to the North for the Southern offshoring firms, and thus causing a rise in the offshoring cutoff (z_V^*) and a drop in the number of offshoring firms (N_V^*) in the South. Analogously, this decreases the demand for Northern high-skilled labor and lowers their wage while slightly raising the low-skilled wage, resulting a fall in the skill premium of the North.

Higher price of imports and less demand for both regular export and offshoring export, coupled with market share being reallocated towards less efficient domestic firms, tend to reduce the real income of households in both countries and depress their consumption, with the negative effect being quantitatively more significant in the South.

North increases offshoring friction τ^V(– –)

The increase in the North's offshoring friction directly raises the cost of offshoring imports of low-skilled task, lowering the profits of Northern offshoring firms. Consequently, it increases the offshoring cutoff (z_V) and reduces the number of offshoring firms (N_V) in the North. As these firms reshore their low-skilled task, it raises the demand for low-skilled labor in the North while reduces that in the South. As a result, low-skilled wage rises in the North but falls in the South. The increase in the low-skilled wage in the North, together with the slight decline of its high-skilled wage, leads to a fall in the skill premium. Meanwhile, as in the case of higher import tariff, the reabsorbing of low-skilled labor into the domestic firms in the South drives up the wage for the high-skilled labor, which implies a rise in the skill premium of the South. This in turn depreciates the high-skilled terms of labor, thus raising the incentive to offshore high-skilled task to the North. It then leads to a drop in the offshoring cutoff (z_V^*) and a rise in the number of offshoring firms (N_V^*) in the South.

As the cost of offshoring imports from the South to the North rises, the demand for it drops, which results in an appreciation (fall) of the real exchange rate (Q) to reach the balance of payment. The appreciation of the real exchange rate in turn increases the competitiveness of the Southern exporters while reducing that of the Northern ones. Consequently, there is a decrease in the export cutoff (z_X^*) and a rise in the number of exporters (N_X^*) in the South, but an opposite response occurs in the North. As the prospects of both offshoring firms and exporters in the North become less profitable, firm entry declines there. On the contrary, the boom of those firms in the South encourages firm entry. In order to finance the new entry, consumption in the South declines on impact.

North increases domestic production subsidy s_D($\cdots$)

The increase in the production subsidy in the North reduces the marginal cost of production for the domestic firms, which raises their profits. As producing domestically and serving the domestic markets become more profitable, the cutoff values of both offshoring (z_V) and export (z_X) rise and the numbers of offshoring firms and exporters drop. In this sense, production subsidy induces firms to reshore.

More domestic production increases the demand for labor, which drives up both the low-skilled and high-skilled wages (w_l, w_h), with the latter increasing relatively less. The significant decline in the number of offshoring firms in the North (N_V) reduces the demand for Southern low-skilled labor, which imposes downward adjustment pressure on their wages (w_l^*). However, as these low-skilled labor being reabsorbed into the domestic firms and exporters in the South, they drive up the marginal product of high-skilled labor which implies higher high-skilled wages (w_h^*). Changes in these wages imply a decline in the skill premium of the North but a rise in that of the South.

Higher labor cost in the North reduces the competitiveness of Northern exporters. As the demand for Northern export declines, real exchange rate (Q) depreciates. It in turn causes the terms of labor for high-skilled (TOL_h) to depreciate slightly, which boosts the southern offshoring as reflected by as a drop in the offshoring cutoff (z_V^*) and a rise in the number of offshoring firms (N_V^*).

Lastly, increases in the wages of the North raises its consumption, while the higher price of imported goods and decline in the low-skilled wage in the South depresses the Southern consumption.

North increases domestic entry subsidy s_E(-·-·)

The increase in the entry subsidy of the North immediately encourages firm entry (N_E) and leads to a gradual increase in the number of firms in the North (N) in the quarters after the shock. In order to finance the entry of new firms, Northern consumption (C) declines. Firm entry tends to raise the demand for labor, and it causes a slight appreciation (fall) in both TOL_l and TOL_h. The appreciation of TOL_l makes offshoring low-skill tasks to the South more profitable, which implies a drop in the North offshoring cutoff (z_V) and a rise in the North offshoring firms (N_V). Meanwhile, the appreciation of TOL_h makes offshoring high-skill tasks to the North less profitable, and it results in a rise in the South offshoring cutoff (z_V^*) and a drop in the number of South offshoring firms (N_V^*).

As the costs of effective low-skill and high-skill labor are now lower in the South compared to the North, it makes the exporters in the North less competitive, which implies a small rise in the export cutoff in the North (z_X) and a slight drop in the number of North exporters (N_X). While this tends to bolster the competitiveness of Southern exporters, the reduction in Northern consumption (hence the reduction in demand for imported goods from the South) has the opposite effect and dominates. As such, we observe an increase in the South export cutoff (z_X^*) and a drop in the number of South exporters (N_X^*).

Among the four instruments, the increase in the North's entry subsidy has the minimum impact on the wages and the skill premiums in the North and the South.

4.2 Combinations of Industrial Policies

In this subsection, we present the combined impact of several industrial policies that are introduced simultaneously.[6] In particular, we consider the following eight cases: (1) import tariff (τ^{IM}) + production subsidy (s_D), (2) import tariff (τ^{IM}) + entry subsidy (s_E), (3) import tariff (τ^{IM}) + offshoring friction (τ^V), (4) production subsidy (s_D) + offshoring friction (τ^V), (5) entry Subsidy (s_E) + offshoring friction (τ^V), (6) import tariff (τ^{IM}) + offshoring friction (τ^V) + production subsidy (s_D), (7) import tariff (τ^{IM}) + offshoring friction (τ^V) + entry subsidy (s_E), (8) import tariffs (τ^{IM}) + offshoring friction (τ^V) + production subsidy (s_D) + entry subsidy (s_E).

In Figure 3, we present the impulse responses for the key variables in our model for the first four possible combinations of industrial policies from the North: (1) – (4). The combination of the import tariff (τ^{IM}) and production subsidy (s_D) (1, —) drives an appreciation (fall) in the low skilled terms of labor (TOL_l) by over 2% on impact, while their offsetting effects on the high skilled terms of labor (TOL_h) drive a more muted drop of around 0.02%. These policy actions give a 20% drop in the mass of offshorers (N_V), a 4% drop in the mass of exporters and a 1% drop in entry (N_E) in the North on impact. This drives a lower short-term need for fixed costs, which releases resources for a boom in consumption (C) in the North for several quarters. As a consequence, the drop in the masses of Southern exporters (N_X^*) and offshorers (N_V^*) is less severe quantitatively than when the Northern tariff is used in isolation.

Combining the Northern tariff (τ^{IM}) and entry subsidy (s_E) (2, – –) yields a substantial boom in the mass of Northern entrants (N_E) of over 2% on impact, while the mass of Northern offshorers (N_V) is effectively unchanged. The impact on the Southern cross-section is contractionary: the mass of Southern entrants (N_E^*) falls by over 1%, while that of the Southern offshorers (N_V^*) falls by almost 20% on impact.

The Northern Government's use of the import tariff (τ^{IM}) and offshoring friction (τ^V) together (3, $\cdots$) inflicts a drop in Southern consumption (C^*) of 0.25%, while leaving Northern consumption (C) relatively unchanged. Note that the changes in the low (w_l) and high skilled wages (w_h) in the North are close to offsetting, while a much more substantial drop in the Southern low skilled wage (w_l^*) outweighs a modest increase in the high skilled wage (w_h^*).

[6] We conduct the analysis of this section, as in the previous, through a first order perturbation around the steady state. Therefore, combinations of policies have linearly additive effects on endogenous variables, leaving no scope for amplification. As such, IRFs for multiple policies can be thought of as being linear combinations of those for the individual instruments; we explore these here as an accounting. We intend to study potential amplification, through higher order approximations, in future versions of this paper.

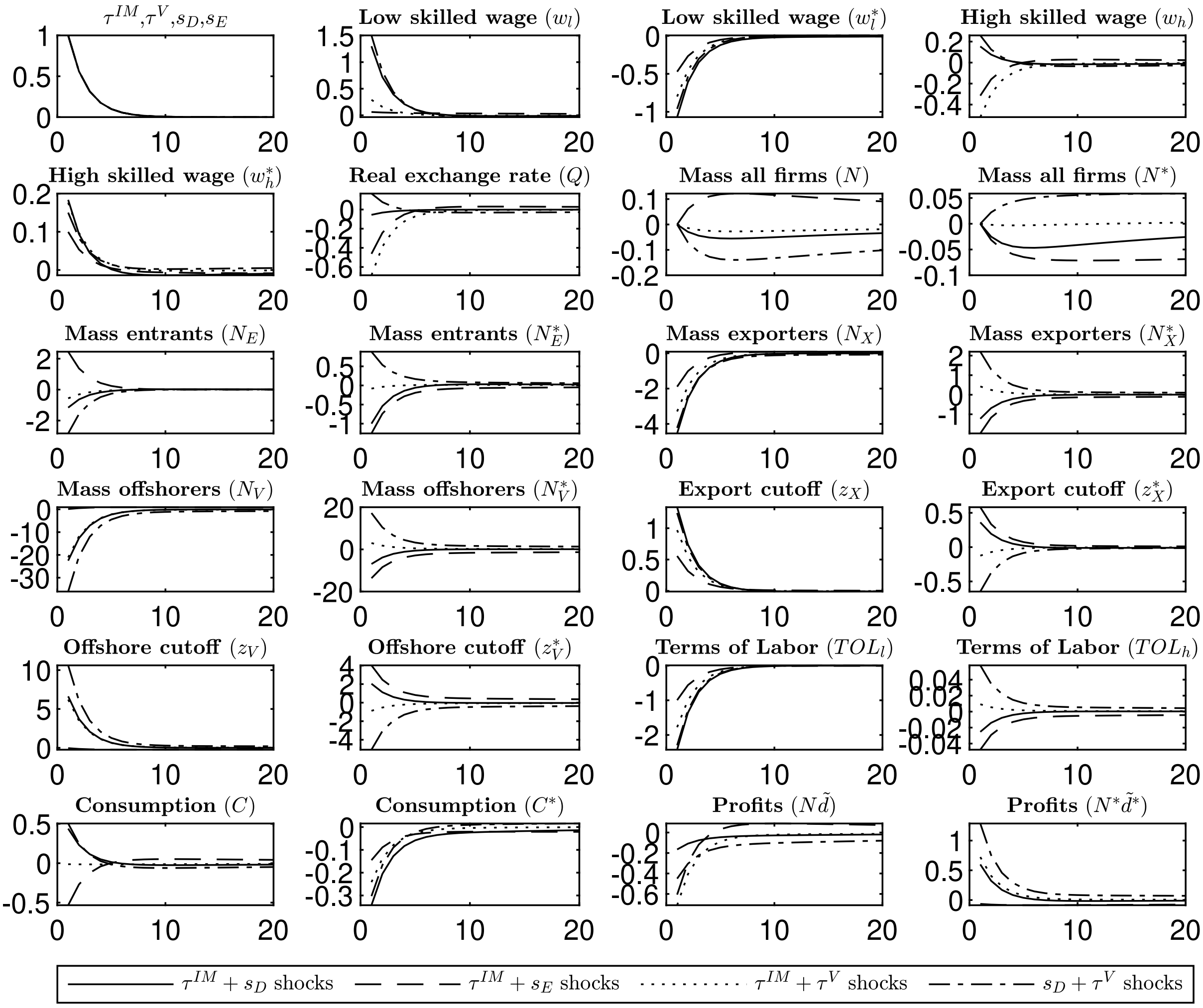

Figure 3. Impulse responses of North and South variables to 1% of combinations industrial policy shocks in the North. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

