The Quantitative Effects of Trade Policy on Industrial and Labor Location*

Lorenzo Caliendo
Yale University and NBER

Fernando Parro
Penn State University and NBER

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PRELIMINARY AND INCOMPLETE

Abstract

We evaluate the quantitative effects of trade policy on the location of firms across space and over time. We develop a multi-country, multi-sector dynamic general-equilibrium trade and spatial model with forward-looking decisions of workers on where to supply labor, forward-looking decisions of firms on where to locate produc-tion, endogenous capital structure accumulation, and trade in intermediate goods with sectoral linkages. We bring the model to data using trade, production, and data on firm demographics across sector and locations. We use the model to study if trade protectionism can revert the declining trend in the U.S. manufacturing em-ployment and firms; and its impact on the location of production across space and over time. We feed into the model the raise in import tariffs between the U.S. and its major trade partners in the year 2018. We find that these changes in trade policy can result in a persistent increase on manufacturing employment and firms. However, these effects do not revert the long run decline in manufacturing employment and firms. Importantly, the relocation of production comes at the cost of higher prices, lower welfare for households, and heterogeneous effects on firm entry across space.

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1 Introduction

The recent backslash against globalization has resulted in increased trade protectionism in many countries, and most notably in the United States. In the year 2018, the trade weighted manufacturing tariffs applied by the U.S. to China increased by about 8 percentage points while the retaliatory tariffs from China to the U.S. increased, on average, by around 9 percentage points. The relocation of industries is probably the most frequent argument for trade protectionism.[1] In this paper, we study how trade policy impacts the dynamics of manufacturing labor and firms. We present several aggregate and regional data on how employment and firms have evolve over time across sectors and regions in the U.S. Motivated by these facts, we develop a framework to study the dynamics of labor, and the dynamic decision of firms on entry and exit. We apply our model to the 2018 increase in trade restrictions between the United States and its trading partners, and evaluate if trade protectionism can have a positive impact on manufacturing employment and on firm's entry, study if protectionism could revert the observed decline in manufacturing employment and firms, and importantly, access the aggregate, and distributional, welfare effects of protectionism.

We build on recent advances in the literature and present a multi sector, multi country, and multi region dynamic general equilibrium model. In the model, households feature dynamic decisions on where to supply labor, decisions determined by expected real wages, mobility costs, and idiosyncratic preferences, and we also allow for non-employment. Firms produce and sell goods domestically and to other locations to maximize profits that depends on demand, factor prices, and are also shaped by trade policy. We introduce firm's forward-looking decisions on where to locate production, as well as entry and exit across locations. To locate production in a given region, firms must pay an entry cost, measured in units of capital structures, thus entry cost is lower in regions with lower rental rates of capital structure, which is also an equilibrium object in our model. Locations in our model can also accumulate capital structures, which in part attracts firms. We embed all these mechanisms into a rich production and trade structure that features input-output linkages.

To study the effects of increased unilateral protectionism in the U.S., with and without retaliation, we first consider the aggregate effects using a multi-country and multi

[1] There are no shortage of historical episodes where governments have explicitly mentioned this argument for trade protectionism (see Baldwin, Forslid, Martin, Ottaviano, and Robert-Nicoud, 2003). Just to mention an example, as early as in the 18th century, the U.S. President Hamilton advocated for high tariffs as a means to shift industrial production from Great Britain back to the U.S.. For more examples, see Irwin (2017).

region model featuring 39 countries, and three industries (manufacturing, wholesale and retail, and services), and a construction sector that we use to discipline the accumulation of new structures, as described later on. We then extend the model, and the quantitative assessment by adding regions. We use the year 2015 as the reference year and to take the model to the data, we obtain data on trade across U.S. states, across countries, and between U.S. states and other countries, as well as production data and labor flows. We also discipline the initial mass of firms across locations, and the different firm's location choice using firms demographic data from the U.S. Census Statistics of U.S. Business (SUSB) database, and OECD Structural and Demographic Business Statistics (SDBS).

To compute the changes in tariffs on U.S. imports and exports in 2018 due to the 2018 trade war, we use information on the tariffs changes applied by U.S. as well as the retaliatory tariffs from China and all other countries at the product level, HS-10 digit classification. We compute the exposure of the manufacturing sector of each country to these tariff increases by using import weights of each targeted product in total manufacturing trade of each country. With this measures, we then evaluate the change in U.S. import tariffs and average changes in retaliatory tariffs.

We find that the increased trade protectionism (all observed tariff increases in 2018) results in a positive effect on manufacturing firms entry and manufacturing employment in the United States. We find a 1.81 percent increase in the number of manufacturing firms in the United States in the long run, and a 0.06 percentage point increase in the the share of population employed in the manufacturing sector. However, we find that this positive effect on firms and employment does not revert their declining trend. Moreover, it comes at the cost of higher prices and lower welfare. We find that welfare declines by 0.18 percent, and the U.S. price index increases by 1.18 percent in the long run. If the foreign countries had not retaliated, we find larger effects on manufacturing firms and employment, U.S. households would have been slightly better off, but still the positive gains in employment and the positive location effect of firms do not revert their declining trend over time.

When looking at the distributional effects of trade policy across space, we find that a handful of states are the ones that attract firms and employment, some of the them are large states such as Florida and Texas, and some other are states with high exposure to imports from China, such as Tennessee and Georgia. We find that the states that attract firms and employment are better off, but the states that experience losses of firms an employment are worse off. Moreover, the gains from the trade war in the states that attract firms and employment are captured by the local governments, firms, and capital developers that experience increases in profits and revenues, but not by households. We find that households in all states experience a decline in welfare as a consequence of the 2018 trade war.

Our paper is related to several strands of the trade literature. The labor market dynamics in our model builds on Artuç, Chaudhuri, and McLaren (2010), and Caliendo, Dvorkin, and Parro (2019), henceforth CDP. The implications of trade policy on industrial location has been primarily studied in the new economic geography theory (Venables, 1987, Puga and Venables, 1997, Martin and Rogers, 1995, Baldwin et al., 2003, Ossa, 2011, among others), which has provided intuitive insights on how the location effect of trade trade policy shapes welfare in the protecting country.[2] Fujita, Krugman, and Venables (2000) call for a general equilibrium quantitative framework to re-assess the spatial effects of trade policy. We provide a tractable general equilibrium framework that allows us to quantitatively re-asses the implications of changes to trade policy at the aggregate and disaggregate level.

We follow the work by Das, Roberts, and Tybout (2007) and add forward looking firms to a international trade model. Different from this work, the main decision of the firms in our model is where to locate production instead of which market to enter as an exporter. More broadly, we relate to research on firm's dynamics in trade that model export decisions, like Roberts and Tybout (1997), Eaton, Eslava, Jinkins, Krizan, and Tybout (2012), Alessandria and Choi (2014), Alessandria, Choi, and Ruhl (2014), and Dickstein and Morales (2018).

Our paper also relates to the recent literature that has provided evidence on the short run effects of the 2018 U.S. trade war (Fajgelbaum et al., 2019, Flaaen et al., 2020, Amiti et al., 2019, among others). Our paper is also closely related to the literature that has found reduced-form evidence on the distributional consequences of trade liberalization on employment and other outcomes (Topalova, 2010, Dix Carneiro and Kovak, 2017, Kovak, 2013), as well as the literature that has studied the aggregate and distributional consequences of the China trade shock (e.g. Autor et al., 2013, Pierce and Schott, 2009, Caliendo, Dvorkin, and Parro, 2019, and Galle et al., 2017). We also relate to the empirical literature on trade policy and industrial location, like Hanson (1996), Hanson (1998), and Hanson (2001).

More generally, our paper is related to the literature on quantitative analysis of trade and domestic policies in static frameworks such as Caliendo and Parro (2015), Caliendo,

[2] These papers have focused on evaluating how trade policy can have a firm relocation effect, which is also related to the home market effect, see Helpman and Krugman (1985), and Davis (1998) for a study on the home market effect in an economy with a non-tradable sector.

Feenstra, Romalis, and Taylor (2015), Handley and Limao (2015), Broda, Limao, and Weinstein (2008), Costinot and Rodriguez-Clare (2014), Ossa (2016), and Bartelme, Costinot, Donaldson, and Rodriguez-Clare (2018). Also related to us are spatial models with a focus on studying the role of trade and domestic policies in shaping the distribution of economic activity such as in Fajgelbaum, Morales, Serrato, and Zidar (2015), Ossa (2015), and Gaubert (2018). More generally, the dynamic entry and exit decisions in our model are closely related to Hopenhayn (1992). Our model is a model of firm's location choice, entry and exit decisions across locations, and it might seem tempting to think of our framework to understand multinational production. However, our model is not a model of multinational production since we avoid dealing with the interdependencies across markets that complicate the firm's decision problem, see Antras and Yeaple (2013), Tintelnot (2017), Antras, Fort, and Tintelnot (2017), Arkolakis, Ramondo, Rodriguez-Clare, and Yeaple (2018) and, Garetto, Oldenski, and Ramondo (2019).

Modeling fixed entry costs in terms of capital relates our paper to the Footloose Capital model developed by Martin and Rogers (1995).[3] Baldwin (1999) extends the model to incorporate endogenous capital accumulation in the context of a two country model. But adding forward looking capital accumulation into a multi-country and multi-region model is not an easy task. Eaton, Kortum, Neiman, and Romalis (2016) incorporate capital accumulation into a multi-country international trade model as in Eaton and Kortum (2002), and show how to take the model to the data expressing the equilibrium condition of the model in changes; building on Dekle, Eaton, and Kortum (2007). We follow a different approach and incorporate accumulation of capital structures at the local level into a multi-country, multi-region, model. In doing so, we follow Desmet and Rossi-Hansberg (2014), and Desmet, Nagy, and Rossi-Hansberg (2016), and simplify the problem of capital accumulation decisions as in Allen and Donaldson (2018).

A large strand of the literature has studied reasons for trade policy with theory such as Grossman and Helpman (1994), Grossman and Helpman (1995a), Grossman and Helpman (1995b), Grossman and Helpman (2018), Bagwell and Staiger (1999), Bagwell and Staiger (2012), Bagwell and Staiger (2015), Gros (1987), Demidova (2008), Demidova and Rodriguez-Clare (2009), Maggi and Rodriguez-Clare (2007), and Costinot, Donaldson, Vogel, and Werning (2015). We propose a general equilibrium framework that shares many of the mechanisms in this literature and study the dynamic effects of trade policy quantitatively.

The spatial trade and production structure builds on recent static spatial economics models such as Allen and Arkolakis (2014), Redding (2016), Redding and Sturm (2008),

[3] See Baldwin et al. (2003) for an in depth explanation of the Footloose Capital model.

Caliendo, Parro, Rossi-Hansberg, and Sarte (2017) and many other papers reviewed in Redding and Rossi-Hansberg (2017).

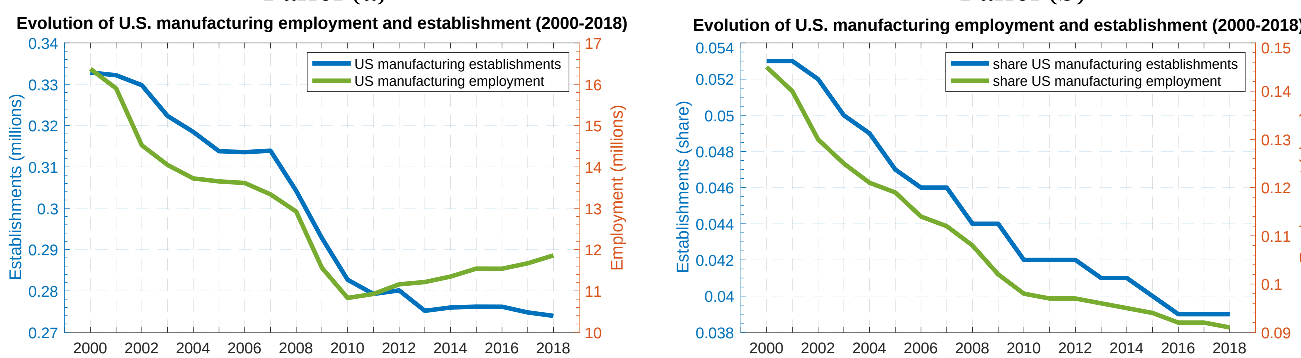
The rest of the paper is organized as follows. Section 2 presents descriptive statistics on the manufacturing sector in the U.S. Section 3 develops the quantitative dynamic model of industrial and labor location, and Section 4 describes how we solve the model and take the model to the data. Section 5 presents the aggregate effects of the 2018 trade war and Section 6 the spatial effects. Finally, Section 7 concludes. All proofs and detailed derivations are relegated to the Appendix.

2 Manufacturing Employment and Firms in the U. S.

We start by documenting the evolution of the manufacturing employment and firms in the United States over the last twenty years, using data from the BLS. Looking first at Figure 1, panel (a), we observe an overall decline in U.S. manufacturing employment from the year 2000 to 2018 which in part has been documented in recent research on the effects of trade on U.S. labor markets (e.g. Autor et al., 2013, Pierce and Schott, 2016). In the same figure, we document that the number of manufacturing establishments that operate in the United States had declined throughout this sample period (figure D.2 in Appendix D.1 shows that firms and establishments have the same pattern over time).

Figure 1: Evolution of U.S. manufacturing employment and firms

Panel (a) Panel (b)



Note: The left-hand panel presents the evolution of employment and number of establishments in the manufacturing sector in the United States. The right-hand side panel presents the share of manufacturing employment in total employment and the share of manufacturing establishments in total U.S. manufacturing establishments. The data used to construct these figures is from the BLS as described in detail in Section 4.2.

A second observation from panel (a) of Figure 1 is that the evolution of employment does not seem to move one-to-one with the evolution of manufacturing establishments in the United States over this period. For instance, the figure shows that while employment has started to increase after 2010, the number of establishments has continued to decline. In panel (b), we display the evolution of manufacturing employment and the number of establishments as a share of total employment and total number of establishments, which also show a decline over this period.

In the next section we develop a framework that can reconcile the observed aggregate behavior of firms and employment. Importantly, we then use the framework to study how trade policy impacts the dynamics of manufacturing labor and firms; and answer questions such as: does trade protectionism have a positive impact on manufacturing employment and on firm's entry?, is it able to revert this observed decline in manufacturing employment and firms?, if so, does it come at a welfare cost?

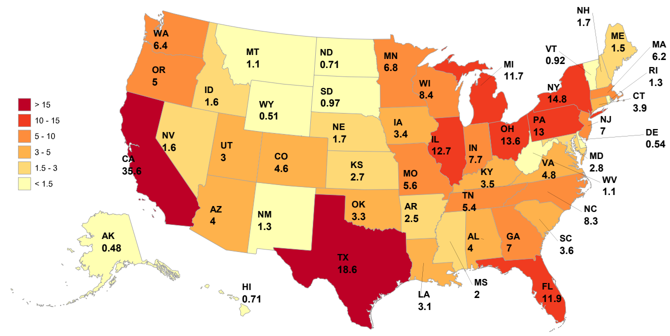
The economic activity is unevenly distributed across space, and as result, employment, firms, and the exposure of each U.S. state to international trade varies. We illustrate this spatial heterogeneity using data on the number of establishment, firms' entry, employment, and trade by U.S. states for the year 2015, using data from from the U.S. Census, Statistics of U.S. Business (SUSB) database. In this section, we present the descriptive statistics, and in the quantitative section we describe in detail the different data sources.

Figure 2 shows the number of establishments across U.S. states in the manufacturing and non-manufacturing sectors. We can see in panel (a) the degree of spatial heterogeneity in the distribution of manufacturing establishments across U.S. states, ranging from about 500 establishments in states such as Alaska, Delaware, and Wyoming, to about 18,000 in Texas and about 35,600 in California, namely the state with the largest number of manufacturing establishments has about 75 times more establishments than the state with the lowest number of manufacturing establishments. In the non manufacturing sector, the dispersion is somewhat lower, but still substantial; the ratio of establishments between the top and the bottom state is about 46 times. The number of non-manufacturing establishments ranges from about 15,000 in states such as Vermont, Alaska, and Wyoming to about 450,000 in Texas and almost 700,000 in California. Also, in the figure we observe that although the states that have more manufacturing establishments tend to be the same states with the largest number of non-manufacturing establishments, the ranking across all states is not the same in both sectors. As an example, Wisconsin is the seventh state with the largest number of non-manufacturing establishments, but it is the twenty second state with the largest number of manufacturing establishments.

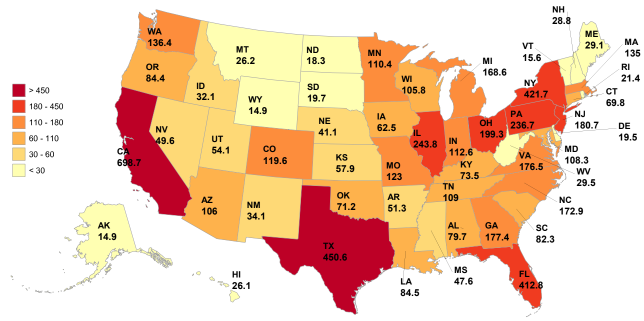
The lower panel of Figure 2 shows manufacturing establishments as a share of each state's total establishments that shows the spatial variation in the concentration of manufacturing establishments within each state. For instance, states such as New York, Nevada, and Florida have a lower concentration of manufacturing establishments compared with states such Wisconsin, Ohio, and Indiana.

Figure 2: U.S. establishments across space

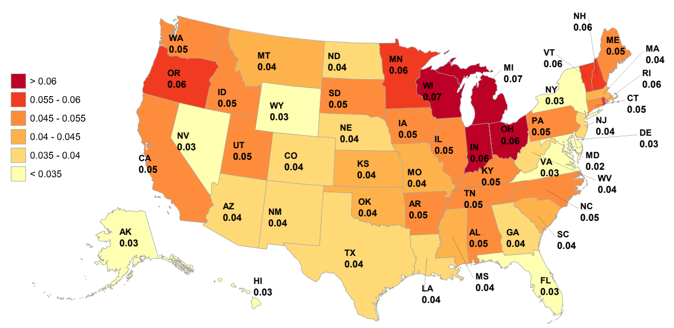
a) Manufacturing - (thousand)



b) Non-manufacturing - (thousand)



c) Manufacturing share
(share of the state's total number of establishments)

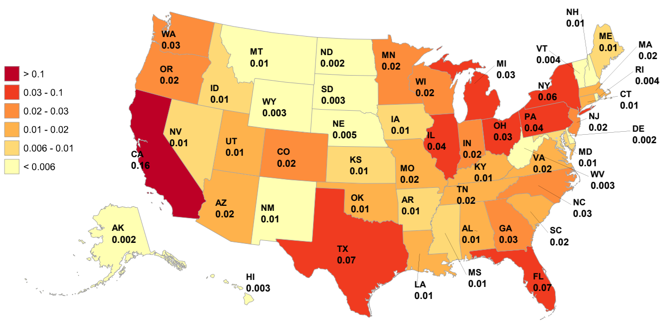


Note: The data on U.S. establishments across space used to construct this figure is from the U.S. Census, Statistics of U.S. Business (SUSB) database, described in detail in Section 6.

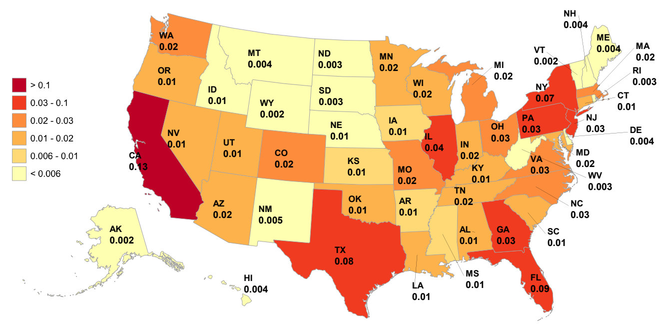
There is also substantial spatial heterogeneity in the firm's entry rates in the United States. Figure 3 displays the annual entry rate of establishments across U.S. states in the manufacturing and non-manufacturing sectors, measured as the fraction of establishments that enter in a given state out of the total entry in the United States. Entry rates in the manufacturing sectors vary from 0.2-0.3 percent in states such as North Dakota, South Dakota, Wyoming, and Alaska, to levels of 7 percent in states such as Florida an Texas, and 16 percent in California. Entry rates in the non-manufacturing sectors exhibits a similar range of variation.

Figure 3: U.S. establishments' annual entry rates across space

a) Manufacturing
(share of U.S. total entry)



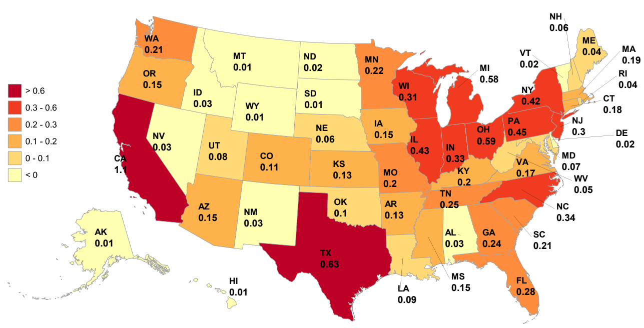
b) Non-manufacturing
(share of U.S. total entry)



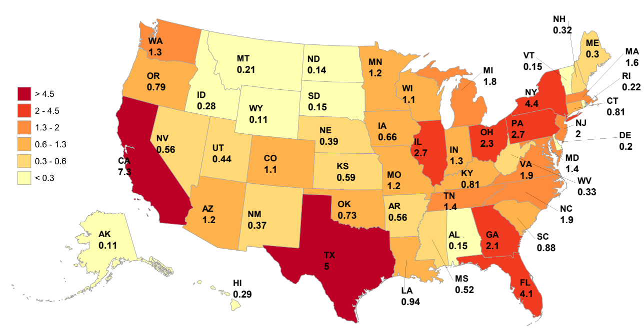
Note: The data on U.S. establishments across space used to construct this figure is from the U.S. Census, Statistics of U.S. Business (SUSB) database, described in detail in Section 6.

Figure 4: U.S. employment across space

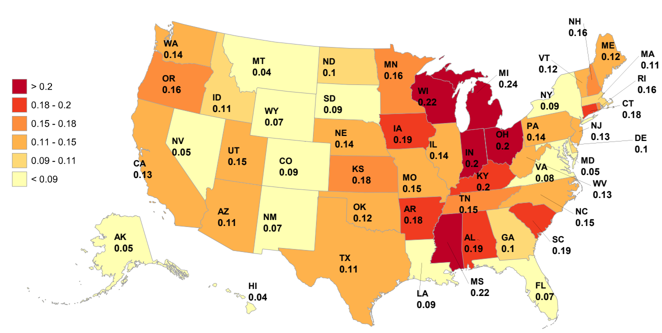
a) Manufacturing - (population share)



b) Non-manufacturing - (population share)



c) Manufacturing share
(share of the state's employment)



Note: The data on U.S. establishments across space used to construct this figure is from the U.S. Census, Statistics of U.S. Business (SUSB) database, described in detail in Section 6.

