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

(First draft, preliminary)

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Abstract

One justification for trade protectionism is the benefits of terms-of-trade manipulation. Another reason, more central in trade policy negotiations, is the idea that trade protectionism brings industries back home. The new economic geography theory has provided intuitive insights on how the location effect of trade policy shapes welfare in the protecting country. Previous work, however, has been able to say much less about the quantitative effects of trade policy on the location of firms across space and over time, and its welfare implications. We develop a multi-country dynamic general-equilibrium trade and spatial model with forward-looking decisions of firms on where to locate production, forward-looking decisions of workers on where to supply labor, and endogenous capital structure accumulation. We take the model to the data using trade and production data for many locations and industries, as well as using data on firms’ demographics from several data sources. We use the model to study how trade protectionism impacts the location of production across space and over time, as well as its welfare consequences. We find quantitative evidence that protection relocates production to the protected country but that this comes at the cost of higher prices and lower welfare.

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1 Introduction

The recent backlash against globalization has resulted in increased trade protectionism in many countries, and most notably in the United States. Although this phenomenon can be related to several factors, the international trade literature has studied at least three reasons for trade protectionism. One of them is the so-called terms-of-trade manipulation, which refers to the idea that an increase in tariffs can benefit a country by allowing it to extract rents from foreign producers by forcing them to reduce prices. A second reason is the influence of special-interest groups on the government’s choice of trade policy (Grossman and Helpman (1994)). A third one is the idea that trade protectionism brings industries back home.

The relocation of industries is probably the most frequent reason for trade protectionism in trade policy negotiations. 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), while references to terms-of-trade manipulation are usually absent in such pro-protectionism historical episodes.\(^1\) Surprisingly, however, there is very little quantitative assessments of this idea in the trade literature, with the exception of the quantitative work in Ossa (2011).\(^2\) 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, among others), which has provided intuitive insights on how the location effect of trade policy shapes welfare in the protecting country.

In this paper we study the impact of trade protectionism on the location of firms across space and time, and its implication on welfare. We present a quantitative assessment using a multi-sector, multi-country, and multi-region dynamic general equilibrium model. Our starting point is a new economic geography framework where 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 then departure from previous trade literature by introducing 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, thus entry cost is lower in regions with lower rental rates of capital structure, which is also an

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\(^1\)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).

\(^2\)Equally scarce is the empirical literature on trade policy and industrial location. Some exemptions are Hanson (1996), Hanson (1998), and Hanson (2001).
equilibrium object in our model. Locations in our model can also accumulate capital structures, which in part attracts firms. Households also 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. We embed all these mechanisms into a rich production and trade structures that features internal trade, international trade, multiple industries and input-output linkages.

In general, a structural model with all these features seems to be intractable and difficult to take to the data. However, by building on recent advances in the quantitative trade and spatial literature we show how to take the model to the data and use the model to quantitatively assess the effects of trade policy on industrial location.

We study the effects of increased unilateral protectionism in the U.S., with and without retaliation, using a version of the model with 39 countries, 50 U.S. states, 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 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).

Our quantitative model can be used to quantify the effects of unilateral, bilateral or multilateral changes in trade policy, either across countries, across regions, or across industries. In the quantitative analysis, we focus on quantifying the effects of unilateral changes in tariffs applied by the United States to other countries, with and without the rest of the world retaliating to the U.S..

We find that increased unilateral protectionism results in a positive industrial location effect that takes time to materialize and is much smaller in the short run than in the long run. This location effect, however, is not large enough so that we find an increase in the U.S. price index as a result. We also find a decline in welfare, and a bigger decline when the rest of the world retaliates by increasing tariffs to the same level of the U.S.