The Northern production subsidy (s_D) and offshoring friction (τ^V) have roughly the same quantitative impact on the mass of offshorers (N_V) when used individually (see Figure 2). When combined (4, -··-), Figure 3 depicts a substantial contraction in this measure by over 30% on impact. The mass of Northern entrants (N_E) contracts by over 2% on impact, which gives a decline in the overall measure of firms (N) of around 0.15%, realized after around one year. These cross-sectional effects are coupled with a large drop in the level of Northern profits ($N\tilde{d}$) of 0.6% on impact. Opposite qualitative effects follow for the mass of Southern entrants (N_E^*) and all firms (N^*), giving a surge in profits ($N^*\tilde{d}^*$) or over 1% in the short-run. However, Southern consumption (C^*) falls by around 0.3% on impact due to strong downward pressure on the Southern low skilled wage (w_l^*).

In Figure 4, we present the impulse responses for the key variables in our model for the second four possible combinations of industrial policies from the North: (5) – (8). Consider first the combination of the Northern entry subsidy (s_E) and offshoring friction (τ^V) (5,—). See that these instruments individually move the measures of entrants (N_E), all firms (N) and offshorers (N_V) in the North in opposite directions (see Figure 2); the entry subsidy pertains to new firms, the offshoring friction affects active incumbents. As such, when combined, Figure 4 shows relatively muted responses of cross-sectional variables. At the household level, Northern consumption (C) mostly tracks the IRF of the entry subsidy, while Southern consumption (C^*) instead follows that of the offshoring friction.

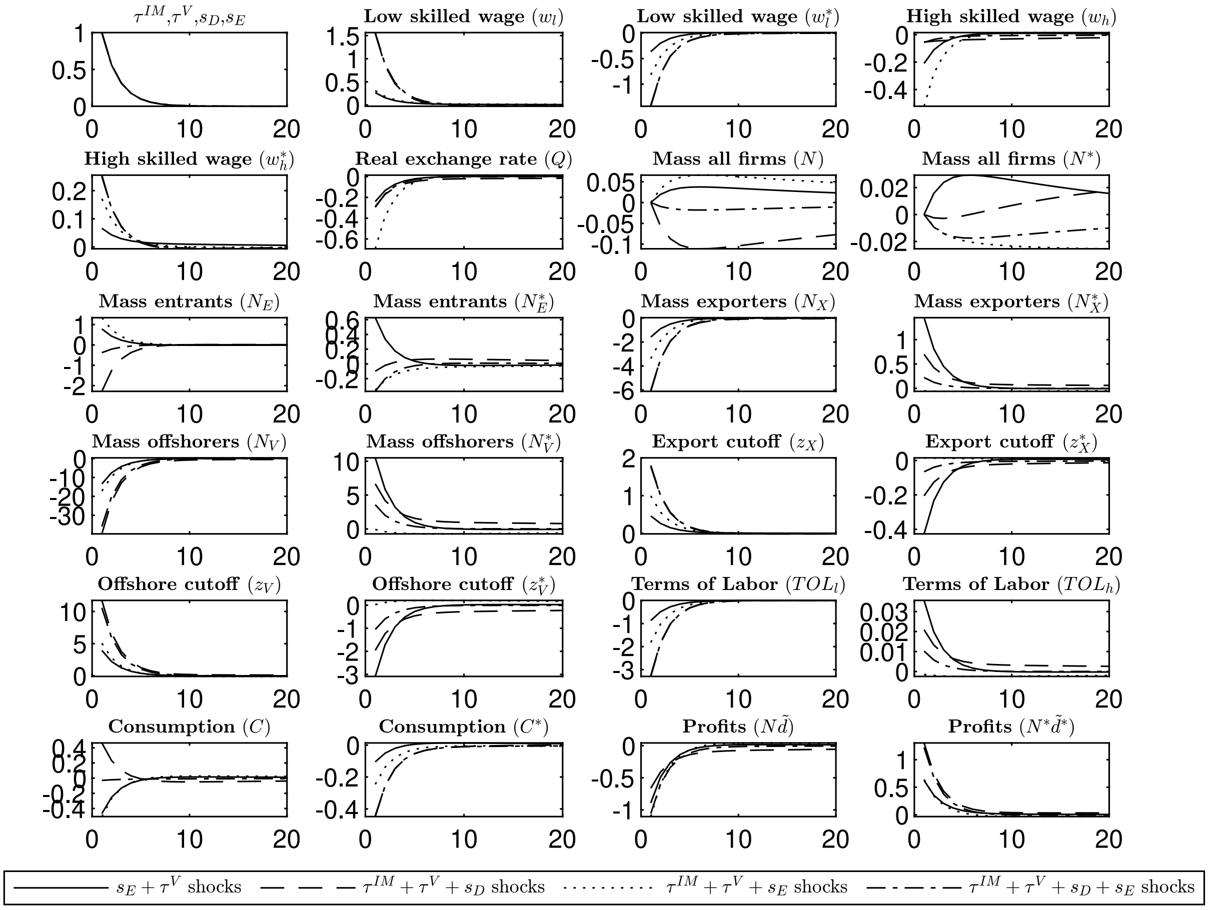

Figure 4. Impulse responses of North and South variables to 1% of combinations industrial policy shocks in the North. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

A key point to notice when combining the Northern tariff (τ^{IM}), offshoring friction (τ^V) and production subsidy (s_D) (6, – –) is the asymmetry in consumption effects across the two countries. This combination of instruments gives around a 0.5% Northern consumption (C) boom, coupled with over a 0.4% contraction of that in the South (C^*), on impact. This latter effect follows from a powerful contraction in the low skilled wage in the South (w_l^*) of close to

1.5% at the time of the shocks. When instead combining τ^{IM} and τ^{V} with the entry subsidy s_E (7,$\cdot\cdot\cdot$), see that the instruments combine to leave the Southern masses of exporters (N_X^*) and offshorers (N_V^*), as well as the high skilled terms of labor (TOL_h) almost unchanged. Lastly, when all four policy instruments are combined (8,-$\cdot\cdot$-$\cdot$), consumption's path in the North (C) is almost unaffected, while the maximal decline in the low skilled terms of labor (TOL_l) drive the corresponding contraction in Southern consumption (C^*).

4.3 Welfare

In this subsection, we first define how we calculate welfare in our model with and without geoeconomic tensions triggered by our industrial policies, both in the short-run and in the long-run. We then explore the welfare implications of each unilateral industrial policy, as well as their possible combinations, over different time horizons. In the end, we study the welfare of bilateral individual policy (i.e. one policy each time) as a proxy for countries that engage in policy war against each other.

4.3.1 Welfare Metrics

We consider welfare in terms of the representative household from each country, in response to 1% shocks to various combinations of policy instruments.[7] The simulations of geoeconomic tension (henceforth GT) are designed such that the economy is shocked in period $t = 1$, where it then takes X periods to return to its initial steady state. To illuminate the effect of policy-maker myopia, we study several different policy horizons (T) — considering horizons of one year ($T = 4$), four years ($T = 16$) and the entire transition path ($T \to \infty$). When considering the whole transition, the lifetime utility measures with and without geoeconomic tension are

[7]The small and transitory shocks to our model imply that our current welfare analysis is mainly about gains and losses along the transition path. We abstract from any discussion of the potential steady-state distortions in our model. We simply take those potential steady-state distortions as given and ask what the additional welfare gains and losses are when we analyze industrial policy shocks in a dynamic setting with a full transition path. However, suppose shocks in our model are sufficiently large and trigger the economy to move to a new steady state. In that case, our industrial policies can potentially improve or exacerbate the potential distortions in our model, such as the number of entrants, the number of varieties, and the degree of market selection. This goes beyond the scope of our paper; therefore, we leave it for future exploration.

given by

$$\mathbb{W}_0^{\text{GT}}(T \to \infty) = \sum_{t=0}^{X} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma} + \frac{\beta^{X+1}}{1-\beta} \times \frac{C_{X+1}^{1-\gamma}}{1-\gamma}$$
$$\mathbb{W}_0^{\text{No GT}}(T \to \infty) = \frac{1}{1-\beta} \times \frac{C_0^{1-\gamma}}{1-\gamma}$$

where C_0 is North's consumption level without geoeconomic tension. The expressions for South are defined similarly. For horizons $T < X$, we instead compute

$$\mathbb{W}_0^{\text{GT}}(T) = \sum_{t=0}^{T} \beta^t \frac{C_t^{1-\gamma}}{1-\gamma}$$
$$\mathbb{W}_0^{\text{No GT}}(T) = \frac{1-\beta^T}{1-\beta} \times \frac{C_0^{1-\gamma}}{1-\gamma}$$

where note that the same (full) transition path is computed as when $T \to \infty$, the policymaker simply disregards welfare information for longer time horizons. Note that there may be long-term costs that come with these policies, but myopic policymakers will abstract away from these costs when making their choices.

4.3.2 Unilateral Policies

In Table 2, we present the welfare effects of various combinations of unilateral policies. Consistent with the results of Section 4, see that welfare inferences can differ markedly across consideration of short and long-run horizons. The use of tariffs (τ^{IM}) typically yields losses at short time horizons, as a sudden contraction in import and offshoring activity leads to limited consumption options for households. However, as more time goes by, positive effects on firm creation will start to dominate, thereby leading to lifetime welfare gains for the tariff-imposing country.