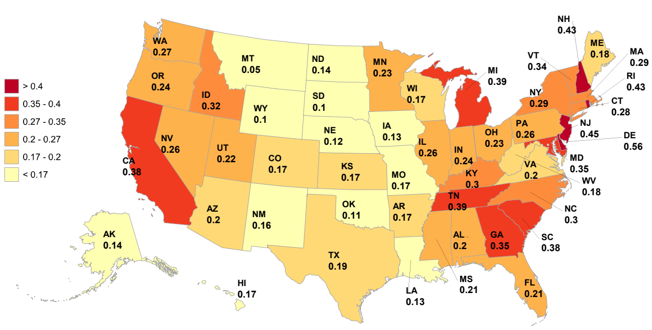
Figure 4 shows the distribution of employment in the manufacturing and non manufacturing industries across U.S. states. As expected, the spatial cross-section of the distribution of employment across firms is highly correlated with the distribution of establishments. The lower panel shows the concentration of manufacturing employment within each states. States such as New York, Montana, Florida, and New Mexico have a lower concentration of manufacturing employment compared to states such as Wisconsin, Ohio, Indiana, and Mississippi.

A second observation that we emphasize is that U.S. states are not only heterogeneous in terms of the distribution of employment and firms, but there is also spatial heterogeneity in the exposure to manufacturing trade, and therefore, to changes in trade policy. To illustrate this point, Figure 5, left-hand side panel, shows imports from the world by each state as a share of total expenditure in each state. The right-hand side panel shows imports from China by state as a share of each state total expenditure. Starting with the left-hand side figure, we can see that the five states that are most expose to manufacturing imports from the world are Delaware, New Jersey, Rhode Island, New Hampshire, and Michigan. On the other hand, the five states least exposed to manufacturing imports from the world are Nebraska, Oklahoma, Wyoming, South Dakota, and Montana.

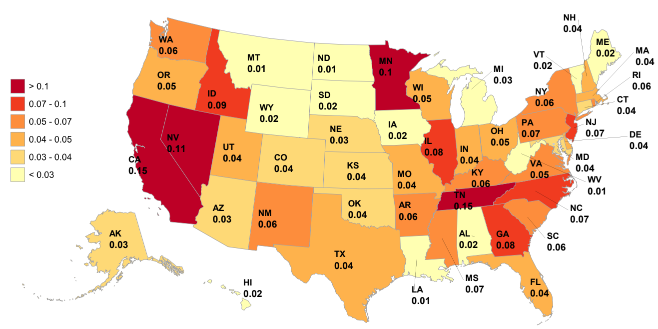
Moving to the right-hand panel of Figure 5, we observe that the five states that are most exposed to manufacturing imports from China are California, Tennessee, Nevada, Minnesota, and Idaho. The states least exposed to manufacturing imports from China are South Dakota, West Virginia, Louisiana, North Dakota, and Montana.

Figure 5: U.S. trade exposure across space

a) Import penetration from the world
(share of total expenditure)



b) Import penetration from China
(share of total expenditure)



Note: The data on U.S. establishments across space used to construct this figure is from the U.S. Census, Statistics of U.S. Business (SUSB) database, described in detail in Section 6.

This heterogeneity across space in the distribution of employment, firms, and trade gives rise to the question on the distributional consequences of trade policy across space. Even when trade policy might have a positive impact on aggregate manufacturing employment and firms, where do firms locate in the United States if they decide to enter the country? Are they going to enter in all states, are they going to concentrate in few larger states where more employment is available, or in smaller states where entry costs might be lower, or in states more exposed to trade? Motivated by these questions, we will also extend our framework to add economic geography in order to study the distributional consequences of trade policy across space.

3 A Dynamic Model of Trade and Industrial Location

In this section, we develop a dynamic general equilibrium model for trade policy analysis. Our model is guided by data presented in the previous section. We first consider an economic environment with no internal geography. Later on we also model spatially distinct later markets inside a country. The economic environment consists of N countries indexed by i and n, and J sectors which we label them by j and k. Time is discrete, and we denote it by $t = 0, 1, 2, ...$ We start by describing the problem of the household and then set up the problem of the firms. We derive the market clearing conditions and after doing so we define the equilibrium of the model.

3.1 Households

At $t = 0$, we assume that there is a mass L_0^{nj} of households in each location n and sector j. Households are forward looking and, at each moment in time, decide in which labor market to supply labor tomorrow (a costly sectoral relocation decision). We model the dynamic labor market decision as a dynamic discrete choice problem following Artuç et al. (2010) and CDP.

Households can be either employed or non-employed. Employed households supply a unit of labor inelastically and receive a competitive market wage, their only source of income. At each moment in time household's decide how to allocate consumption over local final goods from all sectors. We assume logarithmic preferences, where the consumption basket $C_t^{nj} = \prod_k (c_t^{nj,k})^{\alpha^k}$, and $c_t^{nj,k}$ is the consumption of final goods from sector k of a household located in n and working in sector j. We assume that $\sum_{k=1}^{J} \alpha^k = 1$. The ideal local price index is given by $P_t^n = \prod_{k=1}^{J} \left(P_t^{nk}/\alpha^k\right)^{\alpha^k}$. Non-employed households obtain consumption in terms of non-market home production $b^n > 0$. As a result,

$C_t^{n,ne} = b^n$, where $C_t^{n,ne}$ is the consumption of a non-employed household located in n and ne stands for non-employment status. At the end of each period households decide where to supply labor tomorrow or to move to non-employment, a decision that is affected by the expected value in each labor market, labor mobility frictions $m^{nj,nk}$ that depend on the sector of origin j and destination k and idiosyncratic preference shocks ε_t^{nk}. We assume that households discount the future at rate $\beta \geq 0$, and that ε_t^{nk} are the realization of a Type-I Extreme value distribution with zero mean and dispersion parameter ν.

The value function of a worker located in labor market nj at time t is given by

$$u_t^{nj} = log(C_t^{nj}) + \max_{k=ne,1,..,J} \left\{ \beta E_t \left[u_{t+1}^{nj} \right] - m^{nj,nk} + \varepsilon_t^{nk} \right\}.$$

As mentioned above, workers decide at each moment in time where to locate tomorrow. They can move to any $k = ne, 1, ..., J$, where we abused notation and included in the set of options all sectors and ne, non-employment.

Let $U_t^{nj} = E_t \left[u_{t+1}^{nj} \right]$ be the expected value of a household from locating in nj where the expectations are taken over the realizations of the idiosyncratic shocks. It follows that

$$U_t^{nj} = log \left(C_t^{nj} \right) + \nu log \left[\sum_{k=ne,1}^{J} exp \left(\beta U_{t+1}^{nk} - m^{nj,nk} \right)^{1/\nu} \right]. \tag{1}$$

The fraction of workers that relocate from market nj to market nk is given by

$$\mu_t^{nj,nk} = \frac{exp \left(\beta U_{t+1}^{nk} - m^{nj,nk} \right)^{1/\nu}}{\sum_{h=ne,1}^{J} exp \left(\beta U_{t+1}^{nh} - m^{nj,nh} \right)^{1/\nu}}, \tag{2}$$

and the evolution of labor across markets is given by

$$L_{t+1}^{nj} = \sum_{k=ne,1}^{J} \mu_t^{nk,nj} L_t^{nk}. \tag{3}$$

3.2 Production

The production structure builds on the multi-sector with sectoral linkages commercial policy model of Caliendo and Parro (2015) and the spatial models of Caliendo et al. (2017) and CDP. We depart from these frameworks by introducing dynamic decisions of firms on where to locate production as well as entry and exit decisions, and endogenous capital structure accumulation. We first describe the more standard problem of the final good producer and then move to the dynamic decision of firms.

3.2.1 Final Goods Producer

At each location and sector, a final good producer produces a final sectoral composite good with the following constant elasticity of substitution (CES) production function,

$$Q_t^{nj} = \left(\sum_{i=1}^{N} M_t^{ij} \left(q_t^{ij,nj} \right)^{(\sigma_j - 1)/\sigma_j} \right)^{\sigma_j/(\sigma_j - 1)},$$

where M_t^{ij} is the number of varieties produced in location i and sector $j,$ and σ_j is the elasticity of substitution across varieties. The demand in n for sector-j goods produced in i is given by:

$$q_t^{ij,nj} = \left(p_t^{ij,nj} / P_t^{nj} \right)^{-\sigma_j} X_t^{nj} / P_t^{nj}, \tag{4}$$

where $p_t^{ij,nj}$ is the price at nj of varieties produced in ij, and X_t^{nj} is total expenditure in $nj.$ The ideal sectoral price index P_t^{nj} is then given by

$$P_t^{nj} = \left(\sum_{i=1}^{N} M_t^{ij} \left(p_t^{ij,nj} \right)^{1-\sigma_j} \right)^{1/(1-\sigma_j)}. \tag{5}$$

The sectoral composite final good is consumed by local households and used as materials for the production of intermediate varieties.[4]

The price index (5) maps into the one in the new economic geography models discussed in the introduction. In what follows, we departure from them by introducing forward looking dynamics in the number of varieties produced in each location. In particular, the evolution of firms across locations will be shaped by the dynamic decisions of firms and workers, as well as the other mechanisms operating in our model that we discuss in next sections.

3.2.2 Intermediate Goods Producers

As mentioned above, producers of intermediate varieties are monopolistically competitive firms, which make several decisions. Inactive firms decide whether to enter or not into a market. Active firms decide to stay active, exit, or to relocate production. All these

[4]While the local sectoral good is not trade it is still the case that both intermediate goods producers and households, via the direct purchase of these local sectoral aggregate goods, are purchasing tradable varieties.

decisions are forward looking and subject to endogenous entry costs as well as idiosyncratic shocks. Conditional on choosing a location, firms decide how much to produce and sell in domestic and foreign markets. The production decision of the firm is influenced by local and global demand, by trade costs (policy and non-policy), by the price of local factors (labor, capital structures and materials), and by local productivity. We describe first the static profit maximization problem of a firm that is already producing in a given location. After that, we move to the dynamic entry/location choice and exit decision problem.

Gross Profits Producers of intermediate varieties at location n and sector j demand labor l_t^{nj}, capital structures k_t^{nj} and materials $z_t^{nj,nk}$ from all other sectors, k. All firms from industry j produce with a common deterministic local fundamental productivity a_t^{nj}. The production technology to produce in nj is given by

$$q_t^{nj} = a_t^{nj} \left[\left(l_t^{nj} \right)^{1-\xi^n} \left(k_t^{nj} \right)^{\xi^n} \right]^{\gamma^{nj}} \prod_{k=1}^{J} \left(z_t^{nj,nk} \right)^{\gamma^{nj,nk}},$$

where γ^{nj} is the share of value added in production, $\gamma^{nj,nk}$ are the corresponding input-output coefficients, and $1-\xi^n$ is the share of labor in value added. Factors of production are supplied locally. We assume that labor is imperfectly mobile across sectors and regions while capital structures is perfectly mobile across sectors but cannot move across regions. We denote factor prices by w_t^{nj} for labor and r_t^n for capital structures. The price of materials is given by P_t^{nk}. From the cost minimization problem of the firm we obtain that the unit cost of a bundle of inputs, denoted by x_t^{nj}, is given by

$$x_t^{nj} = B^{nj} \left[\left(w_t^{nj} \right)^{1-\xi^n} \left(r_t^n \right)^{\xi^n} \right]^{\gamma^{nj}} \prod_{k} \left(P_t^{nk} \right)^{\gamma^{nj,nk}}, \tag{6}$$

where B^{nj} is a constant.

Firms sell their products locally and to other markets subject to trade costs. Trade costs have a policy and a non-policy component. The policy component are ad-valorem revenue generating tariffs $\tau_t^{nj,ij}$, where $\tau_t^{nj,ij}$ are tariffs applied from i to goods in sector j sourced from n. The non-policy trade costs are transport costs that take the usual iceberg-type formulation, where $d^{nj,ij} \geq 1$ is the cost of shipping goods from n to i in industry j.

Firms maximize profits by taking into account the demand for their goods; namely (4). Let us denote by $\pi_t^{nj,ij}$ to the gross profits of a firm in sector j located in n and selling goods to i. The problem of the firm is given by

$$\pi_t^{nj,ij} = \max_{p_t^{nj,ij} \geq 0} \left\{ \frac{p_t^{nj,ij} q_t^{nj,ij}}{1+\tau_t^{nj,ij}} - \frac{x_t^{nj}}{a_t^{nj}} d^{nj,ij} q_t^{nj,ij}; \text{ subject to (4)} \right\}.$$

The solution to this problem is the standard mill pricing,

$$p_t^{nj,ij} = \frac{1}{1-1/\sigma_j} \frac{\left(1+\tau_t^{nj,ij}\right) d^{nj,ij} x_t^{nj}}{a_t^{nj}}. \tag{7}$$

Firms from industry j that locate production in n have total gross profits given by

$$\pi_t^{nj} = \sum_{i=1}^{N} \pi_t^{nj,ij}. \tag{8}$$

from selling domestically as well as to other locations. We will sometimes refer to π_t^{nj} as the market potential of a firm. Note the market potential is determined by local characteristics, (factor prices), trade costs and trade policy. As we do not include fixed costs of production we abstract from any selection of firms at entry. Instead, as it is going to become clear below, our focus is going to be on where firms decide to produce, and how trade policy affects the location decision of firms and in turn how this impacts the economic environment.

Firm's Dynamic Location Choice Our goal is to present a parsimonious model that is able to match the key salient characteristic on firm behavior that we presented in the previous section. We present a dynamic location choice model related to Das et al. (2007). Our model is a simplified version of their framework where similar to them, we explicitly model the dynamic forward looking behavior of firms; but different from them, we focus on the decision of which location to produce and not on selection to export.

We denote by v_t^{nj} the value of an active firm producing in sector j located in n at time t, and by v_t^{Oj} the value of a firm that is inactive. Active firms at time t have gross profits given by π_t^{nj} from (8), and decide whether to remain producing in nj the next period or exit. After exiting for one period, the firm can decide to locate production in any other location. We assume that firms face idiosyncratic shocks to their future revenues each period of time. We define $V_{t+1}^{nj} \equiv E_t[v_{t+1}^{nj}]$, and $V_{t+1}^{Oj} \equiv E_t[v_{t+1}^{Oj}]$ to be the expected values of a representative firm over all the possible realizations of the idiosyncratic shocks where we denote the idiosyncratic shocks by ϵ_t^{nj} and ϵ_t^{Oj}, and we assume firms discount the future by β.[5] The value of a firm in nj is then given by

$$v_t^{nj} = \pi_t^{nj} + max\left\{\beta V_{t+1}^{nj} - \epsilon_t^{nj}; \beta V_{t+1}^{Oj} - \epsilon_t^{Oj}\right\}, \text{ for all } n, j.$$

An inactive firm has zero current payoffs but has always the option to enter into a location the next period. Entering into a location is costly since it requires paying an entry cost of one unit of capital structures. Firms also face idiosyncratic entry costs, ϵ_t^{hj}. In particular, the value of the firm is given by

$$v_t^{Oj} = \max_{h=\{1,\ldots,N\}} \left\{\beta\left(V_{t+1}^{hj} - r_{t+1}^{h}\right) - \epsilon_t^{hj}\right\}, \text{ for all } n, j.$$

Note that we are assuming that the entry cost is paid the next period, the period in which the firm starts operating. Also note that in our formulation firms that are active in a location have the option to locate into another market but that such relocation decision is costly in terms of time (forgone profits for one period) and an entry cost.[6]

We assume that the idiosyncratic shocks are i.i.d. realizations from a Type-I Extreme value distribution with zero mean and dispersion parameter ϑ. This assumption, which is now standard in dynamic discrete choice literature (see Aguirregabiria and Mira (2010)) allows for simple aggregation of idiosyncratic decisions made by firms, as we now show.

Using the properties of the Type-I extreme value distributions (please refer to Appendix A for further details) we obtain that the value of active firms is given by

$$V_t^{nj} = \pi_t^{nj} + \vartheta log\left[\sum_{i=O,n} exp\left(V_{t+1}^{ij}\right)^{\beta/\vartheta}\right], \text{ for all } n, j, \tag{9}$$

and the value of inactive firms is given by

$$V_t^{Oj} = 0 + \vartheta log\left[\sum_{i=1}^{N} exp\left(V_{t+1}^{ij} - r_{t+1}^{i}\right)^{\beta/\vartheta}\right], \text{ for all } j. \tag{10}$$

[5]The idiosyncratic shocks can be thought to be in utils of entrepreneurs who own the firms and maximize linear utility over profits.

[6]An alternative formulation could be to allow firms to move to another market directly without the cost associated of not operating for a period. While it is no clear that adding this possibility might make the model more realistic it is clear that we would loose in terms of tractability. Ultimately, the choice between moving directly to another market after paying a cost or spending a period out of the market before entering involves choosing between similar, albeit perhaps not ideal, simplifying assumptions. When we take the model to the data it is going to become quite evident that the approach that we take allows us to match the aggregate firm data while at the same time been agnostic about idiosyncratic firm behavior.

Equation (9) indicates that the value of an active firm depends on its current-period gross profits in that location and on the option value to stay or move out of the market in the future. In turn, note that the value of inactivity, equation (10), is not zero since it provides the option value for the firm to produce in other locations, subject to entry costs.

We now solve for the firm location choice probabilities. We denote by $\varphi_t^{nj,nj}$ the fraction of firms located at nj that decides to continue producing at nj tomorrow. Using properties of the Type-I extreme value distribution (please refer to Appendix A) we obtain,

$$\varphi_t^{nj,nj} = \frac{exp\left(V_{t+1}^{nj}\right)^{\beta/\vartheta}}{\sum_{i=O,n} exp\left(V_{t+1}^{ij}\right)^{\beta/\vartheta}}, \text{ for all } n, j. \tag{11}$$

It follows that the fraction of firms that exit nj is given by $\varphi_t^{nj,Oj} = 1 - \varphi_t^{nj,nj}$. Note that (11) is very intuitive. The larger the value of producing in nj relative to exiting, the larger the share of firms that decide to remain producing in nj. Also note that since the value of exit depends on the future values of producing across all locations (equation 10), the more attractive it becomes to produce in a given location the larger the share of firms that would like to exit and produce in the attractive location. For instance, suppose that the value to produce in market n' goes up (or the price of capital structures in n' falls) then, other things equal, a higher fraction of firms will choose to exit n in order to locate to market n'.[7]

Using a similar notation, we denote to the fraction of inactive firms that locate production in nj at time t, $\varphi_t^{Oj,nj}$. This is given by

$$\varphi_t^{Oj,nj} = \frac{exp\left(V_{t+1}^{nj} - r_{t+1}^{n}\right)^{\beta/\vartheta}}{\sum_{i=1}^{N} exp\left(V_{t+1}^{ij} - r_{t+1}^{i}\right)^{\beta/\vartheta}}, \text{ for all } n, j. \tag{12}$$

Analogous to the previous example, from (12) we can see that if the value of producing in location n' goes up (or the price of capital structures in h falls) then, other things

[7] In particular, note that if we substitute (10) into $\varphi_t^{nj,Oj}$, we obtain

$$\varphi_t^{nj,Oj} = \frac{\left(\sum_{n'=1}^{N} exp\left(V_{t+2}^{n'j} - r_{t+2}^{n'}\right)^{\beta/\vartheta}\right)^{\beta}}{\sum_{i=O,n} exp\left(V_{t+1}^{ij}\right)^{\beta/\vartheta}},$$

and, as we can see, $\varphi_t^{nj,Oj}$ is impacted by changes economic circumstances in all other locations.

equal, there is a higher fraction of firms that choose to locate in n'.[8] Of course, in general equilibrium, how economic circumstances affect the location decision of firms to move to h will also depend on how the value to produce at each other location is also impacted by the shock, or change in policy, in h. Characterizing and quantifying the effect that trade policy has in this location decisions is one of our main focus in the next sections of the paper.

Finally, we can determine the evolution of the mass of operating firms across markets. Denote by M_t^{Oj} the mass of inactive firms at time t, then using the location choice probabilities we obtain

$$M_{t+1}^{nj} = M_t^{nj}\varphi_t^{nj,nj} + M_t^{Oj}\varphi_t^{Oj,nj}, \text{ for all } n, j, \tag{13}$$

$$M_{t+1}^{Oj} = \sum_{i=1}^{N} M_t^{ij}\varphi_t^{ij,Oj}, \text{ for all } j. \tag{14}$$

The equilibrium conditions (13) and (14) characterize the evolution of the distribution of firms across all markets in our economy. This is one of the state variables of the model.

It is important to emphasize that after aggregating over the idiosyncratic shocks the model has no predictions over individual firm behavior. Instead, we model the behavior of representative firms across locations. In addition, while we refer to entry and exit of firms throughout the paper, we could have also talked about entry and exit of establishments. In fact, until we do not specify the ownership structure of firms, the equilibrium conditions M_t^{nj} and M_t^{Oj} could characterize the distribution of firms and/or establishments across locations. Later on we describe how we allocate profits globally in order to be consistent with the aggregate data and in a way that allows us not to take a stand on the ownership structure of firms. We now proceed to describe the rest of the production side of the economy.

[8] More formally, note that

$$\frac{\partial \varphi_t^{nj,Oj}}{\partial (V_{t+2}^{n'j} - r_{t+2}^{n'})} = \frac{\beta^2}{\vartheta}\varphi_t^{nj,nj}\varphi_t^{nj,Oj}\varphi_{t+1}^{Oj,n'j} > 0,$$

and this reflects that all locations will experience larger relocation effects to market n' the more attractive the market becomes. Also, that the relocation elasticity crucially depends on the share of firms that stay, namely $\varphi_t^{nj,nj}$.

3.2.3 Development of Capital Structures

Capital structure in the economy is used as an input in the production of intermediate goods and by firms in order to start producing in a location. Adding an endogenous capital accumulation behavior into a multi country and spatial model is, in general, a difficult task because it requires characterizing the forward looking investment decision of agents across all markets. Since this is quite unexplored territory, we consider two approaches to model the development of capital structures. In the first approach, we consider an environment where there is one landowner that does not have the technology to develop structures. In order to build structures, the landowner rents the land to developers (with free entry) using a one period contract. We will see that the presence of a one period contract makes the problem tractable. This model is the model we refer to as: Landowners and Developers. After presenting this model of capital structures, we then present a model where there are an infinite number of landowners and each of them owning a unit of land. Each landowner solves a dynamic programming problem where she has to decide how to improve their land, build capital structures, in order to obtain income at each moment in time an in that way consume local goods. This model we refer to as: Landowners as Developers.