For instance, with a unilateral increase in U.S. tariffs to 15%, in the first year, the mass of firms in the U.S. manufacturing industry increases by 0.18%, and with a tariff increase to 25% the mass of firms increases by 0.33%. In the long run, manufacturing firms located in the United States increases by 2.59% and 4.66% with the unilateral tariff increases of 15% and 25% respectively. The U.S price index increases by 4.7% and 7.9%, and welfare, measured as the consumption equivalent variation, declines by 0.5% and
0.9%, with the tariff increase to 15% and 25%, respectively. With retaliation, welfare declines by 0.9% and 1.4%, respectively.

We find that labor market dynamics and firms’ dynamics are both important in shaping the location effect of trade policy. For instance, we find that locations that attract firms in the short run, because they have much capital structures available, are not necessarily the ones that attract more firms in the long run. This is because firms also need labor to produce, and relocating labor from other regions can be costly or take time. These mechanisms impact the dynamics of production across locations. As a result, the location and welfare effects are heterogeneous across regions, but the increase in prices and decline in welfare is generalized across all states. We also find that manufacturing workers located in the states that attract more firms are better off with trade protectionism, while in the rest of the states are worse off. These results highlight that protectionism has distributional consequences, benefitting a group of workers and hurting others, but these distributional effects occur even within the protected industries, and as mentioned above, also result in generalized average welfare losses across space. More broadly, our results shed light on the inefficacy of trade protectionism to redistribute gains from trade through industrial relocation.

Our paper is related to several strands of the trade literature. Our paper is mainly related to the new economic geography literature on trade policy and industrial location. We provide a tractable general equilibrium framework that allow us to quantitatively re-assess the implications of changes to trade policy at the aggregate and disaggregate level. More closely related to us is the work by Ossa (2011), who was the first to quantitatively study the implications of production relocation for the design of optimal trade policy. We departure by taking the quantitatively analysis in the context of a model with internal geography, labor market dynamics, firms dynamic decisions and capital accumulation. As a result, in addition to study the aggregate effects of trade policy, we can study the firm location and spatial economic effects; the central theme in our paper.


3We are motivated by Fujita, Krugman, and Venables (2000) who call for a general equilibrium quantitative framework to re-assess the spatial effects of trade policy.

4The firm relocation effect mentioned above is very related to the home market effect, see Helpman and Krugman (1985). In this context, Davis (1998) shows that the home market effect might not be present
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, Feenstra, Romalis, and Taylor (2015), Handley and Limao (2015), Broda, Limao, and Weinstein (2008), Fajgelbaum, Goldberg, Kennedy, and Khandelwal (2019), Amiti, Redding, and Weinstein (2019), Flaaen, Hortacsu, and Tintelnot (2019), Costinot and Rodriguez-Clare (2014), Ossa (2016), and Bartelme, Costinot, Donaldson, and Andres (2018). More 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), Garetto et al. (2019), and Antras, Fort, and Tintelnot (2017).

We follow the work by Das, Roberts, and Tybout (2007) and add a forward looking firm decision 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 et al. (2014), and Dickstein and Morales (2018).

Modeling fixed entry costs in terms of capital relates our paper to the Footloose Capital model developed by Martin and Rogers (1995).\(^5\) 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

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\(^5\)See Baldwin et al. (2003) for an in depth explanation of the Footloose Capital model.
Rossi-Hansberg (2014), and Desmet, Nagy, and Rossi-Hansberg (2016), and simplify the problem of capital accumulation decisions as in Allen and Donaldson (2018).

The labor market dynamics in our model builds on Artuç, Chaudhuri, and McLaren (2010), and Caliendo, Dvorkin, and Parro (2019), henceforth CDP; and the trade and production structure builds on recent static spatial economics models such as Allen and Arkolakis (2014), Redding (2016), Redding and Sturm (2008), 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 develops the quantitative dynamic model of industrial and labor location, Section 3 describe how we take the model to the data, Section 4 presents the quantitative analysis, and Section 5 concludes.