The offshoring friction for the North (τ^V) leads to Northern losses in both the short-run and the long-run. Although this instrument serves to protect low-skilled Northern workers, this effect is outweighed by adverse effects on high-skilled workers and profits. In contrast, this friction in the South (τ^{V*}) can realize Southern welfare gains at a one year horizon. This follows since the Southern protected skill class (high skilled) sees their wage (w_h^*) increase by 0.5% on impact (see Figure A.2). This is significantly stronger than the 0.2% response experienced by the Northern protected class (w_l) in response to τ^V. Notice also that the North stands to gain

	Time horizon (T)		
	$T = 4$	$T = 16$	$T \to \infty$
τ^{IM}	(-0.0138, -0.0824)	(0.0045, -0.0369)	(0.0043, -0.0104)
τ^{V}	(-0.0005, -0.0443)	(-0.0176, -0.0021)	(-0.0086, 0.0052)
s_D	(0.2230, -0.1083)	(0.0381, -0.0343)	(-0.0017, -0.0024)
s_E	(-0.2298, -0.0011)	(-0.0374, -0.0015)	(0.0029, -0.0044)
τ^{IM}, s_D	(0.2093, -0.1908)	(0.0426, -0.0712)	(0.0026, -0.0129)
τ^{IM}, s_E	(-0.2436, -0.0836)	(-0.0330, -0.0385)	(0.0072, -0.0148)
τ^{IM}, τ^{V}	(-0.0143, -0.1268)	(-0.0131, -0.0390)	(-0.0042, -0.0052)
τ^{V}, s_D	(0.2224, -0.1524)	(0.0204, -0.0364)	(-0.0102, 0.0027)
τ^{V}, s_E	(-0.2302, -0.0454)	(-0.0550, -0.0036)	(-0.0056, 0.0008)
τ^{IM}, τ^{V}, s_D	(0.2087, -0.2352)	(0.0250, -0.0734)	(-0.0059, -0.0077)
τ^{IM}, τ^{V}, s_E	(-0.2440, -0.1279)	(-0.0505, -0.0406)	(-0.0013, -0.0096)
$\tau^{IM}, \tau^{V}, s_D, s_E$	(-0.0204, -0.2363)	(-0.0121, -0.0749)	(-0.0029, -0.0121)
τ^{IM*}	(-0.0494, -0.0372)	(-0.0279, 0.0048)	(-0.0094, 0.0071)
τ^{V*}	(-0.0106, 0.0159)	(0.0045, -0.0116)	(0.0044, -0.0076)
s_D^*	(-0.0592, 0.2236)	(-0.0155, 0.0323)	(0.0015, -0.0054)
s_E^*	(-0.0038, -0.2279)	(-0.0044, -0.0344)	(-0.0048, 0.0051)
τ^{IM*}, s_D^*	(-0.1085, 0.1865)	(-0.0434, 0.0371)	(-0.0080, 0.0017)
τ^{IM*}, s_E^*	(-0.0532, -0.2652)	(-0.0323, -0.0298)	(-0.0142, 0.0122)
τ^{IM*}, τ^{V*}	(-0.0599, -0.0213)	(-0.0234, -0.0068)	(-0.0051, -0.0005)
τ^{V*}, s_D^*	(-0.0697, 0.2394)	(-0.0110, 0.0206)	(0.0058, -0.0130)
τ^{V*}, s_E^*	(-0.0144, -0.2119)	(0.0001, -0.0460)	(-0.0004, -0.0025)
$\tau^{IM*}, \tau^{V*}, s_D^*$	(-0.1191, 0.2023)	(-0.0389, 0.0255)	(-0.0036, -0.0059)
$\tau^{IM*}, \tau^{V*}, s_E^*$	(-0.0638, -0.2492)	(-0.0278, -0.0413)	(-0.0098, 0.0046)
$\tau^{IM*}, \tau^{V*}, s_D^*, s_E^*$	(-0.1229, -0.0250)	(-0.0433, -0.0086)	(-0.0083, -0.0007)

Table 2. Welfare for unilateral policy actions. Numbers in parentheses are (welfare gain North, welfare gain South) expressed in consumption equivalent variation. Numbers are percentages (after multiplication by 100) of initial steady state consumption level.

at four year and infinite time horizons from τ^{V*}.

Overwhelmingly, the production subsidy (s_D) is the strongest single instrument the two governments have at their disposal with regard to short time horizons. This follows for both positive welfare gains accrued to the levying country, as well as losses inflicted on the opposing. This result comes from the fact that this is the only instrument, which delivers a positive impact response of wages to both types of workers in the levying country. This is also coupled with a slightly positive response of profits. As the policy horizon is extended, from one to four years, the levying country's gains are driven down in magnitude, before eventually turning negative when accounting for the entire transition. This is mainly because production subsidy benefits the incumbents at the cost of potential entrants, causing the economy to suffer from less variety in the long run.

The entry subsidy (s_E) leads to significant welfare losses for the levying country in the short-run. The upfront cost required to facilitate the surge in entry is a considerable drain on the household's resources; Northern losses are 0.23% at a one year horizon from the Northern subsidy. Longer time horizons are required for the benefits of a larger mass of firms overall to be realized; the peak is realized after around a year; it is then highly persistent. Gains are eventually realized at an infinite horizon.

The specific combination of an import tariff and production subsidy inflicts losses on the opposing country, while retaining positive gains for the levying country, at all time horizons for both countries. This leverages the time profiles for realising gains for the two instruments. The large gains are realized in the short-run from the subsidy, while the long-run losses from the subsidy are outweighed by the gains from the tariff starting to take effect. Note finally that the largest unilateral lifetime welfare gains are realized in each country with the combination of the tariff and entry subsidy, again on account of the time profile for the overall number of firms induced by the latter.

4.3.3 Bilateral Actions: Policy Wars

Table 3 presents welfare numbers, at differing horizons, for all possible single-instrument combinations for North and South. One can take these numbers in the spirit of a policy war between the two countries.[8] There is considerable variation across combinations and time horizons, highlighting the need to use dynamic analysis when studying this particular question.

At both one and four year time horizons, using a production subsidy is the dominant policy instrument for each country, regardless of their opponent's policy action. Moreover, this instrument will inflict losses on the opponent at these horizons, unless they also choose to subsidize. When both North and South levy the production subsidy, they realize mutual gains of 0.16% and 0.11%, respectively at a one year horizon. At a four year horizon, North maintains gains while South realizes losses, then over the full transition, losses are realized by each. At no other combination of North-South single policy instruments are mutual gains possible at any time horizon.

When looking at the infinite horizon setting, instead the import tariff arises as the dominant policy instrument for each country. If policymakers in each country made this choice, they

[8]Given the simple nature of our policy exercises, these numbers are meant to be illustrative, rather than a rigorous strategic analysis of the policy wars.

One year horizon ($T = 4$)

		South				
		—	τ^{IM*}	τ^{V*}	s_D^*	s_E^*
North	—	(0.0000, 0.0000)	(-0.0494, -0.0372)	(-0.0106, 0.0159)	(-0.0592, 0.2236)	(-0.0038, -0.2279)
	τ^{IM}	(-0.0138, -0.0824)	(-0.0631, -0.1197)	(-0.0243, -0.0665)	(-0.0729, 0.1412)	(-0.0176, -0.3104)
	τ^{V}	(-0.0005, -0.0443)	(-0.0499, -0.0816)	(-0.0111, -0.0284)	(-0.0596, 0.1794)	(-0.0044, -0.2723)
	s_D	(0.2230, -0.1083)	(0.1737, -0.1456)	(0.2125, -0.0924)	(0.1640, 0.1154)	(0.2192, -0.3364)
	s_E	(-0.2298, -0.0011)	(-0.2792, -0.0384)	(-0.2404, 0.0148)	(-0.2890, 0.2224)	(-0.2336, -0.2290)

Four year horizon ($T = 16$)

		South				
		—	τ^{IM*}	τ^{V*}	s_D^*	s_E^*
North	—	(0.0000, 0.0000)	(-0.0279, 0.0048)	(0.0045, -0.0116)	(-0.0155, 0.0323)	(-0.0044, -0.0344)
	τ^{IM}	(0.0045, -0.0369)	(-0.0234, -0.0322)	(0.0090, -0.0485)	(-0.0110, -0.0045)	(0.0001, -0.0715)
	τ^{V}	(-0.0176, -0.0021)	(-0.0455, 0.0026)	(-0.0131, -0.0137)	(-0.0331, 0.0303)	(-0.0220, -0.0366)
	s_D	(0.0381, -0.0343)	(0.0102, -0.0296)	(0.0425, -0.0459)	(0.0227, -0.0019)	(0.0337, -0.0689)
	s_E	(-0.0374, -0.0015)	(-0.0654, 0.0032)	(-0.0330, -0.0131)	(-0.0530, 0.0307)	(-0.0418, -0.0360)

Infinite horizon ($T \to \infty$)

		South				
		—	τ^{IM*}	τ^{V*}	s_D^*	s_E^*
North	—	(0.0000, 0.0000)	(-0.0094, 0.0071)	(0.0044, -0.0076)	(0.0015, -0.0054)	(-0.0048, 0.0051)
	τ^{IM}	(0.0043, -0.0104)	(-0.0051, -0.0033)	(0.0087, -0.0180)	(0.0058, -0.0158)	(-0.0004, -0.0053)
	τ^{V}	(-0.0086, 0.0052)	(-0.0180, 0.0123)	(-0.0042, -0.0024)	(-0.0071, -0.0003)	(-0.0133, 0.0103)
	s_D	(-0.0017, -0.0024)	(-0.0111, 0.0047)	(0.0027, -0.0100)	(-0.0002, -0.0079)	(-0.0064, 0.0026)
	s_E	(0.0029, -0.0044)	(-0.0065, 0.0028)	(0.0073, -0.0120)	(0.0044, -0.0098)	(-0.0018, 0.0007)

Table 3. Welfare of policy wars between North and South. Numbers in parentheses are (welfare gain North, welfare gain South) expressed in consumption equivalent variation. Numbers are percentages (after multiplication by 100) of initial steady state consumption level. Policy actions of North are indexed by rows and those of South are by columns (note that — means no policy action). Top panel considers a one year time horizon, second panel considers four years and the third panel considers an infinite horizon.

incur mutual, albeit decreasing, welfare losses at every time horizon of the implementation. The fact that each country has the option of taking zero action shows this scenario resembles a "race to the bottom" in terms of policy actions. A similar case also arises if both countries engage in decoupling from offshoring activities.