Landowners and Developers

We assume that at each location there is local rentier or capitalist that owns the land (H^n) and capital structures (K_t^n) in that location. Capital structures can be taught as the local improvements to land. We assume that capital structures depreciate at a rate δ, but new capital structures can be developed. Capitalists do not produce capital, they rent their capital and land to developers that use them to produce new capital structures and rent to firms. We assume that there is an infinite mass of developers that can freely enter into the production of capital structures per unit of land. Developers pay a permit ϖ_t^n to develop new structures at n in period t and we assume that the price of the permit is set in a competitive bidding process. This idea builds on Desmet and Rossi-Hansberg (2014), Desmet et al. (2016), and Allen and Donaldson (2018). This assumption implies that the capitalist has Ricardian rents, namely that it obtains all the surplus and the developer makes zero profits. As a result, the developer solves a static problem to determine the demand of factors to build new structures.[9]

[9] Three key assumptions determine that the solution to the dynamic problem is the solution of the static problem. First, that the contract that the landowner gives to developers are for one period. Second, that there is an infinite mass of developers that bid up to the point in which they make zero profits and third, that the landowners do not develop their land.

The problem of the developer is to demand local labor and together with the local stock of structures to produce new structures. Since this looks pretty much as a construction sector, we will label this sector as the "construction" sector and use the notation co to refer to it. The problem of the developer is as follows,

$$V_t^{n,co} \equiv \underset{l_t^{n,co}\geq 0}{max} \left\{ r_t^n k_t^n - w_t^{n,co} l_t^{n,co} - \varpi_t^n \right\} \text{ subject to } k_t^n = \left(\left(1-\delta\right) k_{t-1}^n \right)^{\kappa_n} \left(l_t^{n,co} \right)^{1-\kappa_n}, k_{t-1}^n \text{ given,}$$

where k_{t-1}^n, $l_t^{n,co}$ are capital structures and labor demand per unit of land, $w_t^{n,co}$ is wages paid to workers in the construction sector, κ_n is the share of labor used in the production of capital structures. From the first order conditions of this problem and after aggregating across all developers in a given location n, we obtain that the labor market clearing condition in the construction sector is given by

$$w_t^{n,co} L_t^{n,co} = \left(1-\kappa_n\right) r_t^n K_t^n, \tag{15}$$

where $L_t^{n,co}$ is the supply of construction workers. The construction sector is one sector more in the economy. The flow of workers into the construction sector is determined by (2) and labor supply evolves as in (3).

The aggregate law of motion of capital structures in each economy is given by

$$K_t^n = \left(K_{t-1}^n \left(1-\delta\right) \right)^{\kappa_n} \left(L_t^{n,co} \right)^{1-\kappa_n}, \tag{16}$$

which turns out to be the same formulation for the law of motion of capital accumulation as in Lucas and Prescott (1971), and Hercowitz and Sampson (1991).

We now present and alternative model where landowners develop capital structures.

Landowners as Developers

Suppose we allow landowners to also develop. In particular, suppose that each landowner owns a unit of land and that at each moment in time needs to hire construction workers to develop capital structures. The technology at time t to produce structures for $t+1$ is given by,

$$k_{t+1}^n = T_t^n \left(l_t^{n,co} \right)^{1-\kappa_n},$$

where the technology to build capital structures is a function of a fundamental productivity T_t^n that varies across locations and time, and has constant returns to scale between labor and land.

The landowner consumes at each moment in time c_t^n goods. The landowner has income from renting capital structures to the firms. At each moment in time the landowner has profits equal to

$$\pi_t^{n,co} = r_t^n k_t^n - w_t^{n,co} l_t^{n,co}$$

where $r_t^n k_t^n$ is the income and $w_t^{n,co} l_t^{n,co}$ is the cost to develop structures for tomorrow. We assume the landowners have log utility. The recursive problem of the landowner is given by

$$V_t^{n,co}\left(k_t^n\right) = log\left(\frac{\pi_t^{n,co}}{P_t^n}\right) + \beta V_{t+1}^{n,co}\left(k_{t+1}^n\right) \text{ s.t. } \pi_t^{n,co}\text{=}r_t^n k_t^n\text{-}w_t^{n.co}\left(k_{t+1}^n/T_t^n\right)^{\frac{1}{1-\kappa_n}}$$

A more compact expression for the Bellman is given by

$$V_t^{n,co}\left(k_t^n\right) = log\left(\frac{r_t^n k_t^n - w_t^{n.co}\left(k_{t+1}^n/T_t^n\right)^{\frac{1}{1-\kappa_n}}}{P_t^n}\right) + \beta V_{t+1}^{n,co}\left(k_{t+1}^n\right).$$

From the first order conditions and the envelope condition and after combining both expression we obtain the Euler equation (a second order non-linear equation of capital structures), namely

$$\frac{w_t^{n.co}\left(k_{t+1}^n/T_t^n\right)^{\frac{1}{1-\kappa_n}}}{r_t^n k_t^n - w_t^{n.co}\left(k_{t+1}^n/T_t^n\right)^{\frac{1}{1-\kappa_n}}} = \frac{\beta\left(1-\kappa_n\right) r_{t+1}^n k_{t+1}^n}{r_{t+1}^n k_{t+1}^n - w_{t+1}^{n.co}\left(k_{t+2}^n/T_{t+1}^n\right)^{\frac{1}{1-\kappa_n}}}.$$

The solution to this difference equation has a closed form solution and it is given by

$$k_{t+1}^n = T_t^n\left(\beta\left(1-\kappa_n\right)\frac{r_t^n}{w_t^{n.co}} k_t^n\right)^{(1-\kappa_n)}.$$

Note that in this model the landowner is forward-looking and the solution to the optimal capital structures accumulation is Markovian. Namely, it depends on the relative price of capital structures and wages and on the capital structures build one period before.

Discussion

We have presented two models for endogenous capital structure accumulation. Both models are tractable and can easily be taken to the data. In this version of the paper we have computed all the effects using the model “Landowners and Developers”. The results of the model with “Landowners as Developers” are in progress.

3.3 Aggregation and Market Clearing

We denote by $\lambda_t^{nj,ij}$ to the aggregate bilateral expenditure shares of goods purchased by ij from nj. Using (4), (5), and (7) we obtain the following bilateral trade gravity equation

$$\lambda_t^{nj,ij} = \frac{M_t^{nj}\left(a_t^{nj}\right)^{\sigma_j-1}\left(\left(1+\tau_t^{nj,ij}\right)d^{nj,ij}x_t^{nj}\right)^{1-\sigma_j}}{\sum_h M_t^{hj}\left(a_t^{hj}\right)^{\sigma_j-1}\left(\left(1+\tau_t^{hj,ij}\right)d^{hj,ij}x_t^{hj}\right)^{1-\sigma_j}}. \tag{17}$$

We now solve for the total expenditure in a given sector j and location n. In doing so, we need take a stand on the ownership of firms across countries, and on how tariff revenues are spent in the economy. We assume that tariff revenues are spent in local goods, that is, the revenues generated in location n are spent by the local government on goods produced in that location. In terms of the ownership of firms, we assume that profits generated from producing in each labor market nj are sent to a global portfolio χ_t; that is, $\chi_t = \sum_{i=1}^N \sum_{k=1}^J M_t^{ik}\pi_t^{ik}$. The capitalist at each location is the owner of a fraction ι^n of the global profits and uses this income, together with the income from land and capital structures, $\varpi_t^n H^n$, to consume local goods and to finance the entry of firms.[10] Therefore, total income in country n is given by

$$I_t^n = \sum_{j=co,1}^J w_t^{nj}L_t^{nj} + \iota^n\chi_t + \varpi_t^n H^n - r_t^n\sum_{j=1}^J M_{t-1}^{Oj}\varphi_{t-1}^{Oj,nj} + \sum_{j=1}^J \frac{\tau_t^{ij,nj}}{1+\tau_t^{ij,nj}}\lambda_t^{ij,nj}X_t^{nj}.$$

The first term on the right-hand side of this equation represents the income of the workers (payment to labor across all sectors, including the construction sector), the second term is the income transferred from the global portfolio to the local capitalist, the third term is the local surplus of the capitalist, the fourth term is entry cost of new firms, and the last term are the tariff revenues generated in location n. Using the zero-profit condition for the capital structure developer we can re-express income as

$$I_t^n = \sum_{j=1}^J w_t^{nj}L_t^{nj} + r_t^n K_t^n - r_t^n\sum_{j=1}^J M_{t-1}^{Oj}\varphi_{t-1}^{Oj,nj} + \iota^n\chi_t + \sum_{j=1}^J \frac{\tau_t^{ij,nj}}{1+\tau_t^{ij,nj}}\lambda_t^{ij,nj}X_t^{nj}, \text{ for all } n. \tag{18}$$

The total expenditure on goods in sector j and location n is given by the expenditure

[10] Differences between the remittances to the global portfolio, and transfers from the global portfolio generate trade imbalances. We will discipline ι^n to match the observed imbalances in the data. See Caliendo et al. (2017) and Caliendo et al. (2019) for a discussion of using this type of transfers to generate trade imbalances.

on materials from firms across all other sectors and for consumption, namely

$$X_t^{nj} = \sum_{k=1}^{N} \gamma^{nk,nj} \sum_{i=1}^{N} \frac{(1-1/\sigma_k)}{1+\tau_t^{nk,ik}} \lambda_t^{nk,ik} X_t^{ik} + \alpha^j I_t^n, \text{ for all } n, j, \tag{19}$$

where the first term is the demand for sector j intermediate goods from all sectors, and $\sum_{i=1}^{N} \frac{(1-1/\sigma_k)}{1+\tau_t^{nk,ik}} \lambda_t^{nk,ik} X_t^{ik}$ is the value of gross output in sector k and location n; that is, total sells net of tariffs and markups.

The labor market clearing conditions for the productive sectors (other than the construction sector) is given by

$$w_t^{nj} L_t^{nj} = (1-\xi^n)\gamma^{nj} \sum_{i=1}^{N} \frac{(1-1/\sigma_j)}{1+\tau_t^{nj,ij}} \lambda_t^{nj,ij} X_t^{ij}, \text{ for all } n, j, \tag{20}$$

and the market clearing condition for the capital structures is given by

$$r_t^n K_t^n = \xi^n \sum_{j=1}^{J} \gamma^{nj} \sum_{i=1}^{N} \frac{(1-1/\sigma_j)}{1+\tau_t^{nj,ij}} \lambda_t^{nj,ij} X_t^{ij} + r_t^n \sum_{j=1}^{J} M_{t-1}^{Oj} \varphi_{t-1}^{Oj,nj}, \tag{21}$$

where the first term represents the demand for capital to produce intermediate goods and the second term represents the demand for capital to start producing in location n across all sectors.

3.4 Equilibrium

The exogenous state of the economy is determined by the set of constant and time-varying fundamentals $\Theta_t = \left\{d^{nj,ij}, m^{nj,ik}, a_t^{nj}\right\}_{n,1=1;j,k=1}^{N,J}$. Namely, bilateral non-tariff (iceberg) trade costs, mobility costs, and productivity across countries and sectors. We define by $\Upsilon_t \equiv \left\{\tau_t^{nj,ij}\right\}_{n,i=1;j=1}^{N,J}$ the set of commercial policies across countries. The endogenous state variables of the economy at any point in time t are given by the distribution of labor across all countries and industries $L_t = \left\{L_t^{nj}\right\}_{n=1;j=co,1}^{N,J}$, the distribution of firms, active and inactive, $M_t = \left\{M_t^{nj}, M_t^{Oj}\right\}_{n=1;j=1}^{N,J}$, and the distribution of capital structures $K_t = \{K_t^n\}_{n=1}^{N}$.

Let us define the equilibrium migration flows at time t by $\mu_t = \left\{\mu_t^{nj,ik}\right\}_{n,i=1;j,k=ne,co,1}^{N,J}$, the equilibrium firm transition rates at time t by $\varphi_t = \left\{\varphi_t^{nj,nj}, \varphi_t^{nj,Oj}, \varphi_t^{Oj,ij}\right\}_{n,i=1;j=1}^{N,J}$, the value function for the firms by $V_t = \left\{V_t^{nj}\right\}_{n=O,1;j=1}^{N,J}$, the value function for the workers by $U_t = \left\{U_t^{nj}\right\}_{n=1;j=ne,1}^{N,J}$, equilibrium wages by $w_t = \left\{w_t^{nj}\right\}_{n=1,j=1}^{N,J}$, rental rates by

$r_t = \{r_t^n\}_{n=1}^N$, aggregate and bilateral expenditures $X_t = \left\{X_t^{nj,ij}\right\}_{n,i=1;j=1}^{N,J}$ where $X_t^{nj,ij}$ is the expenditure of goods by ij on goods produced by nj, that is $X_t^{nj,ij} = \lambda_t^{nj,ij} X_t^{ij}$, and prices by $P_t = \{P_t^n\}_{n=1}^N$, where P_t^n is the ideal local price index in n. We now define the sequential competitive equilibrium of the model given a sequence of fundamentals and policies:[11]

Definition 1. *Given an initial allocation of labor, firms, and capital structures* (L_0, K_0, M_0)*, a sequence of fundamentals* $\{\Theta_t\}_{t=0}^{\infty}$*, and a sequence of policies* $\{\Upsilon_t\}_{t=0}^{\infty}$*, a* **sequential competitive equilibrium** *of the model is a sequence* $\{L_t, \mu_t, K_t, M_t, \varphi_t, V_t, U_t, w_t, r_t, P_t\}_{t=0}^{\infty}$ *that solves the households' dynamic problem, (1-3), the firms dynamic problem, (9-14), the problem of capital structure developers, (15, 16), the static sub-problems of the households and producers at each* t*, using equilibrium conditions (5, 6, 7, 17, 18, 19) and factor markets clear, equations (20), and (21).*

After defining the equilibrium, we now proceed to take the model to the data.

4 Solving and Taking the Model to the Data

We use our quantitative model to quantify the effects of a change to trade policy. Instead of solving the model in levels and directly estimating the set of unobservable fundamentals to compute the model, we follow CDP and use the dynamic hat algebra (henceforth DHA), which refers to the idea of solving for a counterfactual economy with policy changes relative to a baseline economy. The DHA requires to condition on the initial observable allocations of the economy that will contain the information on unobservable fundamentals, and therefore, we describe in next section the different data sources used to obtain the data needed to compute the model

We apply the method to study the effects from a change in trade policy relative to a baseline economy. Our initial period is the year 2015, and we solve for a baseline economy with constant, fundamentals going forward. As described with more detail later on, since we condition the actual observable allocations, we do not need to assume that the economy is in steady state at the initial period.

[11] Kucheryavyy, Lyn, and Rodriguez-Clare (2019) study the theoretical properties of multi sector models with Marshellian externalities and show the presence of corner solutions. In our model, regions have the potential to fully specialize in the production of non-tradable sectors. However, for the set of parameters and policies that we studied we do not find specialized equilibria.

Our model presents two main additional features compared to CDP; a dynamic firm location decision, and the endogenous accumulation of capital structures. We now proceed to show how to compute our model in relative changes, and for the sake of brevity, focus on how to apply the main propositions in CDP to our model. In particular, we first show how to solve for the baseline economy and then, given a sequence of counterfactual changes in trade policy and the baseline economy, we show how to solve for counterfactuals relative to the baseline economy. We relegate to Appendix B the derivations and proofs.

4.1 Solving the Model

Our goal is to solve the model and characterize the effects from a change in policy; i.e. the effects of changes in policy from $\{\Upsilon_t\}_{t=0}^{\infty} \rightarrow \{\Upsilon'_t\}_{t=0}^{\infty}$ where the 'prime' notation refers to a counterfactual variable. We use the 'dot' notation to refer to variables that are in relative time changes; for instance $\dot{y}_{t+1} \equiv y_{t+1}/y_t$. We use the 'hat' notation for relative time differences of the variables; namely $\hat{y}_{t+1} \equiv \dot{y}'_{t+1}/\dot{y}_{t+1}$. To simplify even further the notation, we define $v_t^{nj} = exp(V_t^{nj})$, $\tilde{\pi}_t^{nj} = exp(\pi_t^{nj})$, and $\tilde{r}_{t+1}^i = exp(r_{t+1}^i)$. Using this notation, we now proceed to describe the proposition that shows how to compute the baseline economy.

Proposition 1. *Given an initial allocation of the economy,* $\{L_0, M_0, K_0, \mu_{-1}, \varphi_{-1}, X_0\}$ *and elasticities* $(\nu, \vartheta, \sigma, \beta)$*, solving for the baseline economy with constant fundamentals does not require the level of the fundamentals.*

The proof of Proposition 1 is relegated to Appendix B where we present all the equilibrium conditions in changes. Proposition 1 shows how we can use data and elasticities to solve for a baseline economy. In what follows we show how to solve the model to study the effects of a change in policy. In particular, our strategy is to compute the effects, across industries, regions and countries, of a change in tariffs relative to the baseline, year 2015, economy. Our goal is to quantify the firm location effects as well as the welfare effects of the change in trade policy. We study several policies, but we will mostly focus on a unilateral change in tariffs with and without retaliation from trading partners.

Denote by $\hat{\Upsilon} = \left\{\hat{\Upsilon}_t\right\}_{t=0}^{\infty}$ to the change in tariff policy that we want to study. Recall that the 'hat' notation means in this case the change over time of the new set of tariffs relative to the change over time of the baseline set of tariff policy. The next Proposition shows how to solve the economy under the new set of tariffs.

Proposition 2. *Take as given a baseline economy,* $\{L_t, M_t, K_t, \mu_{t-1}, \varphi_{t-1}, X_t\}$ *for all* t*. Solving for the effects of a change in policy* $\hat{\Upsilon}$*, namely* $\left\{\hat{L}_t, \hat{M}_t, \hat{K}_t, \hat{\mu}_{t-1}, \hat{\varphi}_{t-1}, \hat{X}_t\right\}$*, does not require the level of the fundamentals.*

Proposition 2 shows how to compute the effects of a change in policy relative to the baseline economy. The intuition of this proposition is that solving the model in relative changes is similar to a structural difference in difference between the economy with the change in policy and the baseline economy. As a result, we obtain the effects of the change in tariffs by differentiating out everything that remains common across both economies, that is, the unobservable set of fundamentals.

We now proceed to describe the data we use to compute the baseline economy using Proposition 1. After that, in the next section, we apply the results of Proposition 2 to quantity the effects of several policy changes. In Appendix C we present the algorithm that we implement to solve for the baseline economy and the solution to Proposition 2.

4.2 Taking the Model to the Data

We take the quantitative model to a world with 39 countries, including a constructed Rest of the World (ROW) and three productive industries; Manufacturing, Wholesale and Retail, and Services, and the Construction sector that we use to discipline the production of new structures described in Section 3.2.3. As described in the previous section, computing the model in time differences require to condition on observable initial allocations. We take the years 2014-2015 as the initial period in our model, and proceed to use data for the observable initial allocations and exogenous parameters needed to compute the model. A period in our analysis is a year.

Concretely, the observables initial allocations are given by the sectoral bilateral trade flows, $\lambda_t^{nj,ij}$ across countries; total expenditure by sector and country X_t^{nj}, payment to labor and capital $w_t^{nj} L_t^{nj}$, and the stock of capital and rental rates across countries K_t^n, and r_t^n. We also need to construct the initial distribution of employment in the United States L_t^{nj}, the labor mobility rates across sectors $\mu_t^{nj,nk}$ in the United States, the sectoral distribution of active firms in the Unite States and other countries M_t^{nj} and the mass of inactive firms across sectors M_t^{Oj}. Finally, we need to compute the probability that an active firm will remain active in each sector and country $\varphi_t^{nj,nj}$, the probability that active firms exit a given location $\varphi_t^{nj,Oj}$, and the transition rate for firms that are inactive $\varphi_t^{Oj,nj}$.

In terms of the observable exogenous parameters, we need to compute the shares of value added in gross output γ^{nj}, across sectors and countries, the input-output coefficients $\gamma^{nj,nk}$, the shares of labor in value added ξ^n, the share of labor in the production of new structures κ^n, and the consumption shares α^j, and the ownership of profits ι^n.

Finally we also obtain the set of bilateral tariffs $\tau^{nj,ij}$ and estimates for the value of the elasticities ϑ,ν,σ^j, β.

Some of the data needed to compute the model is readily available from standard databases, while other it is not. In what follows we briefly mention the main data sources, and relegate further details of the data to Appendix D.

Trade and Production Data We obtain bilateral trade flows across countries from the World Input-Output Database (WIOD).[12] Production data to discipline the productions functions, namely the share of value added in gross output, γ^{nj}, and the input-output coefficients $\gamma^{nj,nk}$, are also obtained from the WIOD. The share of labor in value added ξ^n for the United States is constructed using data on labor compensation and value added from the BEA. For the other countries these data are obtained from the OECD STAN database. The share of labor in the production of new structures $1-\kappa^n$ is constructed as the share of labor in gross output in the construction sector. For the U.S. states we construct this parameter using labor compensation and gross output data from the BEA, for the rest of the countries we use the equivalent data from the OECD STAN database.

The Initial Distribution of Firms and Location Choice Probabilities We obtain the mass of active firms M_t^{nj} across sectors in the United States and for other countries in our sample from different data sources. For the U.S. states, the number of active firms is obtained from the U.S. Census, Statistics of U.S. Business (SUSB) database. We use the year 2015 as the reference year, and for each sector we compute the number of establishments, which is the corresponding M_t^{nj} in our model. For the rest of the countries, except for China, we compute M_t^{nj} as the number of active enterprises reported in the OECD Structural and Demographic Business Statistics (SDBS). Similar to the U.S. data, we use 2015 as the reference year. For China, we obtain the data the number of active firms across sectors from the China's National Bureau of Statistics. For the ROW, data on mass of firms is not available, thus we simply assume that the mass of firms in the ROW relative to the total mass of firms in our sample is similar to its relative GDP.

The U.S. Census data and the OECD firms demographic database also report the number of firm births and deaths that we also use to discipline our quantitative model. In particular, we compute the initial probability of exiting a location for an active firm in a given sector $\varphi_t^{nj,Oj}$ as the number of deaths over the total number of active firms

[12] Please refer to Timmer et al. (2015) and Timmer et al. (2016) for further details.

in that sector and location. Consequently, the initial probability of staying in a location for a firm in a given sector is computed as $\varphi_t^{nj,nj} = 1 - \varphi_t^{nj,Oj}$. Finally, we also need to discipline the mass of inactive firms M_t^{Oj}, and the probability of entry to a given location for an inactive firm $\varphi_t^{Oj,nj}$. Our model implies that inactive firms keep that status for one period only, which allow us to discipline the initial entry rates in each location $\varphi_t^{Oj,nj}$ as the ratio of firm births in each location over the total births in the world. Consequently, the number of inactive firms in each sector M_t^{Oj} is computed as the number of deaths in the initial period in that sector.