2 A Dynamic Model of Trade and Industrial Location

In this section, we develop a dynamic general equilibrium model for trade policy analysis. We build on recent advances in the quantitative trade literature and add an explicit role for firm location. The world is composed of $N$ locations indexed by $i$ and $n$. Countries are a collection of these locations, which will become clear as we present the model as well as when we take the model to the data. Time is discrete, and we denote it by $t = 0, 1, 2, ...$. At each location there are $J$ sectors which we label them by $j$ and $k$. Each sector at each location represents a competitive labor market.

We start by describing the production side of the economy, we then set up the problem of the firms and households, and finally, we derive the market clearing conditions. After doing so, we define the equilibrium of the model.

2.1 Production

The production structure builds on the multi-sector 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 accumulation. We first describe the more standard problem of the final good producer and then move to the dynamic decision of firms.
2.1.1 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:

$$Q_{nj}^t = \left( \sum_{i=1}^{N} M_{ij}^t \left( q_{ij,nj}^t \right)^{\frac{\sigma_j - 1}{\sigma_j}} \right)^{\frac{\sigma_j}{\sigma_j - 1}},$$

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

$$q_{ij,nj}^t = \left( \frac{p_{ij,nj}^t}{P_{nj}^t} \right)^{-\sigma_j} X_{nj}^t / P_{nj}^t,$$

(1)

where $p_{ij,nj}^t$ is the price at $n_j$ of varieties produced in $ij$, and $X_{nj}^t$ is total expenditure in $nj$. The ideal sectoral price index $P_{nj}^t$ is then given by

$$P_{nj}^t = \left( \sum_{i=1}^{N} M_{ij}^t \left( p_{ij,nj}^t \right)^{1-\sigma_j} \right)^{\frac{1}{1-\sigma_j}}.$$

(2)

The sectoral composite final good is consumed by local households and used as materials for the production of intermediate varieties.\(^6\)

The price index (2) maps into the one in the new economic geography models discussed in the introduction. In what follows, we depart 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.\(^7\)

2.1.2 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

\(^6\)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.

\(^7\)At this point, one can think that the price index (2) is also isomorphic to a perfect competition Armington model with external increasing returns to scale. In particular, the mass of firms in the price index can be mapped to a productivity shifter in an Armington model. However, as discussed later on, the general equilibrium elasticity of the mass of firms in our model is shaped by forward-looking decision of firms, and not just proportional to current local employment that could shape agglomeration forces in an Armington model with increasing returns to scale.
into a market. Active firms decide to stay active, exit, or to relocate production. All these 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 $l_{nj}$, capital structures $k_{nj}$ and materials $z_{nj,nk}$ from all other sectors, $k$. All firms from industry $j$ produce with a common deterministic local fundamental productivity $a_{nj}$. The production technology to produce in $nj$ is given by

$$q_{nj} = a_{nj} \left( l_{nj} \right)^{1-\xi_n} \left( k_{nj} \right)^{\xi_n} \prod_{k=1}^{J} \left( z_{nj,nk} \right)^{\gamma_{nj,nk}},$$

where $\gamma_{nj}$ 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 $w_{nj}$ for labor and $r_n$ for capital structures. The price of materials is given by $P_{nk}$. From the cost minimization problem of the firm we obtain that the unit cost of a bundle of inputs, denoted by $x_{nj}$, is given by

$$x_{nj} = B_{nj} \left( w_{nj} \right)^{1-\xi_n} \left( r_n \right)^{\xi_n} \prod_{k} \left( P_{nk} \right)^{\gamma_{nj,nk}},$$

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 $\tau_{nj,ij}$, where $\tau_{nj,ij} = 0$ when $n$ and $i$ are locations in the same country. The non-policy trade costs are transport costs that take the usual iceberg-type formulation, where $d_{nj,ij}$ is the cost of shipping goods from $n$ to $i$ in industry $j$.