In terms of other possible outcomes, the largest overall losses come about, with an infinite horizon, when North levies the import tariff, while South employs the production subsidy. The losses to the latter of -0.016% greatly offset the gains to the former of 0.0062%, giving overall losses of around 0.01%. For shorter horizons, jointly choosing the entry subsidy drains worldwide resources, leading to overall losses of 0.08% and 0.47% at four years and one year, respectively.

5 Conclusion

In this paper, we studied the effects of various industrial policies in a two-country DSGE model featuring firm heterogeneity, trade-in-tasks, endogenous export and offshoring decisions. Our focus was to understand the dynamic and welfare implications of each individual industrial policy as well as their possible combinations, both on impact and over time. The rich micro-foundation in our model enabled us to study producer dynamics, in response to various industrial policies and their aggregate implications in a macroeconomic framework. This sets the model apart from the traditional approaches to studying industrial policies.

Our results highlight the importance of using a dynamic general equilibrium framework to analyze the impacts of industrial policies. For instance, the North's import tariff drives a wedge in the labor costs between the North and the South. This would have made the exporters in the South more competitive, implying a lower export cutoff in the South. However, the adjustment on the extensive margin dominates, so we end up with a rise in the South export cutoff and a drop in the number of South exporters. In addition, such tariff hikes also hurt business profits and would have hurt consumers in the North, but due to market reallocation toward domestic firms and the tariff revenue rebate from the government, consumption in the North is barely affected. When it comes to the welfare implications, we find considerable variation across combinations of industrial policies and time horizons. These findings illustrate that the impact of industrial policies and their welfare implications cannot be adequately studied in a static partial equilibrium framework.

Our framework can be easily modified in several ways. For example, by introducing nominal rigidities into our framework, one can investigate what are the monetary policy implications amid these geoeconomic tensions and could monetary policy interact with industrial policies to tackle possible externalities in such a framework. In addition, many of these industrial policies are rooted with a distributional concern. Our framework can be extended to a multiple-sector setting and investigate the dynamic and distributional impacts of these industrial policies. Lastly, there are many more countries in the world besides the North and South in our framework. An extension toward a three-country model can shed important insights for the rest of the world when big nations are in rivalry with each other. Exploration of these issues will contribute valuable insights to ongoing discussions on economic conflicts, geopolitical tensions, and their effects on the global economy.

References

Aghion, Philippe, Jing Cai, Mathias Dewatripont, Luosha Du, Ann Harrison, and Patrick Legros, "Industrial policy and competition," *American economic journal: macroeconomics*, 2015, *7* (4), 1–32.

Aiyar, Mr Shekhar, Mr Jiaqian Chen, Christian Ebeke, Mr Christian H Ebeke, Mr Roberto Garcia-Saltos, Tryggvi Gudmundsson, Ms Anna Ilyina, Mr Alvar Kangur, Tansaya Kunaratskul, Mr Sergio L Rodriguez et al., *Geo-economic fragmentation and the future of multilateralism*, International Monetary Fund, 2023.

Akcigit, Ufuk, Sina T Ates, and Giammario Impullitti, "Innovation and trade policy in a globalized world," Technical Report, National Bureau of Economic Research 2018.

Amiti, Mary, Stephen J Redding, and David E Weinstein, "The impact of the 2018 tariffs on prices and welfare," *Journal of Economic Perspectives*, 2019, *33* (4), 187–210.

_ , _ , and _ , "Who's paying for the US tariffs? A longer-term perspective," in "AEA Papers and Proceedings," Vol. 110 American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203 2020, pp. 541–546.

Antras, Pol and Elhanan Helpman, "Global sourcing," *Journal of political Economy*, 2004, *112* (3), 552–580.

Attinasi, Maria Grazia, Lukas Boeckelmann, and Baptiste Meunier, "The economic costs of supply chain decoupling," 2023.

Auray, Stéphane and Aurélien Eyquem, "Endogenous entry, international business cycles, and welfare," *International Business Cycles, and Welfare (January 1, 2011). GATE Working Paper*, 2011, (1114).

Baldwin, Richard and Paul Krugman, "Industrial policy and international competition in wide-bodied jet aircraft," in "Trade policy issues and empirical analysis," University of Chicago Press, 1988, pp. 45–78.

Barattieri, Alessandro, Matteo Cacciatore, and Fabio Ghironi, "Protectionism and the business cycle," *Journal of International Economics*, 2021, *129*, 103417.

Benguria, Felipe and Felipe Saffie, "The impact of the 2018-2019 Trade War on US local labor markets," *Available at SSRN 3542362*, 2020.

Bergin, Paul R and Giancarlo Corsetti, "Beyond competitive devaluations: The monetary dimensions of comparative advantage," *American Economic Journal: Macroeconomics*, 2020, *12* (4), 246–286.

Bolhuis, Marijn A, Mr Jiaqian Chen, and Benjamin R Kett, *Fragmentation in global trade: Accounting for commodities* number 2023-2073, International Monetary Fund, 2023.

Cacciatore, Matteo and Fabio Ghironi, "Trade, unemployment, and monetary policy," *Journal of International Economics*, 2021, *132*, 103488.

Caliendo, Lorenzo and Fernando Parro, "Trade policy," *Handbook of International Economics*, 2022, *5*, 219–295.

Cerdeiro, Diego A, Rui Mano, Johannes Eugster, and Mr Shanaka J Peiris, *Sizing up the effects of technological decoupling*, International Monetary Fund, 2021.

Choi, Jaedo and Andrei A Levchenko, "The long-term effects of industrial policy," Technical Report, National Bureau of Economic Research 2021.

Chor, Davin and Bingjing Li, "Illuminating the effects of the US-China tariff war on China's economy," Technical Report, National Bureau of Economic Research 2021.

Corsetti, Giancarlo, Philippe Martin, and Paolo Pesenti, "Varieties and the transfer problem," *Journal of International Economics*, 2013, *89* (1), 1–12.

Fajgelbaum, Pablo D, Pinelopi K Goldberg, Patrick J Kennedy, and Amit K Khandelwal, "The return to protectionism," *The Quarterly Journal of Economics*, 2020, *135* (1), 1–55.

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

Góes, Carlos and Eddy Bekkers, "The impact of geopolitical conflicts on trade, growth, and innovation," *arXiv preprint arXiv:2203.12173*, 2022.

Grossman, Gene M and Esteban Rossi-Hansberg, "Trading tasks: A simple theory of offshoring," *American Economic Review*, 2008, *98* (5), 1978–1997.

Hamano, Masashige and Francesco Zanetti, "Endogenous product turnover and macroeconomic dynamics," *Review of Economic Dynamics*, 2017, *26*, 263–279.

Hansen, Jørgen Drud, Camilla Jensen, and Erik Strøjer Madsen, "The establishment of the Danish windmill industry—was it worthwhile?," *Review of World Economics*, 2003, *139*, 324–347.

Head, Keith, "Infant industry protection in the steel rail industry," *Journal of International Economics*, 1994, *37* (3-4), 141–165.

Imura, Yuko and Malik Shukayev, "The extensive margin of trade and monetary policy," *Journal of Economic Dynamics and Control*, 2019, *100*, 417–441.

Irwin, Douglas A, "Could the United States iron industry have survived free trade after the Civil War?," *Explorations in Economic History*, 2000, *37* (3), 278–299.

Javorcik, Beata, Lucas Kitzmueller, Helena Schweiger, and Muhammed Ali Yildirim, "Economic costs of friend-shoring," 2023.

Jiang, Zhe Jasmine, "'Multinational Firms' Sourcing Decisions and Wage Inequality: A Dynamic Analysis," *Journal of Economic Dynamics and Control*, 2023, *146* (C).

Ju, Jiandong, Hong Ma, Zi Wang, and Xiaodong Zhu, "Trade wars and industrial policy competitions: Understanding the US-China economic conflicts," *Journal of Monetary Economics*, 2024, *141*, 42–58.

Juhász, Réka, Nathan J Lane, and Dani Rodrik, "The new economics of industrial policy," Technical Report, National Bureau of Economic Research 2023.

_ , Nathan Lane, Emily Oehlsen, and Verónica C Pérez, "The Who, What, When, and How of Industrial Policy: A Text-Based Approach," *What, When, and How of Industrial Policy: A Text-Based Approach (August 15, 2022)*, 2022.

Kim, Daisoon, "Economies of scale and international business cycles," *Journal of International Economics*, 2021, *131*, 103459.

Lane, Nathan, "Manufacturing revolutions: Industrial policy and industrialization in South Korea," *Available at SSRN 3890311*, 2022.

Lashkaripour, Ahmad and Volodymyr Lugovskyy, "Profits, scale economies, and the gains from trade and industrial policy," *American Economic Review*, 2023, *113* (10), 2759–2808.

Lechthaler, Wolfgang and Mariya Mileva, "The dynamic and distributional aspects of import tariffs," *International Economic Review*, 2021, *62* (1), 199–241.

Liu, Ernest, "Industrial policies in production networks," *The Quarterly Journal of Economics*, 2019, *134* (4), 1883–1948.

Luzio, Eduardo and Shane Greenstein, "Measuring the performance of a protected infant industry: the case of Brazilian microcomputers," *The Review of Economics and Statistics*, 1995, pp. 622–633.

Ma, Hong and Lingsheng Meng, "Heterogeneous impacts of the Section 301 tariffs: Evidence from the revision of product lists," *Canadian Journal of Economics/Revue canadienne d'économique*, 2023, *56* (1), 164–190.

Manelici, Isabela and Smaranda Pantea, "Industrial policy at work: Evidence from Romania's income tax break for workers in IT," *European Economic Review*, 2021, *133*, 103674.

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

Milicevic, Teodora Borota, Fabrice Defever, Giammario Impullitti, and Adam Hal Spencer, *Innovation union: Costs and benefits of innovation policy coordination*, Centre for Economic Performance, London School of Economics and Political . . . , 2022.

Tian, Can, "Firm-level entry and exit dynamics over the business cycles," *European Economic Review*, 2018, *102*, 298–326.

Tu, Xinquan, Yingxin Du, Yue Lu, and Chengrong Lou, "US-China trade war: Is winter coming for global trade?," *Journal of Chinese Political Science*, 2020, *25*, 199–240.

Waugh, Michael E, "The consumption response to trade shocks: Evidence from the US-China trade war," Technical Report, National Bureau of Economic Research 2019.

Zlate, Andrei, "Offshore production and business cycle dynamics with heterogeneous firms," *Journal of International Economics*, 2016, *100*, 34–49.