Below we present some basic statistics and figures on the distribution of firms. Table 1 shows how the aggregate U.S. mass of firms compares with other selected countries across industries.

Table 1: Mass of Firms M_t^{nj} (2015, thousand)

	Manufacturing	Services	Wholesale and Retail
United States	274.8	4,567.8	1,377.6
U.K.	146.9	1,750.6	412.1
France	255.5	2,685.7	887.9
Germany	241.8	2,105.4	638.9
Spain	185.1	1,978.7	412.1

Source: OECD - SDBS.

Capital Stocks and Rental Rates The stock of capital for each country K_t^n is obtained from the Penn World Tables 9.1. We then compute the payment to capital $r_t^n K_t^n$ using data from the BEA for the United States, and from the OECD-STAN database for other countries, and recover the rental rates across countries as $r_t^n = r_t^n K_t^n / K_t^n$. Our computed rental rates are heterogeneous across countries and in the order of magnitude of 10 percent.

Employment and Mobility Rates Across U.S. Labor Markets The initial distribution of employment across sectors in the United States, L_t^{nj}, is obtained from the BEA. We construct the mobility across sectors, using information from the Current Population Survey (CPS) to compute intersectoral mobility as in Caliendo et al. (2019), computing the transition rates for the year 2007. Unfortunately we do not have information on labor mobility rates across countries and across sectors within all other countries in our sample. As a result, we assume for all other countries that labor can freely move across sectors. Hence, the labor market clearing condition for countries other than the United States is such that wages equalized across all sectors, including the construction sector that demands labor to build new structures. Hence, for these countries the labor market clearing condition is given by $w_t^n L_t^n = (1 - \xi^n) \sum_{j=1}^{J} \gamma^{nj} \sum_{i=1}^{N} \frac{(1-1/\sigma_j)}{1+\tau_t^{nj,ij}} \lambda_t^{nj,ij} X_t^{ij} + (1 - \kappa_n) r_t^n K_t^n$ for all n other than the United States.

Bilateral tariffs Bilateral tariffs for the manufacturing sectors across countries are obtained for the year 2016 from the World Integrated Trade Solution (WITS). Even when our initial allocation are computed for the year 2015 (or 2014), we decided to use the most updated state of trade policy to perform our quantitative exercises, and that is the reason why we collected the tariff data for the year 2016.

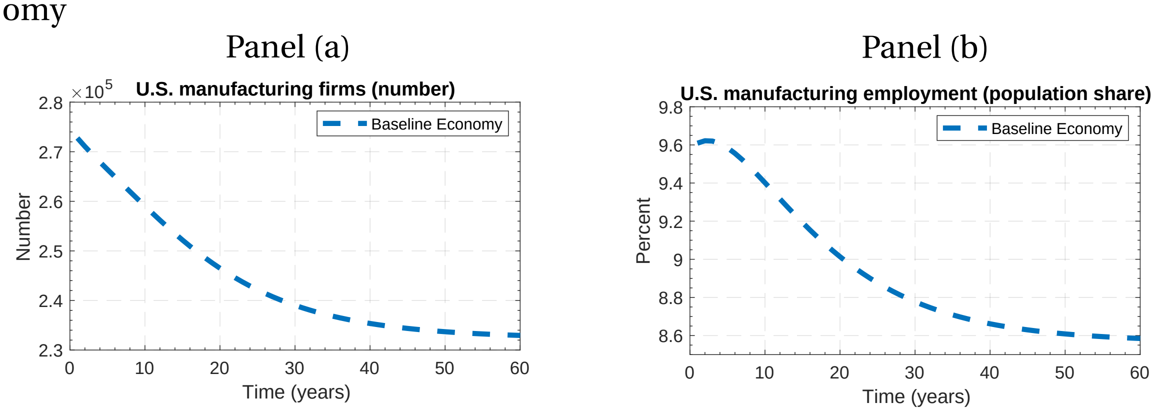
Elasticities We need estimates for the values of the elasticities of the model, ϑ, ν,σ^j, β. Given the annual frequency of our model, we set the discount factor to $\beta = 0.97$. For the trade elasticity, we use $\sigma^j = 4$ for all j, which is a central value in the range of estimates used in the international trade literature (Head and Mayer (2014)). The dispersion of idiosyncratic shocks for households, ν, can be mapped in to the labor market dynamic model in Caliendo et al. (2019), with the difference that Caliendo et al. (2019) estimate a quarterly model. Hence, we re-estimate ν following Artuç et al. (2010) at an annual frequency and obtain a value of $\nu = 2.02$. We postpone the description of the estimation of the dispersion of idiosyncratic shocks for firms ϑ, since we use our structural model with economic geography to estimate this elasticity. The estimation gives us a value $\vartheta = 14.1$.

Finally, we calibrate the ownership structure of global profits ι_n to match the observed trade imbalances across countries at the initial period, and obtain the final expenditure shares α^j with the data in final consumption from WIOD (see Appendix D for details).

4.3 The Baseline Economy

After taking the model to the year 2015, we compute the model given the fundamentals at that year and constant fundamentals forward, namely we answer the question: how would manufacturing employment and firms evolve in the United States in the absence of any changes to trade policy and other fundamentals. Figure 6 presents the evolution of manufacturing establishments (panel a) and manufacturing employment (panel b) in the United States in the baseline economy. In line with the actual evolution of manufacturing firms described in Section 2, in the absence of changes to trade policy, there is a decline in U.S. manufacturing firms and manufacturing employment. In the baseline economy, manufacturing employment experiences an increase in the few years after the initial year 2015. We now turn to quantify the effects of trade policy on manufacturing employment and firms, and its welfare consequences. In particular, in the next section we use our quantitative framework applied to the 2018 tariff changes between the United States and some of its trading partners to answer questions such as: does increased trade protectionism have a positive impact on manufacturing employment and on firm's entry? Even if it does, is it able to revert this observed decline in manufacturing employment and firms?, if so, does it come at a welfare cost?

Figure 6: Evolution of U.S. manufacturing employment and firms in the Baseline Economy



Note: The left-hand panel presents the evolution of number of establishments in the manufacturing sector in the United States in the baseline economy. The right-hand side panel presents the evolution of manufacturing employment in the United States in the baseline economy.

5 The Effects of Commercial Policy on Firms and Employment

In this section, we quantify the effects of the 2018 trade war on manufacturing firms, employment and welfare. We first describe our measure of tariff changes as a consequence of 2018 changes to trade policy, and we then apply our quantitative framework to quantify the effects of the trade war.

5.1 Changes in Trade Protectionism in 2018

The 2018 trade war between the United States and other countries resulted in increases in tariffs applied between the United States and specific countries, most notably China, to specific products. Since our framework is at the level of aggregation of the whole manufacturing sector, we need to compute the exposure of the manufacturing sector to this change in trade policy. To do so, we start by obtaining the changes in tariffs on U.S. imports and exports in 2018 due to the 2018 trade war collected by Fajgelbaum et al. (2019). The data contain information on the tariffs changes applied to U.S. imports for each targeted product at the HS-10 digit classification. It also details the tariffs applied to China, and the tariffs that were increased unilaterally by the U.S. (with exceptions applied to a few countries). The data also contains the tariff increases applied by China and other retaliating countries to imports from the United States, at the HS-8 digit level of desegregation.

To compute the exposure of the manufacturing sector to these tariff increases, we converted the HS codes to ISIC-rev4 industry classification codes using standard concordance tables. We then use the imports by the United States from China, and from the World, and imports by the retaliating countries from the United States at the ISI-rev4 level for the year 2017 to construct the weight of each tariff targeted in total imports. Finally, we apply these weights to compute the changes in tariffs applied between the United States and other countries in the aggregate manufacturing sector. In other words, our measure of the change in tariffs applied by country i to country n in the manufacturing sector is given by

$$\triangle\tau^{in} = \sum_{p} \frac{X^{in,p}}{X^{in}} \triangle\tau^{in,p}$$

where $\triangle\tau^{in,p}$ is the change in tariff applied by country i to country n to the product p at the HS code level, $X^{in,p}/X^{in}$ is the share of imports of product p in total manufacturing imports by country i after concording to the ISIC-rev4 classification.

Table 3 shows the equivalent changes in tariffs to the manufacturing sector applied by the U.S. to China and the world, as well as the retaliatory tariffs.

5.2 The Aggregate Effects of the 2018 U.S. Trade Policy Change

In this section we quantify the effects of the increase in trade protectionism as a consequence of the increase in tariffs applied between the United States and some of its trading partners in 2018. Figure 7 presents the evolution of the U.S. manufacturing establishments and employment in the baseline economy and in the counterfactual economy with the 2018 trade war. The first message that emerges from our results is that the increase in trade protectionism has a positive effect on the number of manufacturing firms and on the manufacturing employment in the United States. However, even more

Table 2: Changes in tariffs applied to the manufacturing sector during the 2018 trade war

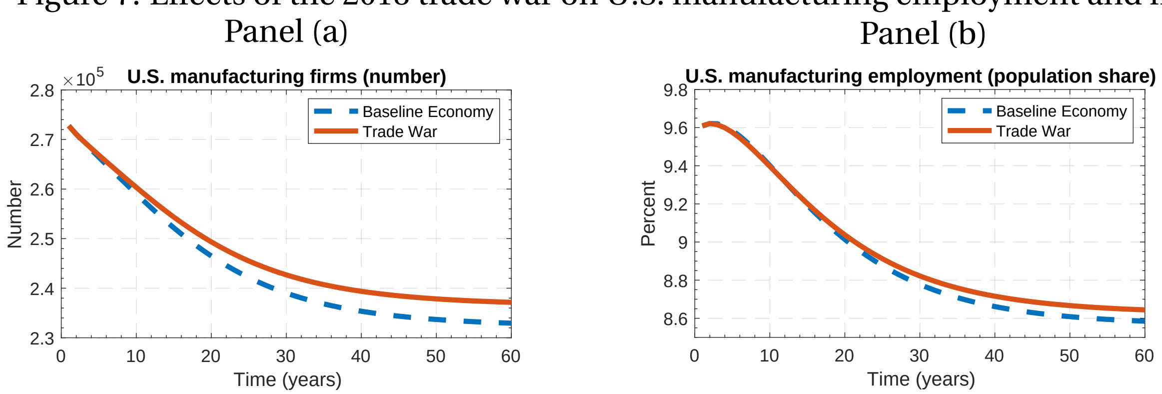
Changes in tariffs applied by the United States to:	
China	7.68%
Rest of the World	0.67%

Changes in Retaliatory tariffs applied to the United States by:	
China	9.17%
European Union	0.68%
Canada	1.13%
Mexico	0.74%
Turkey	2.31%

Note: This table shows equivalent changes in tariffs applied between the United States and other countries to the manufacturing sector as a consequence of the 2018 trade war.

importantly, one of the main results that we highlight is that the 2018 change in trade policy does not revert the declining trend in manufacturing employment and firms in the absence of changes to other fundamentals. Does this conclusion change if China and other other countries had not retaliated?

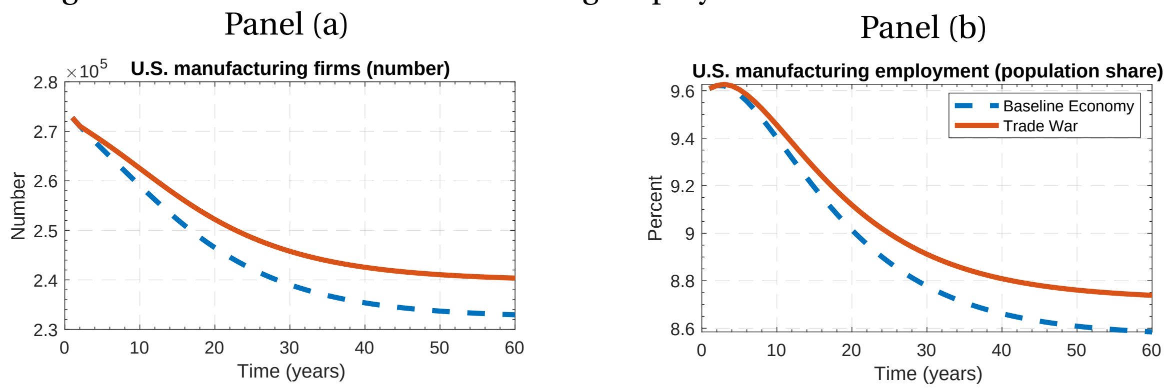
Figure 7: Effects of the 2018 trade war on U.S. manufacturing employment and firms



Note: The left-hand panel presents the evolution of number of establishments in the manufacturing sector in the United States in the baseline economy and in the counterfactual economy. The right-hand side panel presents the evolution of manufacturing employment in the United States in the baseline economy and in the counterfactual economy. The counterfactual economy computes the effects of the changes to trade policy as a consequence of the 2018 trade war.

Figure 8 shows the effects of the increase in tariffs applied by the United States if the other countries had not retaliated. As we can see from the figure, even when the positive effects of the tariff changes on manufacturing employment and firms are larger, we still find that they do not revert the decline in manufacturing employment and firms computed in the baseline economy.

Figure 8: Effects on U.S. manufacturing employment and firms with no retaliation



Note: The left-hand panel presents the evolution of number of establishments in the manufacturing sector in the United States in the baseline economy and in the counterfactual economy. The right-hand side panel presents the evolution of manufacturing employment in the United States in the baseline economy and in the counterfactual economy. The counterfactual economy computes the effects of the changes in tariffs applied by the United States to other countries as a consequence of the 2018 trade war.

In terms of the magnitude of these effects, Table 3 summarizes the long run effects on allocations and welfare from the 2018 trade war, as well as the effects had the other countries would have not retaliated. We find that the 2018 increase in trade protectionism results in an increase in manufacturing employment of 0.06 percentage points. The increase in manufacturing employment is partially offset by a decline in non-manufacturing employment, and as a result, we find that total employment increases by 0.02 percentage points. We find that U.S. manufacturing firms increase by 1.81% and the total number of U.S. firms increases by 0.42% in the long run. We find that the trade war also has some positive effects on the number of non-manufacturing firms, as the better access to local intermediate goods from the manufacturing sector incentives the entry of non-manufacturing firms.

The last three rows in the table show welfare measures. We find that the 2018 trade war resulted in welfare losses for the households of 0.18%, which is measured as the change in consumption equivalent. We also compute the change in real income computed as the present discounted value of nominal income that includes the payments to all factors, tariff revenues, and profit shifting, deflated by the price index. We find that real income declines by a similar (but not equal) magnitude of 0.18%. Finally, we find that the U.S. price index increases by 1.18%. The positive effect on the price index reflects two offsetting forces. On the one hand, prices are higher as a consequence of the tariff increases. On the other hand, the firms' entry in the U.S. result a more goods available at zero trade costs, which reduces the price index. We find that the positive location effect of firms in the U.S. is not big enough to more than offset the price ef-

Table 3: Long run effects of the 2018 trade war in the United States

	2018 trade war	without retaliation
Change in manufacturing employment	0.06 ppt	0.15 ppt
Change in total employment	0.02 ppt	0.26 ppt
Change in manufacturing firms	1.81%	3.19%
Change in total firms	0.42%	0.75%
Change in household's consumption equivalent	-0.18%	0.06%
Change in real income	-0.18%	0.10%
Change in price index	1.18%	1.21%

Note: This table shows the allocation and welfare effects as a consequence of the 2018 trade war, with and without retaliation.

fect of higher tariffs, and the price index increases as a result. If the other countries had not retaliated, as expected, we find larger effects on firms' entry an employment in the United States. Notably, we find that households would have been slightly better off and the real income would have increased.

6 Taking the Economic Geography Model to the Data

We now take the quantitative model to a world with 39 countries, including a constructed Rest of the World (ROW), 50 U.S. states, three productive industries; Manufacturing, Wholesale and Retail, and Services, and the Construction.

The economic geography model extends the model we presented before by allowing the U.S. economy to have several spatially distinct labor markets. We extend the notation and now n,and i are used to represent a country or a region inside the U.S. Each region in the U.S. trades with all other regions and countries in the world. We assume that trade policy only affects trade across countries and from a region to a country and there is not trade policy across regions in the U.S., namely that $\tau_t^{nj,ij} = 0$ when n and i are locations in the same country. We also extend the decision for workers to move across labor markets and for firms to move across space as well. Regarding tariff revenue, we make same the assumption as before but applied to regions. Namely, we assume that tariff revenues are spent in local (regional) goods, that is, the revenues generated in location n are spent by the local government on goods produced in that location. Furthermore, we assume that profits generated from producing in each labor market nj are sent to the global portfolio χ_t and with this we match the trade imbalances at each location in the U.S. and the world. Finally, we assume that in each region of the U.S. there is a landowner and developers solving the same problem as we we solved before but not at the regional level. Of course, taking this model to the data requires additional and more granular data. We now describe the data and steps we have taken to take the model to the data. Appendix D provides further details on the data sources.

Trade and Production Data We obtain bilateral trade flows across U.S.states from the Commodity Flows Survey. The bilateral trade flows between U.S. states and other countries are obtained from the U.S. Census, which contain the direct exposure of each state to foreign trade. Production data to discipline the productions function for the individual U.S. states are from the BEA as described in more detail in Appendix D.

The Initial Distribution of Firms and Location Choice Probabilities We obtain the mass of active firms M_t^{nj} across sectors for each U.S. state from the U.S. Census, Statistics of U.S. Business (SUSB) database. The U.S. Census data also report the number of firm births and deaths across sectors and U.S. states that we also use to discipline the firms's transition rates as described in Section 4.2.

Capital Stocks and Rental Rates For the United States, we split the stock of capital across each states using the estimates of capital stocks across U.S. states in Yamarik (2013) based on the methodology developed in Garofalo and Yamarik (2002). In particular, we use the their estimates for the year 2007 and apply the share of each state to the aggregate U.S. stock of capital from the PWT to compute the stock at the state level for the year 2015. We then compute the payment to capital $r_t^n K_t^n$ using data from the BEA and recover the rental rates across locations as $r_t^n = r_t^n K_t^n / K_t^n$.

Employment and Mobility Rates Across U.S. Labor Markets The initial distribution of employment across U.S. states and sectors L_t^{nj} are obtained from the BEA. We construct the mobility across our regions and sectors, using information from the Current Population Survey (CPS) to compute intersectoral mobility and from the PUMS of the American Community Survey (ACS) to compute interstate mobility as in Caliendo et al. (2019), computing the transition rates for the year 2007.

Elasticities As for the aggregate model, we need estimates for the values of the elasticities of the model, ϑ, ν,σ^j, β. As before, given the annual frequency of our model, we set the discount factor to , for the trade elasticity, we use $\sigma^j = 4$ for all j, and for the dispersion of idiosyncratic shocks for households, we use the estimated value of $\nu = 2.02.$

To estimate the dispersion of idiosyncratic shocks for firms ϑ, we use our structural model to derive an estimating equation, proceeding as follows (please refer to Appendix E for further details).[13] Using equilibrium conditions (9) and (10), we can express the value of active firms relative to the value of inactive firms as

$$V_t^{nj} - V_t^{Oj} = \pi_t^{nj} - \beta r_{t+1}^n + \vartheta log \frac{\varphi_t^{O,nj}}{\varphi_t^{nj,nj}}. \tag{22}$$

Taking the ratio between the fraction of firms that stay in a given location $\varphi_t^{nj,nj}$ and the fraction that exit $\varphi_t^{nj,Oj}$ we obtain that

$$\frac{\varphi_t^{nj,nj}}{\varphi_t^{nj,Oj}} = exp(\beta V_{t+1}^{nj} - \beta V_{t+1}^{Oj})^{1/\vartheta}. \tag{23}$$

Lagging this equation one period, and substituting the resulting expression into (22) and then into (23) we obtain,

$$log \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}} + \beta log \frac{\varphi_t^{nj,nj}}{\varphi_t^{Oj,ij}} = \frac{\beta}{\vartheta} \left(\pi_t^{nj} + \beta r_{t+1}^n \right).$$

We assume that we measure the entry probabilities $\varphi_t^{Oj,ij}$ imperfectly, for instance, due to the fact that they depend on the total world's mass of inactive firms that are not directly observable. In particular, we attribute the measurement error to have a deterministic component C_t and a sector-specific random component ε_t^{nj} that is orthogonal to profits and rental rates. As a result, our empirical equation becomes

$$y_t^{nj} = \tilde{C}_t + \frac{\beta}{\vartheta} \left(\pi_t^{nj} + \beta r_{t+1}^n \right) + \varepsilon_t^{nj}, \tag{24}$$

where $y_t^{nj} \equiv log \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}} + \beta log \frac{\varphi_t^{nj,nj}}{\varphi_t^{Oj,ij}}$. We use (24) to estimate $1/\vartheta$ cross-sectionally with data for the different locations and sectors in the United States (150 observations). The lack of complete time series data for the OECD prevents us to use the rest of the countries in the estimation (note that y_t^{nj} requires observations at t and $t-1$). The estimation of (24) gives us a value $\vartheta = 14.1$ with a robust standard error of 0.027. We are not aware of a benchmark estimate in the literature for this parameter. However, one can imagine that the migration of workers might be less sluggish compared to the mobility of firms since,

[13] The resulting estimation described below is in the spirit of the one in CDP used to estimate the households's idiosyncratic shocks ν. It is also related to the estimation of the location elasticity of Japanese firms in Europe in Head and Mayer (2004), although the main difference with our estimating equation is the dynamics in our model.

for instance, moving establishments across space should take more time than moving to work to a different location. Consistently with this intuition, our migration elasticity $1/\nu$ is higher than out firm's elasticity $1/\vartheta$.

Armed with all these data, parameters, and elasticities, we now proceed to use the model to study the distributional effects of the 2018 trade war across space.

6.1 Distributional Effects of Trade Policy Across Space

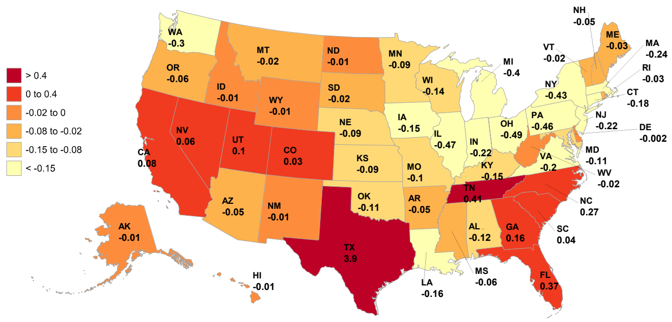
In this section, we compute the spatial effects in the United States of the 2018 trade war. Figure 9 shows the effects on the number of U.S. firms and employment in the manufacturing and non-manufacturing industries across the U.S. states. The left-hand side panels show the effects on the manufacturing sector, panel (a) displays the spatial effects on U.S. manufacturing firms and panel (c) shows the spatial effects on manufacturing employment.We find the aggregate positive effects on manufacturing firms and employment discussed in Section 5.2 are captured by a set of few states that are the ones that attracts firms and employment in the log run. In particular, Texas is the state that attracts more manufacturing firms, followed by Tennessee, Florida, Georgia, Utah, California, Nevada, and Colorado. All the rest of the states loose manufacturing firms at the expenses of these states. A similar picture arises from manufacturing employment; Texas is the state with the largest increase in manufacturing employed, and the other states that gain manufacturing employment are the same as the ones that attract manufacturing firms, except for California that experiences a slight decline in manufacturing employment. The panels on the right-hand side show the effects of the trade war on firms and employment in the non-manufacturing sector. Basically, the same conclusion arises as for the manufacturing sector, a few set of states are the ones that attract employment and firms.

Which states are the ones that attract more manufacturing employment and firms? Some of the states that attract more manufacturing firms and employment are states with high exposure to imports from China such as Tennessee, Nevada, Georgia, North Carolina an South Carolina. Other states that attract firms are large states that concentrate a big fraction of the manufacturing employment and have lower entry costs for firms such as Texas. Even when California is also a large state, our estimated initial rental rate of capital structure is higher than the one for Texas (about 15% and 10%, respectively), which explains why Texas is more attractive for the entry of firms. Finally, states located close to and trade more with large states California, Texas, and Florida also experience positive effects on firms en employment such as Utah, Colorado, North

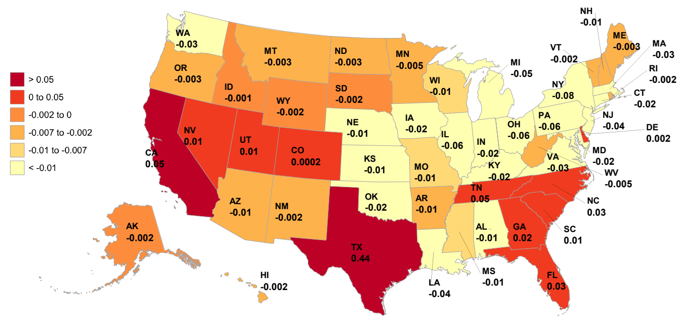
Carolina, and South Carolina.

Figure 9: Distributional effects of the 2018 trade war across U.S. states

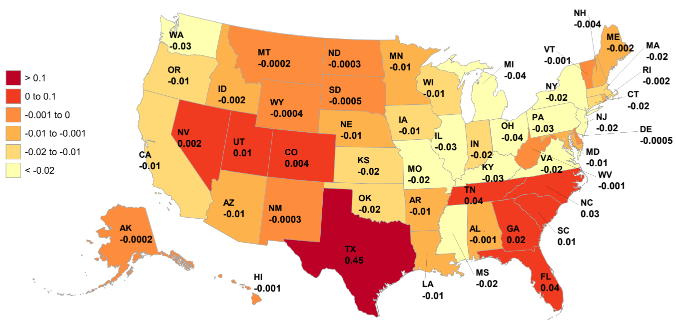
a) Manufacturing firms
(change in the share of total U.S. manuf. firms)



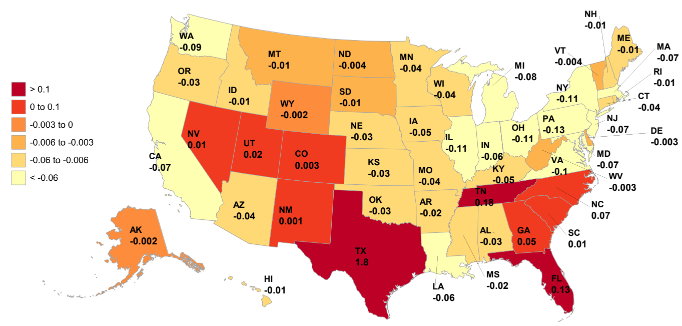
b) Non-manufacturing firms
(change in the share of total U.S. non-manuf. firms)



c) Manufacturing employment
(change in population share)



c) Non-manufacturing employment
(change in population share)



Note: This figure shows the effects of the 2018 trade war on manufacturing and non-manufacturing firms and employment across U.S. states.

Figure 10 shows the welfare effects across space. The left-hand panel presents the change in real income, and the right-hand panel shows the change in households' consumption equivalent. Starting with real income, we find that a few states gain in real income from the trade war, most notably Texas, Florida, Tennessee, and North Carolina, which are the states that also attract firms and employment. However, the gains from the trade war in these states are not captured by the households but they go to firms, the government revenues, and the owners of capital. In fact, as the left-hand side panel shows, households' in all states are worse off as a consequence of the trade war.

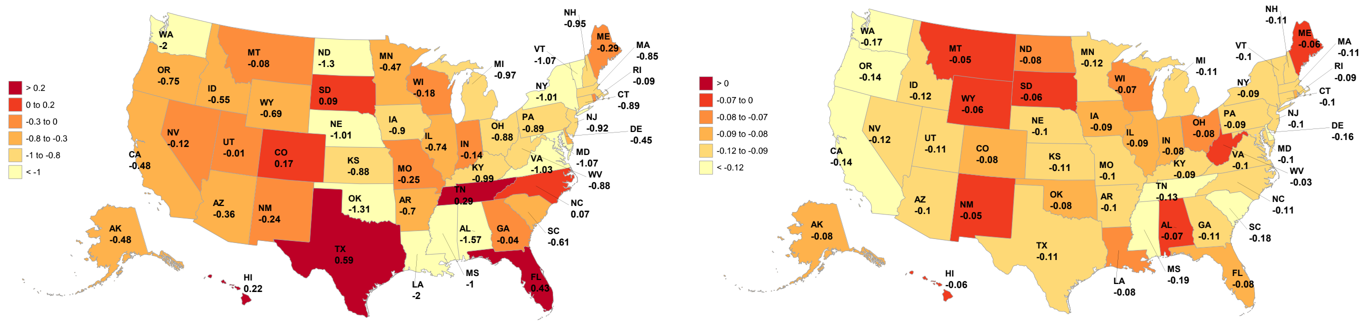
Table 4: Long run effects of the 2018 trade war in the United States

	2018 trade war
Change in manufacturing employment	0.07 ppt
Change in manufacturing firms	1.19%
Change in household's consumption equivalent	-0.11%
Change in real income	-0.45%
Average change in price index	1.82%

Note: This table shows the allocation and welfare effects as a consequence of the 2018 trade war.

Figure 10: Welfare effects of the 2018 trade war across U.S. states

a) Change in real income (percent) b) Change in household's welfare (percent)



Note: This figure shows the welfare effects of the 2018 trade war across U.S. states. The left-hand side panel shows the change in real income, and the right-hand side panel shows the change in household's welfare (consumption equivalent).

Finally, we compare the aggregate effects on manufacturing employment and firms from the economic geography model with those of the aggregate model. Table 4shows the results.

Similar to the aggregate model, we find that the 2018 trade war had a positive effect on manufacturing employment a firms. The effect on employment is similar to the aggregate model, and the effect on manufacturing firms is somewhat smaller. We still find welfare losses and an average increase in the price index that are somewhat larger than in the aggregate model due to the smaller effects on firms' entry.

7 Conclusion

Industrial location is the most frequent argument to justify trade protectionism, yet there is little evidence on its quantitative impact. We departure by developing a dynamic general-equilibrium framework of industrial and labor location with dynamic firms decisions, dynamic households decisions, and capital accumulation. We use the model to study quantitatively the location effect of trade policy and its welfare consequences. The 20018 trade world between the United States and other countries, notably China, results in positive location effects, that take time to materialize, and is much smaller in the short run than in the long run. However, these effects do not revert the long run decline in manufacturing employment and firms. Importantly, the relocation of production comes at the cost of higher prices, lower welfare for households, and heterogeneous effects on firm entry across space.

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A Derivations

Value Function for the Firm In this appendix we derive the value functions of the active and inactive firms, equilibrium conditions (9) and (10). For brevity, in what follows we derive in detail equation (9) and highlight that deriving (10) follows the same steps.

Define $\Xi_t^n = \max\left\{\beta E\left[v_{t+1}^{nj}\right] + \varphi\epsilon_t^{nj}; \beta E\left[v_{t+1}^{Oj}\right] + \varphi\epsilon_t^{Oj}\right\}$, and $\bar{\epsilon}_t^{nj,Oj} = \frac{\beta(V_{t+1}^{nj} - V_{t+1}^{Oj})}{\varphi}$. Recall that ϵ are $i.i.d.$ over time an is a realization of a Type-I Extreme Value distribution with zero mean. Then,

$$\Xi_t^n = \sum_{i=n,O} \int_{-\infty}^{+\infty} \left(\beta V_t^{ij} + \varphi\epsilon_t^{ij}\right) f\left(\epsilon_t^{ij}\right) \prod_{m\neq i} F\left(\bar{\epsilon}_t^{ij,mj} + \epsilon_t^{ij}\right) d\epsilon_t^{ij},$$

From the properties of the Type-I Extreme Value distribution, we get

$$\Xi_t^n = \sum_{i=n,O} \int_{-\infty}^{\infty} \left(\beta V_t^{ij} + \varphi\epsilon_t^{ij}\right) e^{\left[-\epsilon_t^{ij} - \bar{\gamma} - e^{\left(-\epsilon_t^{ij} - \bar{\gamma}\right)}\right]} \prod_{m\neq i} e^{\left[-e^{\left(-\left(\bar{\epsilon}_t^{ij,mj} + \epsilon_t^{ij}\right) - \bar{\gamma}\right)}\right]} d\epsilon_t^{ij},$$

where $\bar{\gamma}$ is an Euler's constant. Manipulating this equation, can be expressed as

$$\Xi_t^n = \sum_{i=n,O} \int_{-\infty}^{\infty} \left(\beta V_t^{ij} + \varphi \epsilon_t^{ij}\right) e^{\left(-\epsilon_t^{ij} - \bar{\gamma}\right)} e^{\left(-e^{\left(-\epsilon_t^{ij} - \bar{\gamma}\right)} \sum_{m=n,O} e^{\left(-\bar{\epsilon}_t^{ij,mj}\right)}\right)} d\epsilon_t^{ij},$$

Defining $\lambda_t = \log \sum_{m=n,O} e^{\left(-\bar{\epsilon}_t^{ij,mj}\right)}$ and $\zeta_t = \epsilon_t^{ij} + \bar{\gamma}$ we get

$$\Xi_t^n = \sum_{i=n,O} \int_{-\infty}^{\infty} \left(\beta V_t^{ij} + \varphi \left(\zeta_t - \bar{\gamma}\right)\right) e^{\left(-\zeta_t - e^{\left(-\left(\zeta_t - \lambda_t\right)\right)}\right)} d\zeta_t,$$

Defining $\tilde{y}_t = \zeta_t - \lambda_t$ we obtain

$$\Xi_t^n = \sum_{i=n,O} \exp\left(-\lambda_t\right) \left(\beta V_t^{ij} + \varphi \left(\lambda_t - \bar{\gamma}\right)\right) + \varphi \int_{-\infty}^{\infty} \tilde{y}_t \exp\left(-\tilde{y}_t - \exp\left(-\tilde{y}_t\right)\right) d\tilde{y}_t.$$

Notice that $\int_{-\infty}^{\infty} \tilde{y}_t \exp\left(-\tilde{y}_t - \exp\left(-\tilde{y}_t\right)\right) d\tilde{y}_t$ is the Euler's constant $\bar{\gamma}$, then

$$\Xi_t^n = \varphi \log \sum_{m=n,O} \exp\left(\beta V_t^{mj}\right)^{1/\varphi} \left[\frac{\sum_{i=n,O} \exp\left(\beta V_t^{ij}\right)^{1/\varphi}}{\sum_{m=n,O} \exp\left(\beta V_t^{m}\right)^{1/\varphi}}\right],$$

which implies

$$\Xi_t^n = \varphi \log \sum_{m=n,O} \exp\left(\beta V_t^{mj}\right)^{1/\varphi},$$

and therefore

$$V_t^{nj} = \pi_t^{nj} + \varphi \log \sum_{i=n,O} \exp\left(\beta V_t^{ij}\right)^{1/\varphi}.$$

Location Choice Probabilities of the Firms We now proceed to derive (11). As before, for brevity, we do not present the derivation of the rest of the location choice probabilities since the derivations follow the same logic. Recall that $\varphi_t^{nj,nj}$ is the fraction of firms that decide to reallocate from labor market n, j to labor market i, k. This fraction is equal to the probability that a given worker moves from labor market n, j to labor market i, k at time t, that is, the probability that the expected utility of moving to i, k is higher than the expected utility in any other location. Formally,

$$\varphi_t^{nj,nj} = Prob\left[\epsilon_t^{Oj} - \epsilon_t^{nj} > \frac{\beta}{\varphi}\left(V_{t+1}^{Oj} - V_{t+1}^{nj}\right)\right].$$

Given our assumption over the idiosyncratic shocks, we obtain that

$$\varphi_t^{nj,nj} = \int_{-\infty}^{\infty} f\left(\epsilon_t^{nj}\right) \prod\nolimits_{m\neq n} F\left(\beta\left(V_{t+1}^{nj} - V_{t+1}^{mj}\right) + \varphi\epsilon_t^{nj}\right)\right) d\epsilon_t^{nj},$$

or

$$\varphi_t^{nj,nj} = \int_{-\infty}^{\infty} \exp\left(-\epsilon_t^{nj} - \bar{\gamma}\right) \exp\left[-\exp\left(-\epsilon_t^{nj} - \bar{\gamma}\right) \sum\nolimits_{m=n,O} \exp\left(-\bar{\epsilon}_t^{nj,mj}\right)\right] d\epsilon_t^{nj},$$

with $\bar{\epsilon}_t^{nj,mj} = \frac{\beta\left(V_{t+1}^{nj} - V_{t+1}^{mj}\right)}{\varphi}$. Defining $\lambda_t = \log \sum_{m=n,O} \exp\left(-\bar{\epsilon}_t^{nj,mj}\right)$ and $\zeta_t = \epsilon_t^{ij} + \bar{\gamma}$ we get

$$\varphi_t^{nj,nj} = \exp\left(-\lambda_t\right) \int_{-\infty}^{\infty} \exp\left(-\left(\zeta_t - \lambda_t\right) - \exp\left(-\left(\zeta_t - \lambda_t\right)\right)\right) d\zeta_t,$$

Defining $\tilde{y}_t = \zeta_t - \lambda_t$ we obtain

$$\varphi_t^{nj,nj} = \exp\left(-\lambda_t\right) \int_{-\infty}^{\infty} \exp\left(-\tilde{y}_t - \exp\left(-\tilde{y}_t\right)\right) d\tilde{y}_t.$$

Solving this integral we get

$$\varphi_t^{nj,nj} = \frac{\exp\left(\beta V_{t+1}^{nj}\right)^{1/\varphi}}{\sum_{m=n,O} \exp\left(\beta V_{t+1}^{mj}\right)^{1/\varphi}}.$$

B Proofs

In this Appendix we display the equilibrium conditions of the model in time differences in order to apply the DHA. Recall that we denote by $\hat{x}_{t+1}$ to the time difference of a variable x, that is, $\hat{x}_{t+1} = x_{t+1}/x_t$.

Proposition 1. *Given an initial allocation of the economy,* $\{L_0, M_0, K_0, \mu_{-1}, \varphi_{-1}, X_0\}$ *and elasticities* $(\nu, \vartheta, \sigma, \beta)$*, solving for the baseline economy with constant fundamentals does not require information on the level of the fundamentals.*

Proof of Proposition 1. *Solving for the baseline economy requires solving the following system of equilibrium conditions*

$$\dot{v}_t^{nj} = \dot{\bar{\pi}}_t^{nj} \left(\varphi_{t-1}^{nj,nj} \left(\dot{v}_{t+1}^{nj}\right)^{\beta/\vartheta} + \varphi_{t-1}^{nj,Oj} \left(\dot{v}_{t+1}^{Oj}\right)^{\beta/\vartheta}\right)^{\vartheta}, \tag{C.1}$$

$$\dot{v}_t^{Oj} = \left(\sum_{i=1}^{N} \varphi_{t-1}^{Oj,ij} \left(\dot{v}_{t+1}^{ij}/\dot{\bar{r}}_{t+1}^{i}\right)^{\beta/\vartheta}\right)^{\vartheta}, \tag{C.2}$$

$$\dot{u}_t^{nj} = \left(\dot{w}_t^{nj}/\dot{P}_t^n\right)\left(\sum_{i=1}^{N}\sum_{k=ne,1}^{J}\mu_{t-1}^{nj,ik}\left(\dot{u}_{t+1}^{ik}\right)^{\beta/\nu}\right)^{\nu}, \tag{C.3}$$

$$\varphi_t^{nj,nj} = \frac{\varphi_{t-1}^{nj,nj}\left(\dot{v}_{t+1}^{nj}\right)^{\beta/\vartheta}}{\varphi_{t-1}^{nj,nj}\left(\dot{v}_{t+1}^{nj}\right)^{\beta/\vartheta} + \varphi_{t-1}^{nj,Oj}\left(\dot{v}_{t+1}^{Oj}\right)^{\beta/\vartheta}}, \tag{C.4}$$

$$\varphi_t^{Oj,nj} = \frac{\varphi_{t-1}^{Oj,nj}\left(\dot{v}_{t+1}^{nj}/\dot{\tilde{r}}_{t+1}^{n}\right)^{\beta/\vartheta}}{\sum_{i=1}^{N}\varphi_{t-1}^{Oj,ij}\left(\dot{v}_{t+1}^{ij}/\dot{\tilde{r}}_{t+1}^{i}\right)^{\beta/\vartheta}}, \tag{C.5}$$

$$\mu_t^{nj,ik} = \frac{\mu_{t-1}^{nj,ik}\left(\dot{u}_{t+1}^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^{N}\sum_{h=ne,1}^{J}\mu_{t-1}^{nj,mh}\left(\dot{u}_{t+1}^{mh}\right)^{\beta/\nu}}, \tag{C.6}$$

together with (13), (14), (16), (3), and the equilibrium conditions (5), (6), (7), (17), (15), (18), (19), (20), and (21) in time differences for all n, i, j, *and* k. *As we can see, conditional on data* $\{L_0, M_0, K_0, \mu_{-1}, \varphi_{-1}, X_0\}$ *we can solve for the allocations at each* t *without information on the level of* $\Theta_t = \left\{d^{nj,ij}, m^{nj,ik}, a_t^{nj}\right\}_{n,1=1;j,k=1}^{N,J}$.

Proposition 2. *Take as given a baseline economy,* $\{L_t, M_t, K_t, \mu_{t-1}, \varphi_{t-1}, X_t\}$ *for all* t. *Solving for the effects of a change in policy* $\hat{\Upsilon}$, *namely* $\left\{\hat{L}_t, \hat{M}_t, \hat{K}_t, \hat{\mu}_{t-1}, \hat{\varphi}_{t-1}, \hat{X}_t\right\}$, *does not require the level of the fundamentals.*

Proof of Proposition 2. *Take as given a baseline economy,* $\{L_t, M_t, K_t, \mu_{t-1}, \varphi_{t-1}, X_t\}$ *for all* t. *The effects of a change in policy* $\hat{\Upsilon}$, *namely* $\left\{\hat{L}_t, \hat{M}_t, \hat{K}_t, \hat{\mu}_{t-1}, \hat{\varphi}_{t-1}, \hat{X}_t\right\}$, *solves the following system of equilibrium conditions*

$$\hat{v}_t^{nj} = \hat{\pi}_t^{nj}\left(\varphi_{t-1}^{nj,nj}\dot{\varphi}_t^{nj,nj}\left(\hat{v}_{t+1}^{nj}\right)^{\beta/\vartheta} + \varphi_{t-1}^{nj,Oj}\dot{\varphi}_t^{nj,Oj}\left(\hat{v}_{t+1}^{Oj}\right)^{\beta/\vartheta}\right)^{\vartheta}, \tag{C.7}$$

$$\hat{v}_t^{Oj} = \left(\sum_{i=1}^{N}\varphi_{t-1}^{Oj,ij}\dot{\varphi}_t^{Oj,ij}\left(\hat{v}_{t+1}^{ij}/\hat{\tilde{r}}_{t+1}^{i}\right)^{\beta/\vartheta}\right)^{\vartheta}, \tag{C.8}$$

$$\hat{u}_t^{nj} = \left(\hat{w}_t^{nj}/\hat{P}_t^n\right)\left(\sum_{i=1}^{N}\sum_{k=ne,1}^{J}\mu_{t-1}^{nj,ik}\dot{\mu}_t^{nj,ik}\left(\hat{u}_{t+1}^{ik}\right)^{\beta/\nu}\right)^{\nu}, \tag{C.9}$$

$$\varphi_t^{\prime nj,nj} = \frac{\varphi_{t-1}^{\prime nj,nj}\dot{\varphi}_t^{nj,nj}\left(\hat{v}_{t+1}^{nj}\right)^{\beta/\vartheta}}{\varphi_{t-1}^{\prime nj,nj}\dot{\varphi}_t^{nj,nj}\left(\hat{v}_{t+1}^{nj}\right)^{\beta/\vartheta} + \varphi_{t-1}^{\prime nj,Oj}\dot{\varphi}_t^{nj,Oj}\left(\hat{v}_{t+1}^{Oj}\right)^{\beta/\vartheta}}, \tag{C.10}$$

$$\varphi_t^{\prime Oj,nj} = \frac{\varphi_{t-1}^{\prime Oj,nj}\dot{\varphi}_t^{Oj,nj}\left(\hat{v}_{t+1}^{nj}/\hat{\tilde{r}}_{t+1}^{n}\right)^{\beta/\vartheta}}{\sum_{i=1}^{N}\varphi_{t-1}^{\prime Oj,ij}\dot{\varphi}_t^{Oj,ij}\left(\hat{v}_{t+1}^{ij}/\hat{\tilde{r}}_{t+1}^{i}\right)^{\beta/\vartheta}}, \tag{C.11}$$

$$\mu_t^{\prime nj,ik} = \frac{\mu_{t-1}^{\prime nj,ik} \dot{\mu}_t^{nj,ik} \left(\hat{u}_{t+1}^{ik}\right)^{\beta/\nu}}{\sum_{m=1}^{N} \sum_{h=ne,1}^{J} \mu_{t-1}^{\prime nj,mh} \dot{\mu}_t^{nj,mh} \left(\hat{u}_{t+1}^{mh}\right)^{\beta/\nu}}, \tag{C.12}$$

$$M_t^{\prime nj} = M_{t-1}^{\prime nj} \varphi_{t-1}^{\prime nj,nj} + M_{t-1}^{\prime Oj} \varphi_{t-1}^{\prime Oj,nj}, \tag{C.13}$$

$$M_t^{\prime Oj} = \sum_{i=1}^{N} M_{t-1}^{\prime ij} \varphi_{t-1}^{\prime ij,Oj}, \tag{C.14}$$

$$\hat{K}_t^n = \left(\hat{K}_{t-1}^n\right)^{\kappa_n} \left(\hat{L}_t^{n,co}\right)^{1-\kappa_n}, \tag{C.15}$$

$$L_t^{\prime nj} = \sum_{i=1}^{N} \sum_{k=ne,1}^{J} \mu_{t-1}^{\prime ik,nj} L_{t-1}^{\prime ik}, \tag{C.16}$$

together with equilibrium conditions (5), (6), (7), (17), (15), (18), (19), (20), and (21) in relative time differences for all n, i, j, and k. Note that conditional on the baseline economy $\{L_t, M_t, K_t, \mu_{t-1}, \varphi_{t-1}, X_t\}_{t=1}^{\infty}$ we can solve for the effects of a change in policy at each t without information on the level of $\Theta_t = \left\{d^{nj,ij}, m^{nj,ik}, a_t^{nj}\right\}_{n,1=1;j,k=1}^{N,J}$.