APPENDIX

A Additional figures and tables

Table A.1. Model equations

Euler equation, bonds	$1=\beta\left(1+r_{t+1}\right)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\right]$
	$1=\beta^*\left(1+r^*_{t+1}\right)E_t\left[\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\gamma}\right]$
Euler equations, stocks	$\tilde{v}_t=\beta\left(1-\delta\right)E_t\left[\left(\frac{C_{t+1}}{C_t}\right)^{-\gamma}\left(\tilde{d}_{t+1}+\tilde{v}_{t+1}\right)\right]$
	$\tilde{v}^*_t=\beta^*\left(1-\delta^*\right)E_t\left[\left(\frac{C^*_{t+1}}{C^*_t}\right)^{-\gamma}\left(\tilde{d}^*_{t+1}+\tilde{v}^*_{t+1}\right)\right]$
Free entry conditions	$\tilde{v}_t=\left(1-s_E\right)\frac{f_E}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{v}^*_t=\left(1-s^*_E\right)\frac{f^*_E}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
Law of motions, firms	$N_{t+1}=\left(1-\delta\right)\left(N_t+N_{E,t}\right)$
	$N^*_{t+1}=\left(1-\delta^*\right)\left(N^*_t+N^*_{E,t}\right)$
Price indices	$1=N_{D,t}\left(\tilde{\rho}_{D,t}\right)^{1-\theta}+N_{V,t}\left(\tilde{\rho}_{V,t}\right)^{1-\theta}+N^*_{X,t}\left[(1+\tau^{IM})\tilde{\rho}^*_{X,t}\right]^{1-\theta}$
	$1=N^*_{D,t}\left(\tilde{\rho}^*_{D,t}\right)^{1-\theta}+N^*_{V,t}\left(\tilde{\rho}^*_{V,t}\right)^{1-\theta}+N_{X,t}\left[(1+\tau^{IM*})\tilde{\rho}_{X,t}\right]^{1-\theta}$
Aggregate accounting	$C_t+N_{E,t}\tilde{v}_t=w_{l,t}L+w_{h,t}H+N_t\tilde{d}_t+T_t$
	$C^*_t+N^*_{E,t}\tilde{v}^*_t=w^*_{l,t}L^*+w^*_{h,t}H^*+N^*_t\tilde{d}^*_t+T^*_t$
Total profits	$N_t\tilde{d}_t=N_{D,t}\tilde{d}_{D,t}+N_{V,t}\tilde{d}_{V,t}+N_{X,t}\tilde{d}_{X,t}$
	$N^*_t\tilde{d}^*_t=N^*_{D,t}\tilde{d}^*_{D,t}+N^*_{V,t}\tilde{d}^*_{V,t}+N^*_{X,t}\tilde{d}^*_{X,t}$
Number of firms	$N_t=N_{D,t}+N_{V,t}$
	$N^*_t=N^*_{D,t}+N^*_{V,t}$
Offshoring profit links	$\tilde{d}_{V,t}=\frac{k}{k-(\theta-1)}\left(\frac{z_{V,t}}{\tilde{z}_{D,t}}\right)^{\theta-1}\tilde{d}_{D,t}+\frac{\theta-1}{k-(\theta-1)}f_V\frac{Q_t}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{d}^*_{V,t}=\frac{k}{k-(\theta-1)}\left(\frac{z^*_{V,t}}{\tilde{z}^*_{D,t}}\right)^{\theta-1}\tilde{d}^*_{D,t}+\frac{\theta-1}{k-(\theta-1)}f^*_V\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
Export profit links	$\tilde{d}_{X,t}=\frac{\theta-1}{k-(\theta-1)}\frac{f_X}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{d}^*_{X,t}=\frac{\theta-1}{k-(\theta-1)}\frac{f^*_X}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
Average productivity	$\tilde{z}_{D,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}z_{V,t}\left[\frac{z_{V,t}^{k-(\theta-1)}-z_{\min}^{k-(\theta-1)}}{z_{V,t}^{k}-z_{\min}^{k}}\right]^{\frac{1}{\theta-1}}$
	$\tilde{z}^*_{D,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}z^*_{V,t}\left[\frac{{z^*_{V,t}}^{k-(\theta-1)}-z_{\min}^{k-(\theta-1)}}{{z^*_{V,t}}^{k}-z_{\min}^{k}}\right]^{\frac{1}{\theta-1}}$
	$\tilde{z}_{V,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}\left(\frac{N_t}{N_{V,t}}\right)^{1/k}$
	$\tilde{z}^*_{V,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}\left(\frac{N^*_t}{N^*_{V,t}}\right)^{1/k}$
	$\tilde{z}_{X,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}\left(\frac{N_t}{N_{X,t}}\right)^{1/k}$
	$\tilde{z}^*_{X,t}=\left(\frac{k}{k-(\theta-1)}\right)^{\frac{1}{\theta-1}}z_{\min}\left(\frac{N^*_t}{N^*_{X,t}}\right)^{1/k}$

Table A.1. Model equations, continued

Offshoring cutoff productivity	$z_{V,t} = z_{\min}\left(\frac{N_t}{N_{V,t}}\right)^{1/k}$
	$z^*_{V,t} = z_{\min}\left(\frac{N^*_t}{N^*_{V,t}}\right)^{1/k}$
Average prices at N	$\tilde{\rho}_{D,t} = \frac{\theta}{\theta-1}\frac{1-s_D}{Z_t\tilde{z}_{D,t}}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{\rho}_{V,t} = \frac{\theta}{\theta-1}\frac{1}{\tilde{z}_{V,t}}\left(\frac{(1+\tau^{IM})\tau^{V}Q_t w^*_{l,t}}{Z^*_t(1-\alpha)}\right)^{1-\alpha}\left(\frac{w_{h,t}}{Z_t\alpha}\right)^{\alpha}$
	$\tilde{\rho}_{X,t} = \frac{\theta}{\theta-1}\frac{\tau Q_t^{-1}}{Z_t\tilde{z}_{X,t}}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
Average prices at S	$\tilde{\rho}^*_{D,t} = \frac{\theta}{\theta-1}\frac{1-s^*_D}{Z^*_t\tilde{z}^*_{D,t}}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{\rho}^*_{V,t} = \frac{\theta}{\theta-1}\frac{1}{\tilde{z}^*_{V,t}}\left(\frac{w^*_{l,t}}{Z^*_t(1-\alpha)}\right)^{1-\alpha}\left(\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{h,t}}{Z_t\alpha}\right)^{\alpha}$
	$\tilde{\rho}^*_{X,t} = \frac{\theta}{\theta-1}\frac{\tau^* Q_t}{Z^*_t\tilde{z}^*_{X,t}}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
Average profits at N	$\tilde{d}_{D,t} = \frac{1}{\theta}\tilde{\rho}_{D,t}^{1-\theta}C_t$
	$\tilde{d}_{V,t} = \frac{1}{\theta}\tilde{\rho}_{V,t}^{1-\theta}C_t - f_V\frac{Q_t}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{d}_{X,t} = \frac{1}{\theta}(1+\tau^{IM*})^{-\theta}\tilde{\rho}_{X,t}^{1-\theta}C^*_tQ_t - \frac{f_X}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
Average profits at S	$\tilde{d}^*_{D,t} = \frac{1}{\theta}\tilde{\rho}^{*1-\theta}_{D,t}C^*_t$
	$\tilde{d}^*_{V,t} = \frac{1}{\theta}\tilde{\rho}^{*1-\theta}_{V,t}C^*_t - f^*_V\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
	$\tilde{d}^*_{X,t} = \frac{1}{\theta}(1+\tau^{IM})^{-\theta}\tilde{\rho}^{*1-\theta}_{X,t}C_tQ_t^{-1} - \frac{f^*_X}{Z^*_t}\left(\frac{w^*_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w^*_{h,t}}{\alpha}\right)^{\alpha}$
High-skilled demand by N	$\tilde{h}_{D,t} = \frac{1}{Z_t\tilde{z}_{D,t}}\left(\frac{\alpha}{1-\alpha}\frac{w_{l,t}}{w_{h,t}}\right)^{1-\alpha}\tilde{\rho}_{D,t}^{-\theta}C_t$
	$\tilde{h}_{V,t} = \frac{1}{Z_t^{\alpha}Z_t^{*1-\alpha}\tilde{z}_{V,t}}\left(\frac{\alpha}{1-\alpha}\frac{(1+\tau^{IM})\tau^{V}Q_tw^*_{l,t}}{w_{h,t}}\right)^{1-\alpha}\tilde{\rho}_{V,t}^{-\theta}C_t$
	$\tilde{h}_{X,t} = \frac{1}{Z_t\tilde{z}_{X,t}}\left(\frac{\alpha}{1-\alpha}\frac{w_{l,t}}{w_{h,t}}\right)^{1-\alpha}\left[(1+\tau^{IM*})\tilde{\rho}_{X,t}\right]^{-\theta}C^*_t$
High-skilled demand by S	$\tilde{h}^*_{D,t} = \frac{1}{Z^*_t\tilde{z}^*_{D,t}}\left(\frac{\alpha}{1-\alpha}\frac{w^*_{l,t}}{w^*_{h,t}}\right)^{1-\alpha}\tilde{\rho}^{*-\theta}_{D,t}C^*_t$
	$\tilde{h}^*_{V,t} = \frac{1}{Z_t^{\alpha}Z_t^{*1-\alpha}\tilde{z}^*_{V,t}}\left(\frac{\alpha}{1-\alpha}\frac{w^*_{l,t}}{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{h,t}}\right)^{1-\alpha}\tilde{\rho}^{*-\theta}_{V,t}C^*_t$
	$\tilde{h}^*_{X,t} = \frac{1}{Z^*_t\tilde{z}^*_{X,t}}\left(\frac{\alpha}{1-\alpha}\frac{w^*_{l,t}}{w^*_{h,t}}\right)^{1-\alpha}\left[(1+\tau^{IM})\tilde{\rho}^*_{X,t}\right]^{-\theta}C_t$

Table A.1. Model equations, continued

Low-skilled demand by N	$\tilde{l}_{D,t} = \frac{1}{Z_t \tilde{z}_{D,t}} \left(\frac{1-\alpha}{\alpha}\frac{w_{h,t}}{w_{l,t}}\right)^{\alpha} \tilde{\rho}_{D,t}^{-\theta} C_t$
	$\tilde{l}_{V,t} = \frac{1}{Z_t^{\alpha} Z_t^{*1-\alpha} \tilde{z}_{V,t}} \left(\frac{1-\alpha}{\alpha}\frac{w_{h,t}}{(1+\tau^{IM})\tau^V Q_t w_{l,t}^*}\right)^{\alpha} \tilde{\rho}_{V,t}^{-\theta} C_t$
	$\tilde{l}_{X,t} = \frac{1}{Z_t \tilde{z}_{X,t}} \left(\frac{1-\alpha}{\alpha}\frac{w_{h,t}}{w_{l,t}}\right)^{\alpha} \left[(1+\tau^{IM*})\tilde{\rho}_{X,t}\right]^{-\theta} C_t^*$
Low-skilled demand by S	$\tilde{l}_{D,t}^* = \frac{1}{Z_t^* \tilde{z}_{D,t}^*} \left(\frac{1-\alpha}{\alpha}\frac{w_{h,t}^*}{w_{l,t}^*}\right)^{\alpha} \tilde{\rho}_{D,t}^{*-\theta} C_t^*$
	$\tilde{l}_{V,t}^* = \frac{1}{Z_t^{\alpha} Z_t^{*1-\alpha} \tilde{z}_{V,t}^*} \left(\frac{1-\alpha}{\alpha}\frac{(1+\tau^{IM*})\tau^{V*} Q_t^{-1} w_{h,t}}{w_{l,t}^*}\right)^{\alpha} \tilde{\rho}_{V,t}^{*-\theta} C_t^*$
	$\tilde{l}_{X,t}^* = \frac{1}{Z_t^* \tilde{z}_{X,t}^*} \left(\frac{1-\alpha}{\alpha}\frac{w_{h,t}^*}{w_{l,t}^*}\right)^{\alpha} \left[(1+\tau^{IM})\tilde{\rho}_{X,t}^*\right]^{-\theta} C_t$
Labor market clearing (H)	$H = N_{D,t}\tilde{h}_{D,t} + N_{X,t}\tilde{h}_{X,t} + N_{V,t}\tilde{h}_{V,t} + \tau^{V*} N_{V,t}^* \tilde{h}_{V,t}^*$
	$+ \left(N_{E,t}\frac{f_E}{Z_t} + N_{X,t}\frac{f_X}{Z_t} + N_{V,t}^*\frac{f_V^*}{Z_t}\right)\left(\frac{\alpha w_{l,t}}{(1-\alpha)w_{h,t}}\right)^{1-\alpha}$
	$H^* = N_{D,t}^*\tilde{h}_{D,t}^* + N_{X,t}^*\tilde{h}_{X,t}^* + \left(N_{E,t}^*\frac{f_E^*}{Z_t^*} + N_{X,t}^*\frac{f_X^*}{Z_t^*} + N_{V,t}\frac{f_V}{Z_t^*}\right)\left(\frac{\alpha w_{l,t}^*}{(1-\alpha)w_{h,t}^*}\right)^{1-\alpha}$
Gov budget constraints	$\tau^V \tau^{IM} N_{V,t} w_{l,t}^* \tilde{l}_{V,t} Q_t + \tau^{IM} N_{X,t}^* \tilde{\rho}_{X,t}^* [(1+\tau^{IM})\tilde{\rho}_{X,t}^*]^{-\theta} C_t - T_t$
	$= s_E N_{E,t}\frac{f_E}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha} + s_D N_{D,t}\tilde{\rho}_{D,t}^{-\theta} C_t \frac{1}{Z_t \tilde{z}_{D,t}}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$
	$\tau^{V*}\tau^{IM*} N_{V,t}^* w_{h,t} \tilde{h}_{V,t}^* Q_t^{-1} + \tau^{IM*} N_{X,t}\tilde{\rho}_{X,t}[(1+\tau^{IM*})\tilde{\rho}_{X,t}]^{-\theta} C_t^* - T_t^*$
	$= s_E^* N_{E,t}^*\frac{f_E^*}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha} + s_D^* N_{D,t}^*\tilde{\rho}_{D,t}^{*-\theta} C_t^* \frac{1}{Z_t^* \tilde{z}_{D,t}^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha}$
Balance of payments	$N_{X,t}\tilde{\rho}_{X,t}\left((1+\tau^{IM*})\tilde{\rho}_{X,t}\right)^{-\theta} C_t^* Q_t + \tau^{V*} N_{V,t}^* w_{h,t}\tilde{h}_{V,t}^* - \tau^V N_{V,t} w_{l,t}^* \tilde{l}_{V,t} Q_t$
	$-N_{X,t}^*\tilde{\rho}_{X,t}^*\left((1+\tau^{IM})\tilde{\rho}_{X,t}^*\right)^{-\theta} C_t$
	$= N_{V,t} f_V \frac{Q_t}{Z_t^*}\left(\frac{w_{l,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}^*}{\alpha}\right)^{\alpha} - N_{V,t}^* f_V^* \frac{1}{Z_t}\left(\frac{w_{l,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{h,t}}{\alpha}\right)^{\alpha}$

The above equations constitute a system of 57 equations in 57 endogenous variables: C_t, r_t, $\tilde{v}_t$, $\tilde{d}_t$, $w_{l,t}$, $w_{h,t}$, N_t, $N_{E,t}$, $N_{D,t}$, $N_{V,t}$, $N_{X,t}$, $\tilde{\rho}_{D,t}$, $\tilde{\rho}_{V,t}$, $\tilde{\rho}_{X,t}$, T_t, $\tilde{d}_{D,t}$, $\tilde{d}_{V,t}$, $\tilde{d}_{X,t}$, $\tilde{z}_{D,t}$, $z_{V,t}$, $\tilde{z}_{V,t}$, $\tilde{z}_{X,t}$, $\tilde{h}_{D,t}$, $\tilde{h}_{V,t}$, $\tilde{h}_{X,t}$, $\tilde{l}_{D,t}$, $\tilde{l}_{V,t}$, $\tilde{l}_{X,t}$, their Southern counterparts and the real exchange rate Q_t.

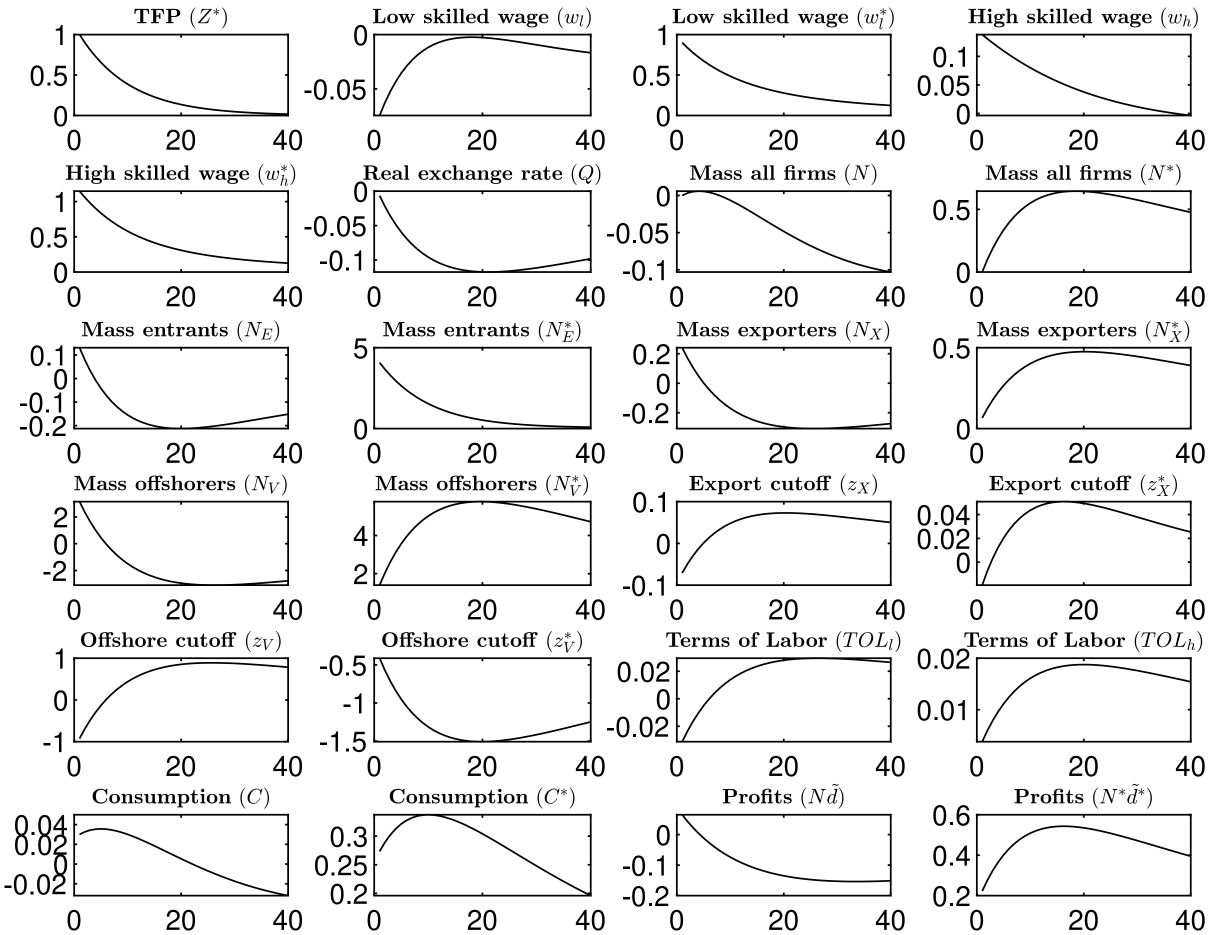

Figure A.1. Impulse responses of North and South variables to 1% TFP shock in South. All variables are presented as percentage deviations from the initial steady state (after multiplication by 100)