B.1 Equilibrium Conditions in Changes

In this appendix, we express the equilibrium conditions of the model in time changes.

1. The value of households for labor market nj (1) in changes are given by

$$\dot{u}_{t+1}^{H,nj} = \left(\dot{w}_{t+1}^{nj} / \dot{P}_{t+1}^{n}\right)^{1/\nu} \left[\sum_i \sum_k \mu_t^{nj,ik} \left(\dot{u}_{t+2}^{H,ik}\right)^{\beta}\right] \tag{C.17}$$

2. The fraction of workers that move from labor market nj to ik (2) in changes is given by

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik} \left(\dot{u}_{t+2}^{H,ik}\right)^{\beta}}{\sum_m \mu_t^{nj,mh} \left(\dot{u}_{t+2}^{H,mh}\right)^{\beta}} \tag{C.18}$$

3. The law as motion of employment are given by

$$L_{t+1}^{nj} = \sum_i \sum_k \mu_t^{ik,nj} L_t^{ik} \tag{C.19}$$

4. The value of active firms (9) and inactive firms (10) in changes are given by

$$\dot{v}^{nj}_{t+1} = \left(exp(\pi^{nj}_{t+1} - \pi^{nj}_{t})\right)^{1/\vartheta} \left\{\varphi^{nj,nj}_{t}\left(\dot{v}^{nj}_{t+2}\right)^{\beta} + (1-\varphi^{nj,nj}_{t})\left(\dot{v}^{Oj}_{t+2}\right)^{\beta}\right\} \tag{C.20}$$

$$v^{Oj}_{t+1} = \sum_{i} \frac{\varphi^{Oj,ij}_{t}\left(\dot{v}^{ij}_{t+2}\right)^{\beta}}{exp(r^{i}_{t+1} - r^{i}_{t})^{\beta/\vartheta}} \tag{C.21}$$

where we have used the transformation $\dot{v}^{a}_{t+1} = exp(V^{a}_{t+1} - V^{a}_{t})^{1/\vartheta}$.

5. The probability choices in changes are given by

$$\varphi^{nj,nj}_{t+1} = \frac{\varphi^{nj,nj}_{t}\left(\dot{v}^{nj}_{t+2}\right)^{\beta}}{\varphi^{nj,nj}_{t}\left(\dot{v}^{nj}_{t+2}\right)^{\beta} + \varphi^{nj,Oj}_{t}\left(\dot{v}^{Oj}_{t+2}\right)^{\beta}} \tag{C.22}$$

$$\varphi^{nj,Oj}_{t+1} = 1 - \varphi^{nj,nj}_{t+1} \tag{C.23}$$

$$\varphi^{Oj,nj}_{t+1} = \frac{\varphi^{Oj,nj}_{t}\frac{\left(\dot{v}^{nj}_{t+2}\right)^{\beta}}{exp(\beta(r^{n}_{t+2} - r^{n}_{t+1}))^{1/\vartheta}}}{\sum_{i}\varphi^{Oj,ij}_{t+1}\frac{\left(\dot{v}^{ij}_{t+2}\right)^{\beta}}{exp(\beta(r^{i}_{t+2} - r^{i}_{t+1}))^{1/\vartheta}}} \tag{C.24}$$

6. The law of motion of firms

$$M^{nj}_{t+1} = M^{nj}_{t}\varphi^{nj,nj}_{t} + M^{Oj}_{t}\varphi^{Oj,nj}_{t}, \text{ for all } n, j \tag{C.25}$$

$$M^{Oj}_{t+1} = \sum_{i} M^{ij}_{t}\varphi^{ij,Oj}_{t}. \tag{C.26}$$

B.2 Deriving the Static Sub-problem in Changes

The sectoral price index *(5)* in changes is given by:

$$\dot{P}^{nj}_{t+1} = \frac{1}{P^{nj}_{t}}\left(\sum_{i}\dot{M}^{ij}_{t+1}M^{ij}_{t}\left(\dot{p}^{ij,nj}_{t+1}p^{ij,nj}_{t}\right)^{1-\sigma_j}\right)^{1/(1-\sigma_j)}$$

Notice that $\lambda^{nj,ij}_{t} = M^{nj}_{t}\frac{p^{nj,ij}_{t}q^{nj,ij}_{t}}{X^{ij}_{t}} = M^{nj}_{t}\left(p^{nj,ij}_{t}/P^{ij}_{t}\right)^{1-\sigma_j}$. Hence,

$$\dot{P}^{nj}_{t+1} = \left(\sum_{i}\lambda^{ij,nj}_{t}\dot{M}^{ij}_{t+1}\left(\dot{p}^{ij,nj}_{t+1}\right)^{1-\sigma_j}\right)^{1/(1-\sigma_j)}$$

The price of sector-j intermediate goods produced in i and sold in n *(7)* in changes is given by:

$$\frac{p_{t+1}^{nj,ij}}{p_t^{nj,ij}} = \frac{\frac{\sigma_j}{\sigma_j-1}\frac{\left(1+\tau_{t+1}^{nj,ij}\right)d^{nj,ij}x_{t+1}^{nj}}{a^{nj}}}{\frac{\sigma_j}{\sigma_j-1}\frac{\left(1+\tau_t^{nj,ij}\right)d^{nj,ij}x_t^{nj}}{a^{nj}}}$$

Hence,

$$\dot{p}_{t+1}^{ij,nj} = \left(1+\dot{\tau}_{t+1}^{ij,nj}\right)\dot{x}_{t+1}^{ij}$$

The cost of the input bundle in ij *(6)* in changes is given by:

$$\frac{x_{t+1}^{nj}}{x_t^{nj}} = \frac{B^{nj}\left[\left(w_{t+1}^{nj}\right)^{1-\xi^n}\left(r_{t+1}^{n}\right)^{\xi^n}\right]^{\gamma^{nj}}\prod_k\left(P_{t+1}^{nk}\right)^{\gamma^{nj,nk}}}{B^{nj}\left[\left(w_t^{nj}\right)^{1-\xi^n}\left(r_t^{n}\right)^{\xi^n}\right]^{\gamma^{nj}}\prod_k\left(P_t^{nk}\right)^{\gamma^{nj,nk}}}$$

Hence

$$\hat{x}_{t+1}^{nj} = \left[\left(\dot{w}_{t+1}^{nj}\right)^{1-\xi^n}\left(\dot{r}_{t+1}^{n}\right)^{\xi^n}\right]^{\gamma^{nj}}\prod_k\left(\dot{P}_{t+1}^{nk}\right)^{\gamma^{nj,nk}}$$

The profit function *(8)* in changes is given by:

$$\frac{\pi_{t+1}^{nj,ij}}{\pi_t^{nj,ij}} = \frac{\frac{\left(\left(1+\tau_{t+1}^{nj,ij}\right)d^{nj,ij}x_{t+1}^{nj}\right)^{1-\sigma_j}X_{t+1}^{ij}}{(\sigma_j-1)\left(1+\tau_{t+1}^{nj,ij}\right)\left(a^{nj}P_{t+1}^{ij}\right)^{1-\sigma_j}}}{\frac{\left(\left(1+\tau_t^{nj,ij}\right)d^{nj,ij}x_t^{nj}\right)^{1-\sigma_j}X_t^{ij}}{(\sigma_j-1)\left(1+\tau_t^{nj,ij}\right)\left(a^{nj}P_t^{ij}\right)^{1-\sigma_j}}}$$

Hence,

$$\hat{\pi}_{t+1}^{nj,ij} = \left(1+\dot{\tau}_{t+1}^{nj,ij}\right)^{-\sigma_j}\left(\dot{x}_{t+1}^{nj}\right)^{1-\sigma_j}\left(\dot{P}_{t+1}^{ij}\right)^{\sigma_j-1}\dot{X}_{t+1}^{ij}$$

Total profits in nj at $t+1$ *(8)* can be expressed as:

$$\pi_{t+1}^{nj} = \sum_{i=1}^{N}\dot{\pi}_{t+1}^{nj,ij}\pi_t^{nj,ij}$$

Using the fact that $\pi_t^{nj,ij} = \frac{p_t^{nj,ij}q_t^{nj,ij}}{\sigma_j\left(1+\tau_t^{nj,ij}\right)} = \frac{\lambda_t^{nj,ij}N_t^{nj}X_t^{ij}}{\sigma_j\left(1+\tau_t^{nj,ij}\right)}$ we have

$$\pi_{t+1}^{nj} = \sum_{i=1}^{N}\frac{\lambda_t^{nj,ij}X_t^{ij}}{M_t^{nj}\sigma_j\left(1+\tau_t^{nj,ij}\right)}\dot{\pi}_{t+1}^{nj,ij}$$

The change in the stock of capital structures is given by

$$\dot{K}_{t+1}^{n} = (\dot{K}_t^{n})^{\kappa_n}(\dot{L}_{t+1}^{k,n})^{1-\kappa_n}$$

where $L_{t+1}^{k,n}$ is taken as given for the U.S. regions. For the other countries, we know that wages are going to be equalized across sectors, thus using (15) we get

$$\dot{K}_{t+1}^{n} = (\dot{K}_t^n)^{\kappa_n} \left(\frac{\dot{r}_{t+1}^{n} \dot{K}_{t+1}^{n}}{\dot{w}_{t+1}^{n}} \right)^{1-\kappa_n}$$

and solving for the change in the stock of capital structures we get

$$\dot{K}_{t+1}^{n} = (\dot{K}_t^n) \left(\frac{\dot{r}_{t+1}^{n}}{\dot{w}_{t+1}^{n}} \right)^{\frac{1-\kappa_n}{\kappa_n}}$$

for n other than the United States.

The change in aggregate bilateral expenditure shares (17) is given by

$$\frac{\lambda_{t+1}^{nj,ij}}{\lambda_t^{nj,ij}} = \frac{M_{t+1}^{nj} \frac{p_{t+1}^{nj,ij} q_{t+1}^{nj,ij}}{X_{t+1}^{ij}}}{M_t^{nj} \frac{p_t^{nj,ij} q_t^{nj,ij}}{X_t^{ij}}}$$

which can be re-expressed as

$$\begin{aligned} \dot{\lambda}_{t+1}^{nj,ij} &= \dot{M}_{t+1}^{nj} \frac{\hat{p}_{t+1}^{nj,ij} \hat{q}_{t+1}^{nj,ij}}{\hat{X}_{t+1}^{ij}}, \\ &= \dot{M}_{t+1}^{nj} \frac{\left((1+\dot{\tau}_{t+1}^{nj,ij}) \dot{x}_{t+1}^{nj} \right)^{1-\sigma_j}}{\left(\dot{P}_{t+1}^{ij} \right)^{1-\sigma_j}} \end{aligned}$$

Hence

$$\dot{\lambda}_{t+1}^{nj,ij} = \dot{M}_{t+1}^{nj} \left((1+\dot{\tau}_{t+1}^{nj,ij}) \dot{x}_{t+1}^{nj} \right)^{1-\sigma_j} \left(\dot{P}_{t+1}^{ij} \right)^{\sigma-1}$$

Total income and expenditure (18), (19) in changes are given by

$$\begin{aligned} I_{t+1}^{n} = \sum_k \dot{w}_{t+1}^{nk} \dot{L}_{t+1}^{nk} w_t^{nk} L_t^{nk} + \dot{r}_{t+1}^{n} \dot{K}_{t+1}^{n} r_t^n K_t^n \\ + \iota^n \chi_{t+1} - \sum_k r_{t+1}^{n} M_t^{O,k} \varphi_t^{Ok,nk} + \sum_j \frac{\tau_{t+1}^{ij,nj} \lambda_{t+1}^{ij,nj} X_{t+1}^{nj}}{\left(1+\tau_{t+1}^{ij,nj}\right)} \end{aligned}$$

where $\chi_{t+1} = \sum_{n=1}^{N} \sum_{j=1}^{J} M_{t+1}^{nj} \pi_{t+1}^{nj}$

$$X_{t+1}^{nj} = \sum_{k=1}^{J} \gamma^{nk,nj} \sum_{i=1}^{N} \frac{(\sigma_k - 1) \lambda_{t+1}^{nk,ik} X_{t+1}^{ik}}{\sigma_k \left(1+\tau_{t+1}^{nk,ik}\right)} + \alpha^j I_{t+1}^{n}$$

It is straightforward to show that the market clearing conditions in changes can be expressed as The labor market clearing conditions (20) and (21) in changes are given by

$$\dot{w}_{t+1}^{nj}\dot{L}_{t+1}^{nj}w_t^{nj}L_t^{nj} = (1-\xi^n)\gamma^{nj}\sum_{i=1}^{N}\frac{(\sigma_j-1)\lambda_{t+1}^{nj,ij}X_{t+1}^{ij}}{\sigma_j(1+\tau_{t+1}^{nj,ij})}$$

$$\dot{r}_{t+1}^{n}\dot{K}_{t+1}^{n}r_t^{n}K_t^{n} = \sum_{j=1}^{J}\xi^n\gamma^{nj}\sum_{i=1}^{N}\frac{(\sigma_j-1)\lambda_{t+1}^{nj,ij}X_{t+1}^{ij}}{\sigma_j(1+\tau_{t+1}^{nj,ij})} + \sum_{j=1}^{J} r_{t+1}^{n}M_t^{Oj}\varphi_t^{Oj,nj}$$

and as explained above the labor market clearing condition for countries other than the United States in changes is given by

$$\dot{w}_{t+1}^{n}\dot{L}_{t+1}^{n}w_t^{n}L_t^{n} = \sum_{j=1}^{J}(1-\xi^n)\gamma^{nj}\sum_{i=1}^{N}\frac{(\sigma_j-1)\lambda_{t+1}^{nj,ij}X_{t+1}^{ij}}{\sigma_j(1+\tau_{t}^{nj,ij})} + (1-\kappa_n)r_{t+1}^{n}K_{t+1}^{n}$$

B.3 Deriving the Households' Dynamic Problem in Changes

We know turn to express the equilibrium conditions of the dynamic problem of the household on where to supply labor in time differences. As before, the details of the derivations are relegated to the appendix

The value of households for labor market nj (1) in changes are derived using the following steps (analogous for the case of the firm's problem). We have that

$$U_t^{nj} = log(w_t^{nj}/P_t^n) + \nu log\left[\sum_{i=1}^{N}\sum_{k=1}^{J} exp\left(\beta U_{t+1}^{ik} - m^{nj,ik}\right)^{1/\nu}\right].$$

In time differences we get

$$U_{t+1}^{nj} - U_t^{nj} = log(\dot{w}_{t+1}^{nj}/\dot{P}_{t+1}^n) + \nu log\frac{\left[\sum_{i=1}^{N}\sum_{k=1}^{J} exp\left(\beta U_{t+2}^{ik} - m^{nj,ik}\right)^{1/\nu}\right]}{\left[\sum_{i=1}^{N}\sum_{k=1}^{J} exp\left(\beta U_{t+1}^{ik} - m^{nj,ik}\right)^{1/\nu}\right]}.$$

which can be re-expressed as

$$\begin{aligned} U_{t+1}^{H,nj} - U_t^{nj} &= log(\dot{w}_{t+1}^{nj}/\dot{P}_{t+1}^n) \\ &+ \nu log\frac{\left[\sum_i\sum_k exp\left(\beta U_{t+2}^{ik} - m^{nj,ik}\right)^{1/\nu}\frac{exp\left(\beta U_{t+1}^{ik} - m^{nj,ik}\right)^{1/\nu}}{exp\left(\beta U_{t+1}^{ik} - m^{nj,ik}\right)^{1/\nu}}\right]}{\left[\sum_i\sum_k exp\left(\beta U_{t+1}^{ik} - m^{nj,ik}\right)^{1/\nu}\right]} \end{aligned}$$

and using the definition of $\mu_t^{nj,ik}$we get

$$U_{t+1}^{nj} - U_t^{nj} = log(\dot{w}_{t+1}^{nj}/\dot{P}_{t+1}^{n}) + \nu log\left[\sum_i \sum_k \mu_t^{nj,ik} exp\left(\beta U_{t+2}^{ik} - \beta U_{t+1}^{ik}\right)^{1/\nu}\right]$$

or

$$\dot{u}_{t+1}^{nj} = \left(\dot{w}_{t+1}^{nj}/\dot{P}_{t+1}^{n}\right)^{1/\nu}\left[\sum_i \sum_k \mu_t^{nj,ik} exp\left(\dot{u}_{t+2}^{ik}\right)^{\beta}\right],$$

where $\hat{u}_{t+1}^{nj}$ $=exp(U_{t+1}^{nj} - U_t^{nj})^{1/\nu}$.

The fraction of workers that move from labor market nj to ik (2) is given by

$$\mu_t^{nj,ik} = \frac{exp(\beta U_{t+1}^{ik} - m^{nj,ik})^{1/\nu}}{\sum_m exp(\beta U_{t+1}^{mh} - m^{nj,mh})^{1/\nu}}$$

which analogously for the case of firms can be re-expressed as

$$\mu_{t+1}^{nj,ik} = \frac{exp(\beta U_{t+2}^{ik} - m^{nj,ik})^{1/\nu}\frac{exp(\beta U_{t+1}^{ik} - m^{nj,ik})^{1/\nu}}{exp(\beta U_{t+1}^{ik} - m^{nj,ik})^{1/\nu}}}{\sum_m exp(\beta U_{t+2}^{mh} - m^{nj,mh})^{1/\nu}}\frac{\sum_m exp(\beta U_{t+1}^{mh} - m^{nj,mh})^{1/\nu}}{\sum_m exp(\beta U_{t+1}^{mh} - m^{nj,mh})^{1/\nu}}$$

Hence

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik} exp(\beta U_{t+2}^{ik} - \beta U_{t+1}^{ik})^{1/\nu}}{\sum_m \mu_t^{nj,mh} exp(\beta U_{t+2}^{mh} - \beta U_{t+1}^{mh})^{1/\nu}}$$

or

$$\mu_{t+1}^{nj,ik} = \frac{\mu_t^{nj,ik}\left(\dot{u}_{t+2}^{ik}\right)^{\beta}}{\sum_m \sum_h \mu_t^{nj,mh}\left(\dot{u}_{t+2}^{mh}\right)^{\beta}}.$$

B.4 Deriving the Firm's Location Choice Problem in Changes

In this section of the appendix we describe the equilibrium conditions of the dynamic problem of the firm on where to locate production in time differences.

The value of active firms (9) is given by

$$V_t^{nj} = \pi_t^{nj} + \vartheta log\left\{exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta}\right\}$$

In time differences we have that

$$V_{t+1}^{nj} - V_t^{nj} = \pi_{t+1}^{nj} - \pi_t^{nj} + \vartheta log\frac{\left\{exp(\beta V_{t+2}^{nj})^{1/\vartheta} + exp(\beta V_{t+2}^{Oj})^{1/\vartheta}\right\}}{\left\{exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta}\right\}}$$

Multiplying and diving each term in the parenthesis by $exp(\beta V_{t+1}^{nj})^{1/\vartheta}$ and $exp(\beta V_{t+1}^{Oj})^{1/\vartheta}$ respectively we have

$$V_{t+1}^{nj} - V_t^{nj} = \pi_{t+1}^{nj} - \pi_t^{nj} + \vartheta log \frac{\left\{ exp(\beta V_{t+2}^{nj})^{1/\vartheta} \frac{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+1}^{nj})^{1/\vartheta}} + exp(\beta V_{t+2}^{Oj})^{1/\vartheta} \frac{exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}{exp(\beta V_{t+1}^{Oj})^{1/\vartheta}} \right\}}{\left\{ exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta} \right\}}$$

which can be expressed as

$$\begin{aligned} V_{t+1}^{nj} - V_t^{nj} &= \pi_{t+1}^{nj} - \pi_t^{nj} \\ &+ \vartheta log \frac{\left\{ exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta} exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+2}^{Oj} - \beta V_{t+1}^{Oj})^{1/\vartheta} exp(\beta V_{t+1}^{Oj})^{1/\vartheta} \right\}}{\left\{ exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta} \right\}} \end{aligned}$$

Let's use the transformation $\hat{u}_{t+1}^{nj} = exp(V_{t+1}^{nj} - V_t^{nj})^{1/\vartheta}$.

Using the fact that $\varphi_t^{nj,nj} = \frac{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}$ we get

$$\begin{aligned} V_{t+1}^{nj} - V_t^{nj} &= \pi_{t+1}^{nj} - \pi_t^{nj} \\ &+ \vartheta log \left\{ \varphi_t^{nj,nj} exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta} + (1 - \varphi_t^{nj,nj}) exp(\beta V_{t+2}^{Oj} - \beta V_{t+1}^{Oj})^{1/\vartheta} \right\} \end{aligned}$$

And therefore

$$\dot{u}_{t+1}^{nj} = \left(exp(\pi_{t+1}^{nj} - \pi_t^{nj}) \right)^{1/\vartheta} \left\{ \varphi_t^{nj,nj} \left(\dot{u}_{t+2}^{nj} \right)^{\beta} + (1 - \varphi_t^{nj,nj}) \left(\dot{u}_{t+2}^{Oj} \right)^{\beta} \right\}$$

The value of inactive firms (10) is given by

$$V_t^{Oj} = 0 + \vartheta log \left\{ \sum_i exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta} \right\}$$

and in time differences is given by

$$V_{t+1}^{Oj} - V_t^{Oj} = \vartheta log \frac{\sum_i exp(\beta V_{t+2}^{ij} - \beta r_{t+2}^i)^{1/\vartheta}}{\sum_i exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}$$

Multiplying and diving each term in the parenthesis by $exp(\beta V_{t+1}^{nj} - r_t^n)^{1/\vartheta}$ respectively we have

$$V_{t+1}^{Oj} - V_t^{Oj} = \vartheta log \frac{\sum_i e^{(\beta V_{t+2}^{ij} - \beta r_{t+2}^i)^{1/\vartheta}} \frac{e^{(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}{e^{(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}}{\sum_i e^{(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}$$

which can be re-written as

$$V_{t+1}^{Oj} - V_t^{Oj} = \vartheta log \frac{\sum_i e^{((\beta V_{t+2}^{ij} - \beta r_{t+2}^i) - (\beta V_{t+1}^{nj} - \beta r_{t+1}^i)))^{1/\vartheta}} e^{(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}{\sum_i e^{(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}$$

and using (12) we get

$$V_{t+1}^{Oj} - V_t^{Oj} = \vartheta log \sum_i \varphi_t^{Oj,ij} e^{((\beta V_{t+2}^{ij} - \beta r_{t+2}^i) - (\beta V_{t+1}^{ij} - \beta r_{t+1}^i)))^{1/\vartheta}}$$

and using the transformation introduced above we get

$$\hat{v}_{t+1}^{Oj} = \sum_i \frac{\varphi_t^{Oj,ij} \left(\dot{v}_{t+2}^{ij} \right)^\beta}{exp(r_{t+2}^i - r_{t+1}^i)^{\beta/\vartheta}},$$

where $\hat{v}_{t+1}^{Oj} = exp(V_{t+1}^{Oj} - V_t^{Oj})^{1/\vartheta}$.

The fraction of firms that stays producing in nj is given by

$$\varphi_t^{nj,nj} = \frac{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}$$

which can be re-written as

$$\varphi_{t+1}^{nj,nj} = \frac{exp(\beta V_{t+2}^{nj})^{1/\vartheta} \frac{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}}{exp(\beta V_{t+2}^{nj})^{1/\vartheta} \frac{exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+1}^{nj})^{1/\vartheta}} + exp(\beta V_{t+2}^{Oj})^{1/\vartheta} \frac{exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}{exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}}$$

which can be expressed as

$$\varphi_{t+1}^{nj,nj} = \frac{exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta} exp(\beta V_{t+1}^{nj})^{1/\vartheta}}{exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta} exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+2}^{Oj} - \beta V_{t+1}^{Oj})^{1/\vartheta} exp(\beta V_{t+1}^{Oj})^{1/\vartheta}}$$

Multiplying this expression by $exp(\beta V_{t+1}^{nj})^{1/\vartheta} + exp(\beta V_{t+1}^{Oj})^{1/\vartheta}$ we get

$$\varphi_{t+1}^{nj,nj} = \frac{\varphi_t^{nj,nj} exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta}}{\varphi_t^{nj,nj} exp(\beta V_{t+2}^{nj} - \beta V_{t+1}^{nj})^{1/\vartheta} + \varphi_t^{nj,Oj} exp(\beta V_{t+2}^{Oj} - \beta V_{t+1}^{Oj})^{1/\vartheta}}$$

or

$$\varphi_{t+1}^{nj,nj} = \frac{\varphi_t^{nj,nj} \left(\hat{u}_{t+2}^{nj} \right)^\beta}{\varphi_t^{nj,nj} \left(\hat{u}_{t+2}^{nj} \right)^\beta + \varphi_t^{nj,Oj} \left(\hat{u}_{t+2}^{Oj} \right)^\beta}$$

It immediately follows that

$$\varphi_{t+1}^{nj,Oj} = 1 - \varphi_{t+1}^{nj,nj}$$

Finally, the fraction of inactive firms that enter a given location is given by

$$\varphi_t^{Oj,nj} = \frac{exp(\beta V_{t+1}^{nj} - r_t^n)^{1/\vartheta}}{\sum_i exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}$$

which following the same steps as before can be expressed as

$$\varphi_{t+1}^{Oj,nj} = \frac{exp(\beta V_{t+2}^{nj} - \beta r_{t+2}^n)^{1/\vartheta} \frac{exp(\beta V_{t+1}^{nj} - r_t^n)^{1/\vartheta}}{\sum_i exp(\beta V_{t+1}^{nj} - \beta r_{t+1}^n)^{1/\vartheta})}}{\frac{\sum_i exp(\beta V_{t+2}^{ij} - r_{t+1}^i)^{1/\vartheta} \frac{exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}{exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}{\sum_i exp(\beta V_{t+1}^{ij} - \beta r_{t+1}^i)^{1/\vartheta}}}$$

and therefore

$$\varphi_{t+1}^{Oj,nj} = \frac{\varphi_t^{Oj,nj} exp((\beta V_{t+2}^{nj} - \beta r_{t+2}^n) - (\beta V_{t+1}^{nj} - \beta r_{t+1}^n)^{1/\vartheta}))^{1/\vartheta}}{\sum_i \varphi_{t+1}^{Oj,ij} exp((\beta V_{t+2}^{ij} - \beta r_{t+2}^i) - (\beta V_{t+1}^{ij} - \beta r_{t+1}^i))^{1/\vartheta}}$$

or

$$\varphi_{t+1}^{Oj,nj} = \frac{\varphi_t^{Oj,nj} \frac{\left(\dot{v}_{t+2}^{nj}\right)^{\beta}}{exp(r_{t+1}^n - r_{t+1}^n)^{\beta/\vartheta}}}{\sum_i \varphi_{t+1}^{Oj,ij} \frac{\left(\dot{v}_{t+2}^{ij}\right)^{\beta}}{exp(r_{t+2}^i - r_{t+1}^i)^{1/\vartheta}}}.$$

B.5 Solving for Unexpected Change in Trade Policy at $t = 1$

B.5.1 Household's Problem

We start first by indexing variables according to the sequence of policy Υ or to the change in policy Υ'.

Consider the values at $t = 0$,

$$U_0^{nj}(\Upsilon) = log(w_0^{nj}(\Upsilon)/P_0^n(\Upsilon)) + \nu log\left[\sum_{i=1}^{N}\sum_{k=ne,1}^{J} exp\left(\beta U_1^{ik}(\Upsilon) - m^{nj,ik}\right)^{1/\nu}\right],$$

and labor market flows

$$\mu_0^{nj,ik}(\Upsilon) = \frac{exp(\beta U_1^{ik}(\Upsilon) - m^{nj,ik})^{1/\nu}}{\sum_m \sum_h exp(\beta U_1^{mh}(\Upsilon) - m^{nj,mh})^{1/\nu}},$$

and at $t=1$ after the change in policy

$$U_1^{nj}\left(\Upsilon'\right)=log(w_1^{nj}\left(\Upsilon'\right)/P_1^n\left(\Upsilon'\right))+\nu log\left[\sum_{i=1}^{N}\sum_{k=ne,1}^{J}exp\left(\beta U_2^{ik}\left(\Upsilon'\right)-m^{nj,ik}\right)^{1/\nu}\right],$$

$$\mu_1^{nj,ik}\left(\Upsilon'\right)=\frac{exp(\beta U_2^{ik}\left(\Upsilon'\right)-m^{nj,ik})^{1/\nu}}{\sum_m\sum_h exp(\beta U_2^{mh}\left(\Upsilon'\right)-m^{nj,mh})^{1/\nu}}.$$

Taking the time difference we get

$$U_1^{nj}\left(\Upsilon'\right)-U_0^{nj}\left(\Upsilon\right)=log\left(\frac{w_1^{nj}\left(\Upsilon'\right)/w_0^{nj}\left(\Upsilon\right)}{P_1^n\left(\Upsilon'\right)/P_0^n\left(\Upsilon\right)}\right)+\nu log\left[\frac{\sum_{i=1}^{N}\sum_{k=ne,1}^{J}exp\left(\beta U_2^{ik}\left(\Upsilon'\right)-m^{nj,ik}\right)^{1/\nu}}{\sum_{i=1}^{N}\sum_{k=ne,1}^{J}exp\left(\beta U_1^{ik}\left(\Upsilon\right)-m^{nj,ik}\right)^{1/\nu}}\right],$$

$$\begin{aligned}U_1^{nj}\left(\Upsilon'\right)-U_0^{nj}\left(\Upsilon\right)&=log\left(\frac{w_1^{nj}\left(\Upsilon'\right)/w_0^{nj}\left(\Upsilon\right)}{P_1^n\left(\Upsilon'\right)/P_0^n\left(\Upsilon\right)}\right)\\&+\nu log\left[\sum_{i=1}^{N}\sum_{k=ne,1}^{J}\frac{\frac{exp\left(\beta U_2^{ik}(\Upsilon')-m^{nj,ik}\right)^{1/\nu}}{exp\left(\beta U_1^{ik}(\Upsilon)-m^{nj,ik}\right)^{1/\nu}}}{\frac{\sum_{i=1}^{N}\sum_{k=ne,1}^{J}exp\left(\beta U_1^{ik}(\Upsilon)-m^{nj,ik}\right)^{1/\nu}}{exp\left(\beta U_1^{ik}(\Upsilon)-m^{nj,ik}\right)^{1/\nu}}}\right],\end{aligned}$$

$$\begin{aligned}U_1^{nj}\left(\Upsilon'\right)-U_0^{nj}\left(\Upsilon\right)&=log\left(\frac{w_1^{nj}\left(\Upsilon'\right)/w_0^{nj}\left(\Upsilon\right)}{P_1^n\left(\Upsilon'\right)/P_0^n\left(\Upsilon\right)}\right)\\&+\nu log\left[\sum_{i=1}^{N}\sum_{k=ne,1}^{J}\mu_0^{nj,ik}\left(\Upsilon\right)\frac{exp\left(U_1^{ik}\left(\Upsilon'\right)\right)^{\beta/\nu}}{exp\left(U_1^{ik}\left(\Upsilon\right)\right)^{\beta/\nu}}exp\left(\beta U_2^{ik}\left(\Upsilon'\right)-U_1^{ik}\left(\Upsilon'\right)\right)^{\beta/\nu}\right],\end{aligned}$$

then

$$\begin{aligned}U_1^{nj}\left(\Upsilon'\right)-U_0^{nj}\left(\Upsilon\right)&=log\left(\frac{w_1^{nj}\left(\Upsilon'\right)/w_0^{nj}\left(\Upsilon\right)}{P_1^n\left(\Upsilon'\right)/P_0^n\left(\Upsilon\right)}\right)\\&+\nu log\left[\sum_{i=1}^{N}\sum_{k=ne,1}^{J}\tilde{\mu}_0^{nj,ik}\left(\Upsilon'\right)exp\left(U_2^{ik}\left(\Upsilon'\right)-U_1^{ik}\left(\Upsilon'\right)\right)^{\beta/\nu}\right],\end{aligned}$$

and

$$\mu_1^{nj,ik}\left(\Upsilon'\right)=\frac{\mu_0^{nj,ik}\left(\Upsilon\right)\frac{exp\left(U_1^{ik}(\Upsilon')\right)^{\beta/\nu}}{exp\left(U_1^{ik}(\Upsilon)\right)^{\beta/\nu}}exp\left(U_2^{ik}\left(\Upsilon'\right)-U_1^{ik}\left(\Upsilon'\right)\right)^{\beta/\nu}}{\sum_m\sum_h\mu_0^{nj,mh}\left(\Upsilon\right)\frac{exp\left(U_1^{mh}(\Upsilon')\right)^{\beta/\nu}}{exp\left(U_1^{mh}(\Upsilon)\right)^{\beta/\nu}}exp\left(U_2^{mh}\left(\Upsilon'\right)-U_1^{mh}\left(\Upsilon'\right)\right)^{\beta/\nu}}.$$

Using our notation, we get at $t = 1$,

$$\hat{u}_1^{nj} = \frac{\hat{w}_1^{nj}}{\hat{P}_1^n} \left[\sum_{i=1}^{N} \sum_{k=ne,1}^{J} \tilde{\mu}_0^{nj,ik} \left(\hat{u}_2^{ik} \right)^{\beta/\nu} \right]^{\nu},$$

$$\mu_1'^{nj,ik} = \frac{\tilde{\mu}_0^{nj,ik} \left(\hat{u}_2^{ik} \right)^{\beta/\nu}}{\sum_m \sum_h \tilde{\mu}_0^{nj,mh} \left(\hat{u}_2^{mh} \right)^{\beta/\nu}},$$

where

$$\tilde{\mu}_0^{nj,ik} = \mu_0^{nj,ik} (\hat{u}_1^{ik})^{\beta/\nu}.$$

For all other $t > 1$

$$\hat{u}_t^{nj} = \frac{\hat{w}_t^{nj}}{\hat{P}_t^n} \left[\sum_{i=1}^{N} \sum_{k=ne,1}^{J} \mu_{t-1}'^{nj,ik} \dot{\mu}_t^{nj,ik} \left(\hat{u}_{t+1}^{ik} \right)^{\beta/\nu} \right]^{\nu},$$

$$\mu_t'^{nj,ik} = \frac{\mu_{t-1}'^{nj,ik} \dot{\mu}_t^{nj,ik} \left(\hat{u}_{t+1}^{ik} \right)^{\beta/\nu}}{\sum_m \sum_h \mu_{t-1}'^{nj,mh} \dot{\mu}_t^{nj,mh} \left(\hat{u}_{t+1}^{mh} \right)^{\beta/\nu}}.$$

B.5.2 Firm's Problem

We start first by indexing variables according to the sequence of policy Υ or to the change in policy Υ'.

$$V_0^{nj} (\Upsilon) = \pi_0^{nj} (\Upsilon) + \vartheta log \left\{ \sum_{h=n,O} exp \left(V_1^{hj} (\Upsilon) \right)^{\beta/\vartheta} \right\},$$

and

$$\varphi_0^{nj,hj} (\Upsilon) = \frac{exp \left(V_1^{hj} (\Upsilon) \right)^{\beta/\vartheta}}{\sum_{i=n,O} exp \left(V^{ij} (\Upsilon) \right)^{\beta/\vartheta}},$$

where $h = n, O$. Under the change in policy,

$$V_1^{nj} (\Upsilon') = \pi_1^{nj} (\Upsilon') + \vartheta log \left\{ \sum_{h=n,O} exp \left(V_2^{hj} (\Upsilon') \right)^{\beta/\vartheta} \right\},$$

and

$$\varphi_1^{nj,hj} (\Upsilon') = \frac{exp \left(V_2^{hj} (\Upsilon') \right)^{\beta/\vartheta}}{\sum_{i=n,O} exp \left(V_2^{ij} (\Upsilon') \right)^{\beta/\vartheta}},$$

then, in time differences we get

$$V_1^{nj}(\varUpsilon') - V_0^{nj}(\varUpsilon) = \pi_1^{nj}(\varUpsilon') - \pi_0^{nj}(\varUpsilon) + \vartheta log\left\{\frac{\sum_{h=n,O} exp\left(V_2^{hj}(\varUpsilon')\right)^{\beta/\vartheta}}{\sum_{h=n,O} exp\left(V_1^{hj}(\varUpsilon)\right)^{\beta/\vartheta}}\right\},$$

$$\begin{aligned} V_1^{nj}(\varUpsilon') - V_0^{nj}(\varUpsilon) &= \pi_1^{nj}(\varUpsilon') - \pi_0^{nj}(\varUpsilon), \\ &+ \vartheta log\left\{\sum_{h=n,O}\frac{exp\left(V_1^{hj}(\varUpsilon)\right)^{\beta/\vartheta}}{\sum_{i=n,O} exp\left(V_1^{hj}(\varUpsilon)\right)^{\beta/\vartheta}}\frac{exp\left(V_2^{hj}(\varUpsilon')\right)^{\beta/\vartheta}}{exp\left(V_1^{hj}(\varUpsilon)\right)^{\beta/\vartheta}}\right\}\end{aligned}$$

$$\begin{aligned} V_1^{nj}(\varUpsilon') - V_0^{nj}(\varUpsilon) &= \pi_1^{nj}(\varUpsilon') - \pi_0^{nj}(\varUpsilon), \\ &+ \vartheta log\left\{\sum_{h=n,O}\varphi_0^{nj,hj}(\varUpsilon)\frac{exp\left(V_1^{hj}(\varUpsilon')\right)^{\beta/\vartheta}}{exp\left(V_1^{hj}(\varUpsilon)\right)^{\beta/\vartheta}} exp\left(V_2^{hj}(\varUpsilon') - V_1^{hj}(\varUpsilon')\right)^{\beta/\vartheta}\right\}\end{aligned}$$

and

$$\varphi_1^{nj,hj}(\varUpsilon') = \frac{\varphi_0^{nj,hj}(\varUpsilon)\, exp\left(\frac{V_1^{hj}(\varUpsilon')}{V_1^{hj}(\varUpsilon)}\right)^{\beta/\vartheta} exp\left(V_2^{hj}(\varUpsilon') - V_1^{hj}(\varUpsilon')\right)^{\beta/\vartheta}}{\sum_{i=n,O}\varphi_0^{nj,ij}(\varUpsilon)\, exp\left(\frac{V_1^{ij}(\varUpsilon')}{V_1^{ij}(\varUpsilon)}\right)^{\beta/\vartheta}(\varUpsilon')\, exp\left(V_2^{ij}(\varUpsilon') - V_1^{hj}(\varUpsilon')\right)^{\beta/\vartheta}},$$

Similarly,

$$V_0^{Oj}(\varUpsilon) = 0 + \vartheta log\left\{\sum_i exp\left(V_1^{ij}(\varUpsilon) - r_1^i(\varUpsilon)\right)^{\beta/\vartheta}\right\},$$

$$\varphi_0^{Oj,nj}(\varUpsilon) = \frac{exp\left(V_1^{nj}(\varUpsilon) - r_1^n(\varUpsilon)\right)^{\beta/\vartheta}}{\sum_i exp\left(V_1^{ij}(\varUpsilon) - r_1^i(\varUpsilon)\right)^{\beta/\vartheta}},$$

$$V_1^{Oj}(\varUpsilon') = 0 + \vartheta log\left\{\sum_i exp\left(V_2^{ij}(\varUpsilon') - r_2^i(\varUpsilon')\right)^{\beta/\vartheta}\right\},$$

$$\varphi_1^{Oj,nj}(\varUpsilon') = \frac{exp\left(V_2^{nj}(\varUpsilon') - r_2^n(\varUpsilon')\right)^{\beta/\vartheta}}{\sum_i exp\left(V_2^{ij}(\varUpsilon') - r_2^i(\varUpsilon')\right)^{\beta/\vartheta}},$$

then

$$V_1^{Oj}(\varUpsilon') - V_0^{Oj}(\varUpsilon) = \vartheta log\left\{\frac{\sum_i exp\left(V_2^{ij}(\varUpsilon') - r_2^i(\varUpsilon')\right)^{\beta/\vartheta}}{\sum_i exp\left(V_1^{ij}(\varUpsilon) - r_1^i(\varUpsilon)\right)^{\beta/\vartheta}}\right\},$$

finally

$$V_1^{Oj}\left(\Upsilon'\right) - V_0^{Oj}\left(\Upsilon\right) = \vartheta log\left\{\sum_{i=1}^{N}\varphi_0^{Oj,ij}\left(\Upsilon\right)exp\left(\frac{V_1^{ij}\left(\Upsilon'\right)}{V_1^{ij}\left(\Upsilon\right)}\right)^{\beta/\vartheta}\frac{exp\left(V_2^{ij}\left(\Upsilon'\right)-V_1^{ij}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}{exp\left(r_2^{i}\left(\Upsilon'\right)-r_1^{i}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}\right\},$$

and

$$\varphi_1^{Oj,nj}\left(\Upsilon'\right)=\frac{\varphi_0^{Oj,nj}\left(\Upsilon\right)exp\left(\frac{V_1^{nj}\left(\Upsilon'\right)}{V_1^{nj}\left(\Upsilon\right)}\right)^{\beta/\vartheta}\frac{exp\left(V_2^{nj}\left(\Upsilon'\right)-V_1^{nj}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}{exp\left(r_2^{n}\left(\Upsilon'\right)-r_1^{n}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}}{\sum_i\varphi_0^{Oj,ij}\left(\Upsilon\right)exp\left(\frac{V_1^{ij}\left(\Upsilon'\right)}{V_1^{ij}\left(\Upsilon\right)}\right)^{\beta/\vartheta}\frac{exp\left(V_2^{ij}\left(\Upsilon'\right)-V_1^{ij}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}{exp\left(r_2^{i}\left(\Upsilon'\right)-r_1^{i}\left(\Upsilon'\right)\right)^{\beta/\vartheta}}}.$$

Using our notation, for $t = 1$

$$\hat{v}_1^{Oj} = \left(\sum_{i=1}^{N}\tilde{\varphi}_0^{Oj,nj}\left(\hat{v}_2^{ij}/\hat{\tilde{r}}_2^{i}\right)^{\beta/\vartheta}\right)^{\vartheta},$$

$$\varphi_1'^{Oj,hj}=\frac{\tilde{\varphi}_0^{Oj,hj}\left(\hat{v}_2^{hj}\right)^{\beta/\vartheta}}{\sum_{i=1}^{N}\tilde{\varphi}_0^{Oj,ij}\left(\hat{v}_2^{ij}\right)^{\beta/\vartheta}},$$

$$\hat{v}_1'^{nj} = \hat{\tilde{\pi}}_1'^{nj}\left(\sum_{h=n,O}\tilde{\varphi}_0^{nj,hj}\left(\hat{v}_2^{hj}\right)^{\beta/\vartheta}\right)^{\vartheta},$$

$$\varphi_1'^{nj,hj}=\frac{\tilde{\varphi}_0^{nj,hj}\left(\hat{v}_2^{hj}\right)^{\beta/\vartheta}}{\sum_{i=n,O}\tilde{\varphi}_0^{nj,ij}\left(\hat{v}_2^{ij}\right)^{\beta/\vartheta}},$$

where

$$\tilde{\varphi}_0^{Oj,hj} = \varphi_0^{Oj,hj}\left(\hat{v}_1^{hj}/\hat{\tilde{r}}_1^{h}\right)^{\beta/\vartheta},$$

$$\tilde{\varphi}_0^{nj,hj} = \varphi_0^{nj,hj}\left(\hat{v}_1^{hj}\right)^{\beta/\vartheta},$$

for $h = n, O$.