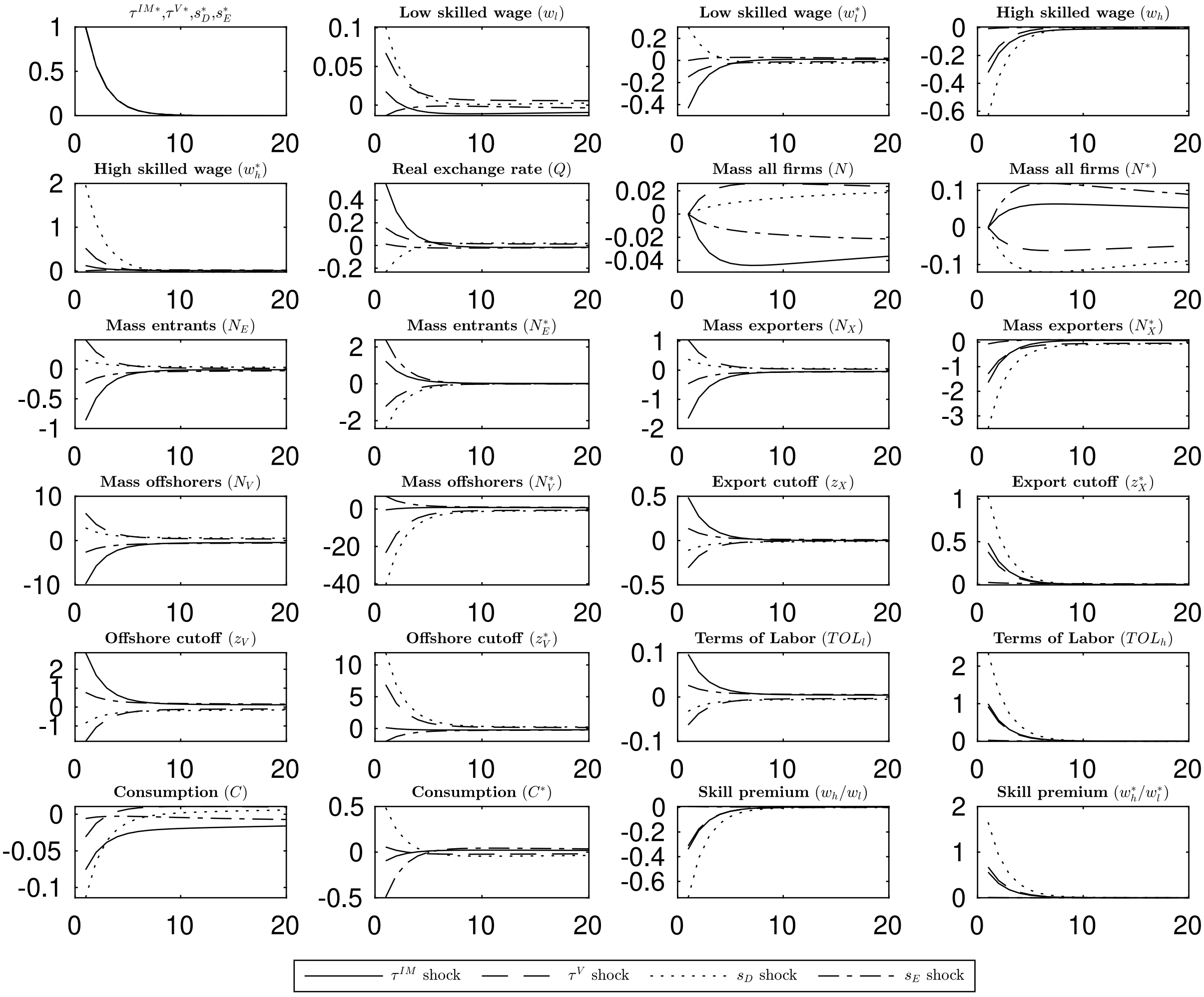

Figure A.2. Impulse responses of North and South variables to 1% of individual industrial policy shocks in the South. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

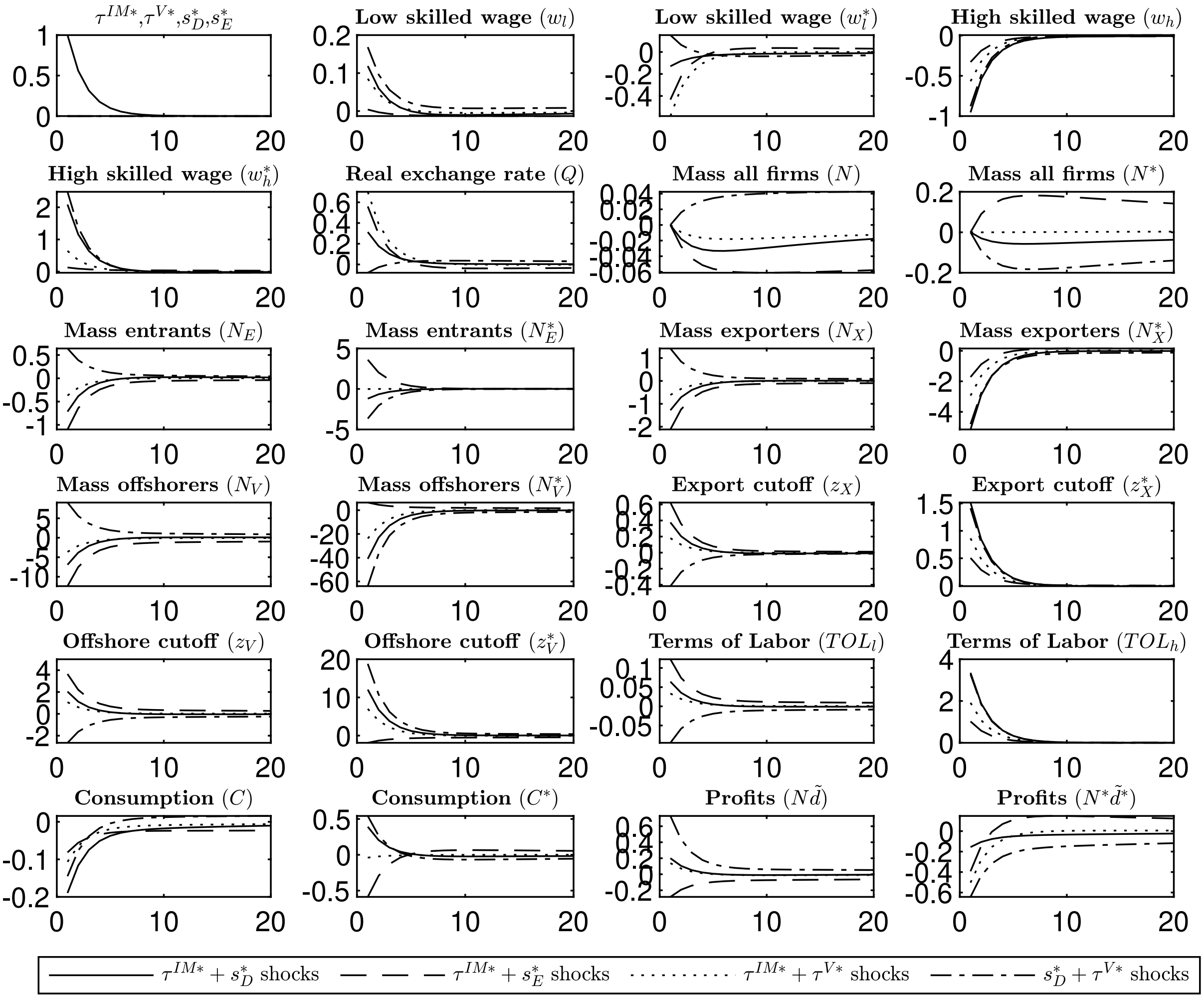

Figure A.3. Impulse responses of North and South variables to 1% of combinations industrial policy shocks in the South. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

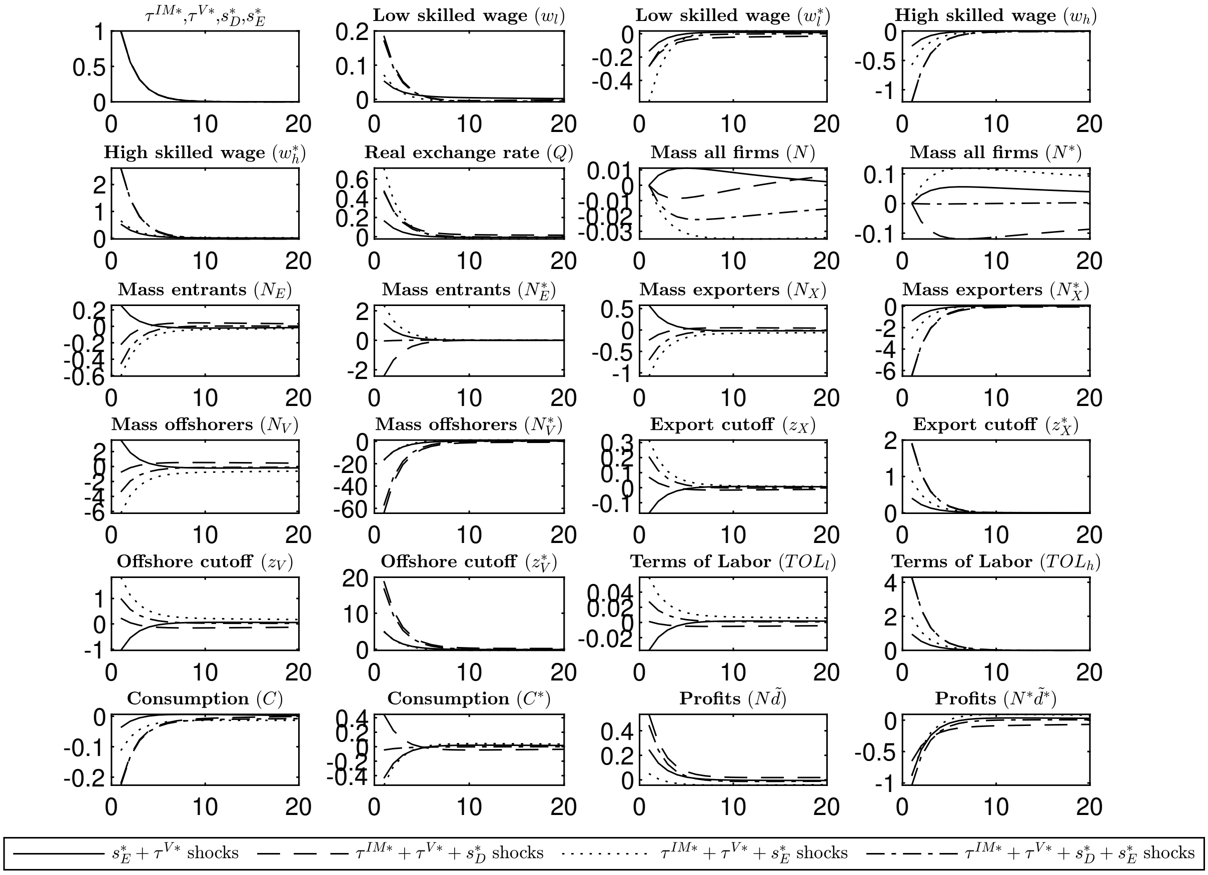

Figure A.4. Impulse responses of North and South variables to 1% of combinations industrial policy shocks in the South. The policy instrument is presented as absolute percentage points, while all other variables are presented as percentage deviations from the initial steady state (all after multiplication by 100).