for all $t > 1$

$$\hat{v}_t^{Oj} = \left(\sum_{i=1}^{N}\varphi_{t-1}'^{Oj,nj}\dot{\varphi}_t^{Oj,nj}\left(\hat{v}_{t+1}^{ij}/\hat{\tilde{r}}_{t+1}^{i}\right)^{\beta/\vartheta}\right)^{\vartheta},$$

$$\varphi_t'^{Oj,nj}=\frac{\varphi_{t-1}'^{Oj,nj}\dot{\varphi}_t^{Oj,nj}\left(\hat{v}_{t+1}^{nj}/\hat{\tilde{r}}_{t+1}^{n}\right)^{\beta/\vartheta}}{\sum_i\varphi_{t-1}'^{Oj,ij}\dot{\varphi}_t^{Oj,ij}\left(\hat{v}_{t+1}^{ij}/\hat{\tilde{r}}_{t+1}^{i}\right)^{\beta/\vartheta}},$$

$$\hat{v}_t^{\prime nj} = \hat{\tilde{\pi}}_t^{nj} \left(\sum_{h=n,O} \varphi_{t-1}^{\prime nj,hj} \dot{\varphi}_t^{nj,hj} \left(\hat{v}_{t+1}^{hj} \right)^{\beta/\vartheta} \right)^{\vartheta},$$

$$\varphi_t^{\prime nj,hj} = \frac{\varphi_{t-1}^{\prime nj,hj} \dot{\varphi}_t^{nj,hj} \left(\hat{v}_{t+1}^{hj} \right)^{\beta/\vartheta}}{\sum_{i=n,O} \varphi_{t-1}^{\prime nj,ij} \dot{\varphi}_t^{\prime nj,ij} \left(\hat{v}_{t+1}^{ij} \right)^{\beta/\vartheta}}.$$

C Algorithm

Solving for Static per period Trade Equilibrium

The solution to the per period Trade Equilibrium at $t+1$ takes as given the path of mass of firms M_t^{nj},M_t^{Oj}, the path of employment L_t^{nj}, the bilateral trade shares at t, $\lambda_t^{nj,ij}$, total expenditure at t, X_t^{nj},and the change in the stock of capital at t, $\dot{K}_t^n$, and the probability choices $\varphi_{t+1}^{Oj,nj}$

1. Guess a path for the change in wages $\dot{w}_{t+1}^{nj}$ and the change in the rental rate $\dot{r}_{t+1}^n$.

2. Solve for the change in the sectoral price index using

$$\dot{P}_{t+1}^{nj} = \left(\sum_i \lambda_t^{ij,nj} \dot{M}_{t+1}^{ij} (\dot{p}_{t+1}^{ij,nj})^{1-\sigma_j} \right)^{1/(1-\sigma_j)}$$

$$\dot{p}_{t+1}^{ij,nj} = (1 + \dot{\tau}_{t+1}^{ij,nj}) \dot{x}_{t+1}^{ij}$$

$$\dot{x}_{t+1}^{nj} = \left[\left(\dot{w}_{t+1}^{nj} \right)^{1-\xi^n} \left(\dot{r}_{t+1}^n \right)^{\xi^n} \right]^{\gamma^{nj}} \prod_k \left(\dot{P}_{t+1}^{nk} \right)^{\gamma^{nj,nk}}$$

3. Solve for the bilateral expenditure shares using

$$\dot{\lambda}_{t+1}^{nj,ij} = \dot{M}_{t+1}^{nj} \left((1 + \dot{\tau}_{t+1}^{nj,ij}) \dot{x}_{t+1}^{nj} \right)^{1-\sigma_j} \left(\dot{P}_{t+1}^{ij} \right)^{\sigma-1}$$

4. Solve for capital structure accumulation for the United States using

$$\hat{K}_{t+1}^n = (\hat{K}_t^n)^{\kappa_n} (\hat{L}_{t+1}^{k,n})^{1-\kappa_n}$$

and for the other countries using

$$\dot{K}_{t+1}^n = (\dot{K}_t^n) \left(\frac{\dot{r}_{t+1}^n}{\dot{w}_{t+1}^n} \right)^{\frac{1-\kappa_n}{\kappa_n}}$$

5. Solve for total expenditure using

$$I_{t+1}^{n} = \sum_{k} \dot{w}_{t+1}^{nk} \dot{L}_{t+1}^{nk} w_{t}^{nk} L_{t}^{nk} + \hat{r}_{t+1}^{n} \dot{K}_{t+1}^{n} r_{t}^{n} K_{t}^{n} + \iota^{n} \chi_{t+1} - \sum_{k} r_{t+1}^{n} M_{t}^{O,k} \varphi_{t}^{Ok,nk} + \sum_{j} \frac{\tau_{t+1}^{ij,nj} \lambda_{t+1}^{ij,nj} X_{t+1}^{nj}}{\left(1+\tau_{t+1}^{ij,nj}\right)}$$

where $\chi_{t+1} = \sum_{n} \sum_{j} M_{t+1}^{nj} \pi_{t+1}^{nj}$=$\sum_{n} \sum_{i} \sum_{j} \frac{\lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_{j}(1+\tau_{t+1}^{nj,ij})}$

$$X_{t+1}^{nj} = \sum_{k} \gamma^{nk,nj} \sum_{i} \frac{(\sigma_{k}-1) \lambda_{t+1}^{nk,ik} X_{t+1}^{ik}}{\sigma_{k}\left(1+\tau_{t+1}^{nk,ik}\right)} + \alpha^{j} I_{t+1}^{n}$$

Note that total expenditure is solved as a fixed point

6. Solve for changes in profits using

$$\dot{\pi}_{t+1}^{nj,ij} = \left(1+\dot{\tau}_{t+1}^{nj,ij}\right)^{-\sigma_{j}} \left(\dot{x}_{t+1}^{nj}\right)^{1-\sigma_{j}} \left(\dot{P}_{t+1}^{ij}\right)^{\sigma_{j}-1} \dot{X}_{t+1}^{ij}$$

Solve for total profits using

$$\pi_{t+1}^{nj} = \sum_{i=1}^{N} \frac{\lambda_{t}^{nj,ij} X_{t}^{ij}}{M_{t}^{nj} \sigma_{j}\left(1+\tau_{t}^{nj,ij}\right)} \dot{\pi}_{t+1}^{nj,ij}$$

Alternatively solve total profits as

$$\pi_{t+1}^{nj} = \sum_{i} \frac{\lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{M_{t+1}^{nj} \sigma_{j}(1+\tau_{t+1}^{nj,ij})}$$

7. Solve for the market clearings using

$$\dot{w}_{t+1}^{nj} \dot{L}_{t+1}^{nj} w_{t}^{nj} L_{t}^{nj} = (1-\xi^{n}) \gamma^{nj} \sum_{i} \frac{(\sigma_{j}-1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_{j}(1+\tau_{t+1}^{nj,ij})}$$

$$\dot{r}_{t+1}^{n} \dot{K}_{t+1}^{n} r_{t}^{n} K_{t}^{n} = \sum_{j} \xi^{n} \gamma^{nj} \sum_{i} \frac{(\sigma_{j}-1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_{j}(1+\tau_{t+1}^{nj,ij})} + \sum_{j} r_{t+1}^{n} M_{t}^{Oj} \varphi_{t}^{Oj,nj}$$

and as explained above the labor market clearing condition for countries other than the United States in changes is given by

$$\dot{w}_{t+1}^{n} \dot{L}_{t+1}^{n} w_{t}^{n} L_{t}^{n} = \sum_{j} (1-\xi^{n}) \gamma^{nj} \sum_{i} \frac{(\sigma_{j}-1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_{j}(1+\tau_{t}^{nj,ij})} + (1-\kappa_{n}) r_{t+1}^{n} K_{t+1}^{n}$$

8. Update the path of wages and rental rates until it converges

Solving for the sequential competitive equilibrium

1. Guess a path for the changes in all the values for the firms and households $\dot{v}_{t+1}^{nj}$, $\dot{v}_{t+1}^{Oj}$, $\dot{u}_{t+1}^{H,nj}$

2. Solve for the probability choices by firms and gross flows of households $\varphi_{t+1}^{nj,nj}$, $\varphi_{t+1}^{nj,O}$, $\varphi_{t+1}^{Oj,nj}$, $\mu_t^{nj,ik}$ using a path of rental rates $r_t^n = r_0^n$ for the first iteration and the path from the temporary equilibrium thereafter

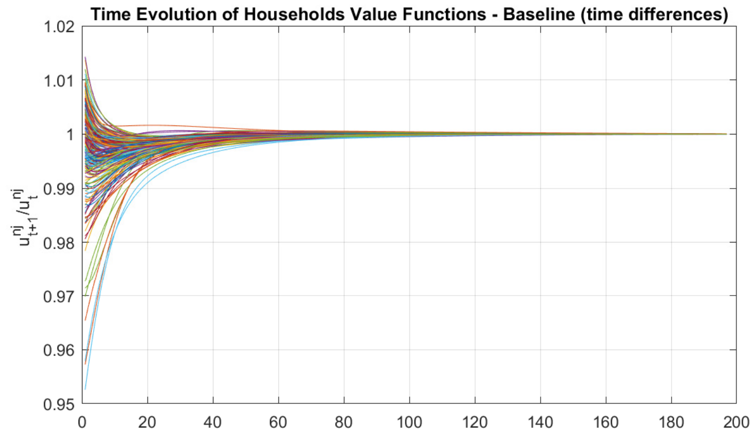
3. Solve for the law of motion of firms and employment $M_{t+1}^{nj}, M_{t+1}^{Oj},\ L_{t+1}^{nj}$

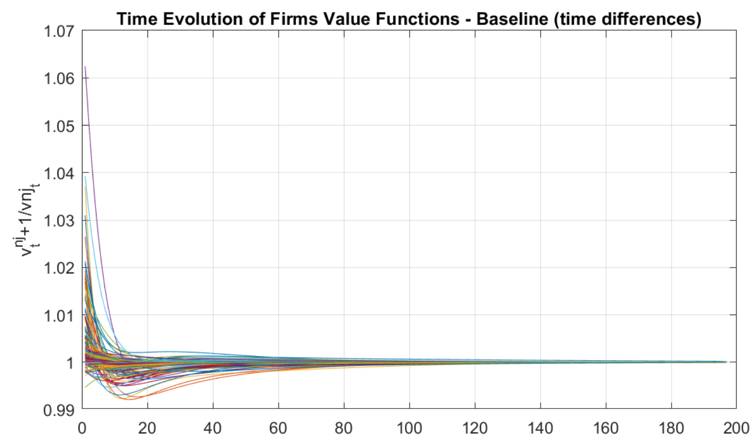
4. Solve for the temporary equilibrium as described in the previous section. Construct the path of rental rates r_t^n. Given the initial guess of values, update the path of firms and employment $M_{t+1}^{nj}, M_{t+1}^{Oj},\ L_{t+1}^{nj}$, and solve again the temporary equilibrium until the path of rental rates converge.

5. Construct the path of profits π_{t+1}^{nj} y real wages $\dot{w}_{t+1}^{nj}$ (including the construction sector)

6. Update the path for the changes in all the values for the firms and households $\dot{v}_{t+1}^{nj}$, $\dot{v}_{t+1}^{Oj}$, $\dot{u}_{t+1}^{H,nj}$ using the path of profits, real wages, and rental rates from the temporary equilibrium until reach convergence

Figure D.1: Time Evolution of Value Functions





D Appendix: Data

In this appendix we provide more detail on the data used as well as additional information on the sample of U.S. locations, countries, and industries used in our quantitative analysis.

International Bilateral Trade Flows Bilateral trade trade shares $\lambda_t^{nj,ij}$ for the 38 countries, including the constructed ROW, and sectors are obtained from the World Input-Output Database (WIOD) for the year 2014, which is the latest available year. The WIOD has information on transaction in final and intermediate goods across sectors and countries as well as domestic sales, which allow as to recover sectoral bilateral trade flows and total expenditure, and therefore construct the bilateral trade shares $\lambda_t^{nj,ij}$.

Inter-regional Bilateral Trade Flows Imports and exports between the 50 U.S. states the rest of countries in our sample are obtained from the Import and Export Merchandise Trade Statistics, data elaborated by the U.S. Census Bureau. The Census data reports imports and exports between each U.S. state and each other country in the world at HS and NAICS industry classification. We use the year 2014 to construct the bilateral trade flows between the U.S. states and the rest of the countries in our sample. The bilateral trade flows across U.S. states are obtained from the Commodity Flows Survey (CFS) for the year 2012, which is the closest available year to 2014 that we use to construct the rest of the trade data. In order to keep consistency across the different trade databases and years, we made two adjustment to the trade data. First, since the CFS and the U.S. census data only contain trade flows for manufacturing industries, we treat the wholesale and retail and services industries as non-tradable. Second, since the CFS data is for the year 2012, while we use the WIOD data for the year 2014, there is some discrepancy between the total amount of transaction reported in the CFS and the total U.S. domestic sales reported in the WIOD database. To make them consistent, we proceed as follows. We use the CFS to construct the the bilateral trade shares across the U.S. states, and apply the share of each state to the U.S. total domestic sales to construct total domestic sales across states. We then recover the bilateral trade flows across U.S. states using the constructed bilateral expenditure shares and the total domestic sales across states. As a result, the bilateral trade shares across U.S. states are as in the 2012 CFS, and the implied total domestic sales in the United States matches exactly the one in the WIOD for the year 2014.

Production Data Gross output for the manufacturing sector across U.S. states can be inferred directly from the trade matrices. For the wholesale and retail, services industries, we obtain gross output from the Bureau of Economic Analysis. For the rest of the country, gross output is obtained from the WIOD database. The WIOD has also information on the purchases of material across sectors, which allow us to construct the input-output coefficients $\gamma^{nj,ij}$ across countries and sectors. We assume that the input-output coefficients for each individual U.S. state are the same those for the U.S. aggregate, since state-level input-output tables are not available. Since WIOD also has information on value added and gross output across countries, we proceed in the same way to construct the shares of value added in gross output γ^{nj}. The share of labor in value added ξ^n for the United States is constructed using data on labor compensation and value added from the BEA. For the other countries these data are obtained from the OECD STAN database. We assume that the shares of labor in value added vary by countries but not by industries due to incomplete industry-level information in the OECD data. The share of labor in the production of new structures $1 - \kappa^n$ is constructed as the share of labor in gross output in the construction sector. For the U.S. states we construct this parameter using labor compensation and gross output data from the BEA, for the rest of the countries we use the equivalent data from the OECD STAN database.

Final Consumption Shares and Profits Ownership We also use equilibrium conditions from our model to compute some of the variables at the initial period. To calibrate the share of each location in the global portfolio of profits, i^n, we proceed as follows. We compute the total profits in each location at the initial period as $M_t^{nj}\pi_t^{nj} = \frac{1}{\sigma_j}\sum_i \lambda_t^{nj,ij} X_t^{ij}$. As explained in Section 3.3, we assume that profits are transferred to a global portfolio. We discipline the share of the global portfolio that is redistributed back to each n, i^n, in order to match the observed initial trade deficits D_t^n, that is, $\iota^n = \frac{\frac{1}{\sigma_j}\sum_{i=1}^N \lambda_t^{nj,ij} X_t^{ij} - D_t^n}{\chi_t}$. The final consumption shares α^j are also computed using the equilibrium conditions of the model. In particular $\alpha^j = \frac{\sum_{n=1}^N X_t^{nj} - \sum_{n=1}^N \sum_{k=1}^J \gamma^{nk,nj} \sum_{i=1}^N \frac{(1-1/\sigma_k)\lambda_t^{nk,ik} X_t^{ik}}{1+\tau_t^{nk,ik}}}{\sum_{n=1}^N I_t^n}$.

The Initial Distribution of Firms and Location Choice Probabilities We compute M_t^{nj} as the number of active enterprises reported in the OECD Structural and Demographic Business Statistics (SDBS). Similar to the U.S. data, we use 2015 as the reference year. When the number of firms for a given country is missed, we look for the previous year. In particular, for Cyprus and Denmark, we use data for 2014 and for Mexico, we use data for for 2013. For a few countries, Canada, Norway, Turkey, and Brazil, the OECD only reported the number of employer enterprises for each sector, thus we use that data to infer M_t^{nj} for those countries. For China, we obtain the data the number of active firms across sectors from the China's National Bureau of Statistics. For the ROW, data on mass of firms is not available, thus we simply assume that the mass of firms in the ROW relative to the total mass of firms in our sample is similar to its relative GDP. A few countries in our sample, Mexico, China, and Switzerland did not report data on firm deaths, thus we apply to these countries the average death rates across all other countries.

U.S. States The U.S. states included in the analysis are: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming. The District of Columbia is aggregated with the state of Virginia in our data.

Countries The sample of countries in our constructed data is: Australia, Austria, Belgium, Bulgaria, Brazil, Canada, China, Croatia, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Turkey, ROW.

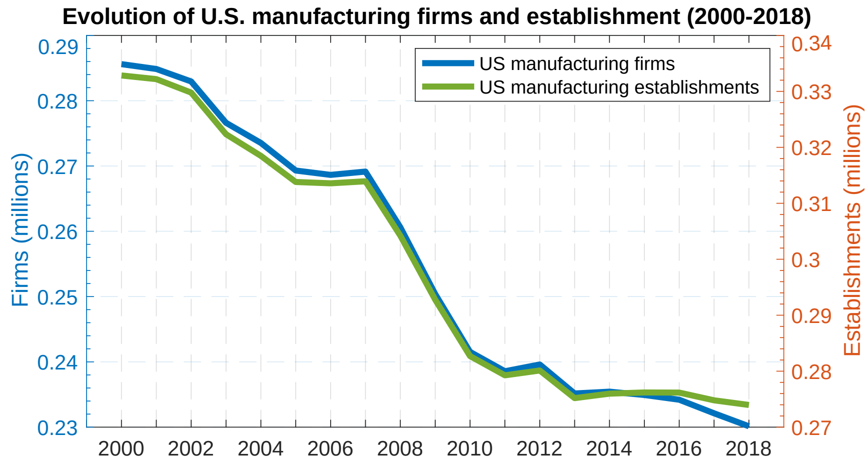
Sectors As mentioned above, in our analysis we construct data for three productive industries; Manufacturing, Wholesale and Retail, and Services, and the construction sector that we use to discipline the production of new structures. The manufacturing sector is defined the aggregate of the NAICS-three-digit industries Food, Beverage, and Tobacco Products (NAICS 311-312); Textile, Textile Product Mills, Apparel, Leather, and Allied Products (NAICS 313-316); Wood Products, Paper, Printing, and Related Support Activities (NAICS 321-323); Petroleum and Coal Products (NAICS 324); Chemical (NAICS 325); Plastics and Rubber Products (NAICS 326); Nonmetallic Mineral Products (NAICS 327); Primary Metal and Fabricated Metal Products (NAICS 331-332); Machinery (NAICS 333); Computer and Electronic Products, and Electrical Equipment and Appliance (NAICS 334-335); Transportation Equipment (NAICS 336); Furniture and Related Products, and Miscellaneous Manufacturing (NAICS 337-339). The services sectors is the aggregate of Transport Services (NAICS 481-488); Information Services (NAICS 511-518); Finance and Insurance (NAICS 521-525); Real Estate (NAICS 531-533); Education (NAICS 61); Health Care (NAICS 621-624); Accommodation and Food Services (NAICS 721-722); Other Services (NAICS 493, 541, 55, 561, 562, 711-713, 811-814).

D.1 The Evolution of U.S. Manufacturing Firms and Establishments

In this section we display in Figure D.2the evolution of the number of manufacturing establishments and firms in the United States over the period 2000-2018.

Figure D.2: Evolution of U.S. manufacturing firms and establishments

Panel (a)



Note: The left-hand panel presents the evolution of number of establishments and firms in the manufacturing sector in the United States. The data used to construct these figures is from the BLS as described in detail in Section 4.2.

E Appendix: Estimation

In this appendix we describe with more detail the derivation of the estimating equation for the dispersion of idiosyncratic shocks for the firms.

The value of an active firm in location n and industry j is given by equation (9). Adding and subtracting the continuation value to this equation we obtain

$$V_t^{nj} = \pi_t^{nj} + \beta V_{t+1}^{nj} + \vartheta log \left\{ exp(\beta V_{t+1}^{Oj} - \beta V_{t+1}^{nj})^{1/\vartheta} \right\}.$$

On the other hand we have that the fraction of firms that stays in a given location is given by equation (xx). Using this equation, we can express the value of active firms as

$$V_t^{nj} = \pi_t^{nj} + \beta V_{t+1}^{nj} - \vartheta log \varphi_t^{nj,nj}.$$

Analogously, we use the value of inactive firms V_t^{Oj} and the fraction of firms that enter location n to express the value function of a representative inactive firm as

$$V_t^{Oj} = \beta V_{t+1}^{nj} - \beta r_{t+1}^{n} - \vartheta log \varphi_t^{O,nj}.$$

Taking differences with the corresponding value of active firms we get

$$V_t^{nj} - V_t^{Oj} = \pi_t^{nj} + \beta r_{t+1}^n + \vartheta log \frac{\varphi_t^{O,nj}}{\varphi_t^{nj,nj}}.$$

Using the expression for the fraction of firms that stay in a given location $\varphi_t^{nj,nj}$ and the fraction of firms that exit $\varphi_t^{nj,Oj}$ we obtain an expression for the differences in the values $V_t^{nj} - V_t^{Oj}$, in particular

$$exp(\beta V_t^{nj} - \beta V_t^{Oj})^{1/\vartheta} = \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}},$$

and therefore we have that

$$log \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}} + \beta log \frac{\varphi_t^{nj,nj}}{\varphi_t^{Oj,nj}} = \frac{\beta}{\vartheta} \left(\pi_t^{nj} + \beta r_{t+1}^n \right)$$

As discussed in the main text, we assume the entry probabilities $\varphi_t^{Oj,ij}$ are measured imperfectly, for instance, due to the fact that they depend on the total world's mass of inactive firms that are not directly observable. In particular, we attribute the measurement error to have a deterministic component C_t and a sector-specific random component ε_t^{nj} that is orthogonal to profits and rental rates, that is, $\tilde{\varphi}_t^{Oj,ij} = \varphi_t^{O,i} \left(C_t + \varepsilon_t^{nj} \right)$. Hence, our estimating equation becomes

$$y_t^{nj} = \tilde{C}_t + \frac{\beta}{\vartheta} \left(\pi_t^{nj} + \beta r_{t+1}^n \right) + \varepsilon_t^{nj}$$

where $y_t^{nj} = log \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}} + \beta log \frac{\varphi_t^{nj,nj}}{\varphi_t^{Oj,ij}}$.