B Solution Methods

We adopt an iterative approach to solve for the steady state of the model. In this section, we first derive analytical expressions of the offshoring and export cutoffs. We then leverage these expressions in developing our solution algorithm.

Northern firms

The period profits for a domestic firm are

$$\begin{aligned} d_{D,t}(z) &= \frac{1}{\theta}\{\rho_{D,t}^{1-\theta}\}C_t \\ &= \frac{1}{\theta}\left\{\left(\frac{\theta}{\theta-1}\right)\left(\frac{1-s_D}{zZ_t}\right)\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t \\ &= \frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}\left(\frac{1-s_D}{zZ_t}\right)^{1-\theta}\left(\frac{w_{L,t}}{1-\alpha}\right)^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha(1-\theta)} C_t \end{aligned}$$

and those for offshoring firms are

$$
\begin{aligned}
d_{V,t}(z) =& \frac{1}{\theta}\left\{\rho_{V,t}(z)^{1-\theta}C_t\right\} - f_V\left(\frac{Q_t}{Z_t^*}\right)\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha} \\
=& \frac{1}{\theta}\left\{\frac{\theta}{\theta-1}\frac{1}{z}\left[\frac{(1+\tau^{IM})\tau^V Q_t w_{L,t}^*}{Z_t^*(1-\alpha)}\right]^{1-\alpha}\left(\frac{w_{H,t}}{Z_t\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t \\
& - f_V\left(\frac{Q_t}{Z_t^*}\right)\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha} \\
=& \frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}\left(\frac{1}{z}\right)^{1-\theta}\left[\frac{(1+\tau^{IM})\tau^V Q_t w_{L,t}^*}{Z_t^*(1-\alpha)}\right]^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{Z_t\alpha}\right)^{\alpha(1-\theta)} C_t \\
& - f_V\left(\frac{Q_t}{Z_t^*}\right)\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha}.
\end{aligned}
$$

So an expression for the cutoff $z_{V,t}$ comes from $d_{D,t}(z) = d_{V,t}(z)$

$$
\begin{aligned}
\Rightarrow & \frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}\left(\frac{1-s_D}{z_{V,t}Z_t}\right)^{1-\theta}\left(\frac{w_{L,t}}{1-\alpha}\right)^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha(1-\theta)} C_t \\
& = \frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}\left(\frac{1}{z_{V,t}}\right)^{1-\theta}\left[\frac{(1+\tau^{IM})\tau^V Q_t w_{L,t}^*}{Z_t^*(1-\alpha)}\right]^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{Z_t\alpha}\right)^{\alpha(1-\theta)} C_t \\
& - f_V\left(\frac{Q_t}{Z_t^*}\right)\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha} \\
z_{V,t}^{\theta-1} & = \frac{f_V\left(\frac{Q_t}{Z_t^*}\right)\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha}}{\frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}C_t\left\{\left[\frac{(1+\tau^{IM})\tau^V Q_t w_{L,t}^*}{Z_t^*(1-\alpha)}\right]^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{Z_t\alpha}\right)^{\alpha(1-\theta)} - \left(\frac{1-s_D}{Z_t}\right)^{1-\theta}\left(\frac{w_{L,t}}{1-\alpha}\right)^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha(1-\theta)}\right\}}.
\end{aligned}
$$

Then similarly, the exporting profits are given by

$$
d_{X,t}(z) = \frac{1}{\theta}(1+\tau^{IM*})^{-\theta}\rho_{X,t}(z)^{1-\theta}C_t^*Q_t - \frac{f_X}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}
$$

where the cutoff is then given as $d_{X,t}(z) = 0$

$$
\begin{aligned}
& \frac{1}{\theta}(1+\tau^{IM*})^{-\theta}\left\{\frac{\theta}{\theta-1}\frac{\tau Q_t^{-1}}{z_{X,t}Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t^*Q_t - \frac{f_X}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha} = 0 \\
\Rightarrow & z_{X,t}^{\theta-1} = \frac{\frac{f_X}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}}{\frac{1}{\theta}(1+\tau^{IM*})^{-\theta}\left\{\frac{\theta}{\theta-1}\frac{\tau Q_t^{-1}}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t^*Q_t}.
\end{aligned}
$$

Southern firms

The optimal price for a domestic firm is

$$\rho_{D,t}(z) = \frac{\theta}{\theta-1}\frac{(1-s_D^*)}{Z_t^* z}\left(\frac{w_L^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_H^*}{\alpha}\right)^{\alpha}$$

and their profits are

$$\begin{aligned} d_{D,t}^*(z) &= \frac{1}{\theta}\rho_{D,t}^*(z)^{1-\theta}C_t^* \\ &= \frac{1}{\theta}\left\{\frac{\theta}{\theta-1}\frac{(1-s_D^*)}{Z_t^* z}\left(\frac{w_L^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_H^*}{\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t^*. \end{aligned}$$

The optimal price for an offshoring firm is

$$\rho_{V,t}^*(z) = \frac{\theta}{\theta-1}\frac{1}{z}\left(\frac{w_{L,t}^*}{Z_t^*(1-\alpha)}\right)^{1-\alpha}\left[\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{H,t}}{Z_t\alpha}\right]^{\alpha}.$$

Then we can write their profits as

$$\begin{aligned} d_{V,t}^*(z) = {} & \rho_{V,t}^*(z)y_{V,t}^*(z) - \frac{1}{z}\left(\frac{w_{L,t}}{Z_t^*(1-\alpha)}\right)^{1-\alpha}\left(\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{H,t}}{Z_t\alpha}\right)^{\alpha} y_{V,t}^*(z) - \\ & f_V^*\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha} \\ = {} & \frac{1}{\theta}\rho_{V,t}^*(z)^{1-\theta}C_t^* - f_V^*\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha} \\ = {} & \frac{1}{\theta}\left\{\frac{\theta}{\theta-1}\frac{1}{z}\left(\frac{w_{L,t}^*}{Z_t^*(1-\alpha)}\right)^{1-\alpha}\left[\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{H,t}}{Z_t\alpha}\right]^{\alpha}\right\}^{1-\theta} C_t^* \\ & - f_V^*\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha} \end{aligned}$$

So we can find the cutoff $z_{V,t}^*$ as

$$z_{V,t}^{*(\theta-1)} = \frac{f_V^*\frac{Q_t^{-1}}{Z_t}\left(\frac{w_{L,t}}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}}{\alpha}\right)^{\alpha}}{\frac{1}{\theta}\left(\frac{\theta}{\theta-1}\right)^{1-\theta}\left\{\left(\frac{w_{L,t}^*}{Z_t^*(1-\alpha)}\right)^{(1-\alpha)(1-\theta)}\left[\frac{(1+\tau^{IM*})\tau^{V*}Q_t^{-1}w_{H,t}}{Z_t\alpha}\right]^{\alpha(1-\theta)} - \left(\frac{(1-s_D^*)}{Z_t^*}\right)^{1-\theta}\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{(1-\alpha)(1-\theta)}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha(1-\theta)}\right\}C_t^*}$$

Then the exporting cutoff is

$$z_{X,t}^{*(\theta-1)} = \frac{\frac{f_X^*}{Z_t^*}\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha}}{\frac{1}{\theta}(1+\tau^{IM})^{-\theta}\left\{\frac{\theta}{\theta-1}\frac{\tau^* Q_t}{Z_t^*}\left(\frac{w_{L,t}^*}{1-\alpha}\right)^{1-\alpha}\left(\frac{w_{H,t}^*}{\alpha}\right)^{\alpha}\right\}^{1-\theta} C_t Q_t^{-1}}$$

Algorithm

The following iterative process solves for the steady state.

1. Conjecture objects $\widehat{\Psi} = \left(\hat{Q}, \hat{C}, \hat{C}^*, \hat{w}_L, \hat{w}_L^*, \hat{w}_H^*\right)$. Fix $\hat{w}_H = 1$, (can then treat the fixed cost of entry as a free parameter below).
2. Find the associated cutoffs z_V, z_X, z_V^*, z_X^*.
3. Find the average productivity levels $\tilde{z}_D, \tilde{z}_V, \tilde{z}_X, \tilde{z}_D^*, \tilde{z}_V^*, \tilde{z}_X^*$.
4. Find average real price levels $\tilde{\rho}_D, \tilde{\rho}_V, \tilde{\rho}_X, \tilde{\rho}_D^*, \tilde{\rho}_V^*, \tilde{\rho}_X^*$.
5. Find average profits $\tilde{d}_D, \tilde{d}_V, \tilde{d}_X, \tilde{d}_D^*, \tilde{d}_V^*, \tilde{d}_X^*$.
6. Find high skilled demand $\tilde{h}_D, \tilde{h}_V, \tilde{h}_X, \tilde{h}_D^*, \tilde{h}_V^*, \tilde{h}_X^*$ and low skilled demand $\tilde{l}_D, \tilde{l}_V, \tilde{l}_X, \tilde{l}_D^*, \tilde{l}_V^*, \tilde{l}_X^*$.
7. Compute the value of entry $\tilde{v}$. Then back-out the fixed cost of entry (given the wage normalization) as $f_E = \tilde{v}\frac{1}{1-s_e} Z\left(\frac{1-\alpha}{w_L}\right)^{1-\alpha}\left(\frac{\alpha}{w_H}\right)^{\alpha}$. Then set $f_E^* = f_E$.
8. Using the average labor demand levels found above, find the masses of firms N and N^* that clear the high skilled labor market in each country.
9. Aggregate to find total profits and entry costs as well as government tax collections.
10. Compute the following metrics of distance

$$\Delta^C = |C - \hat{C}|$$
$$\Delta^{C*} = |C^* - \hat{C}^*|$$
$$\Delta^Q = |BOP|$$
$$\Delta^L = |L - L^D|$$
$$\Delta^{L*} = |L^* - L^{D*}|$$
$$\Delta^{H*} = |H^* - H^{D*}|$$

where Δ^C captures the difference of consumption good supply C and that conjectured, Δ^{C*} is the same but for the foreign country, BOP is the balance of payments, Δ^L captures the distance of the low skilled labor market clearing (supply L equals demand L^D), Δ^{L*} is the analogue for the South and Δ^{H*} is the distance of high skilled labor in the South H^* meeting the corresponding demand H^{D*}.

11. Update the conjecture of $\widehat{\Psi}$ in accordance with the distance metrics and repeat the process until convergence.