Firms maximize their profits by taking into account the demand for their goods; namely (1). Let us denote by $\pi_{nj,ij}$ 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
\[ \pi_{t}^{n,j,ij} = \max_{p_{t}^{n,j,ij} \geq 0} \left\{ p_{t}^{n,j,ij} q_{t}^{n,j,ij} \frac{x_{t}^{n,j,ij}}{a_{t}^{n,j}} d_{t}^{n,j,ij} q_{t}^{n,j,ij} ; \text{subject to (1)} \right\}. \]

Note that there are no fixed costs of production and as a result 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 shapes the spatial equilibrium.

The solution to this problem is the standard mill pricing,

\[ p_{t}^{n,j,ij} = \frac{1}{1 - \frac{1}{\sigma_{j}}} \frac{(1 + \tau_{t}^{n,j,ij}) d_{t}^{n,j,ij} x_{t}^{n,j}}{\sigma_{j}}, \quad (4) \]

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

\[ \pi_{t}^{n,j} = \sum_{i=1}^{N} \pi_{t}^{n,j,ij}. \quad (5) \]

from selling domestically as well as to other locations.

**Firm’s Dynamic Location Choice**  Our dynamic location choice model is 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 \( v_{t}^{n,j} \) the value of an active firm producing in sector \( j \) located in \( n \) at time \( t \), and by \( v_{t}^{O,j} \) the value of a firm that is inactive. Active firms at time \( t \) have gross profits given by \( \pi_{t}^{n,j} \) from (5), and decide whether to remain producing in \( n,j \) the next period or exit a location. 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 \( V_{t+1}^{n,j} \equiv E_{t}[v_{t+1}^{n,j}] \), and \( V_{t+1}^{O,j} \equiv E_{t}[v_{t+1}^{O,j}] \) 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 \( \epsilon_{t}^{n,j} \) and \( \epsilon_{t}^{O,j} \), and we assume firms discount the future by \( \beta. \)

\[ v_{t}^{n,j} = \pi_{t}^{n,j} + \max \left\{ \beta V_{t+1}^{n,j} - \epsilon_{t}^{n,j} ; \beta V_{t+1}^{O,j} - \epsilon_{t}^{O,j} \right\}, \quad \text{for all } n,j. \]

\(^8\)The idiosyncratic shocks can be thought to be in utils of entrepreneurs who own the firms and maximize linear utility over profits.
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, $\epsilon_{t}^{hj}$. In particular, the value of the firm is given by

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

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.\(^9\)

We assume that the idiosyncratic shocks are i.i.d realizations from a Type-I Extreme value distribution with zero mean and dispersion parameter $\vartheta$. 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 B for further details) we obtain that the value of active firms is given by

$$V_{t}^{nj} = \pi_{t}^{nj} + \vartheta \log \left[ \sum_{i=O,n} \exp \left( V_{ij}^{ij}_{t+1} \right)^{\beta/\vartheta} \right], \text{ for all } n, j, \quad (6)$$

and the value of inactive firms is given by

$$V_{t}^{Oj} = 0 + \vartheta \log \left[ \sum_{i=1}^{N} \exp \left( V_{ij}^{ij}_{t+1} - r_{i}^{ij}_{t+1} \right)^{\beta/\vartheta} \right], \text{ for all } j. \quad (7)$$

Equation (6) 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 (7), is not zero since it provides the option value for the firm to produce in other locations, subject to entry costs.

\(^9\)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.
We now solve for the location choice probabilities. We denote by \( \varphi_{nj,nj}^{t+1} \) 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 B) we obtain,

\[
\varphi_{nj,nj}^{t+1} = \exp \left( V_{nj}^{t+1} \frac{\beta}{\vartheta} \right) / \sum_{i=O,n} \exp \left( V_{ij}^{t+1} \frac{\beta}{\vartheta} \right), \quad \text{for all } n, j.
\]

(8)

It follows that the fraction of firms that exit \( nj \) is given by \( \varphi_{nj,Oj}^{t+1} = 1 - \varphi_{nj,nj}^{t+1} \). Note that (8) 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 7), 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 \( n' \).10

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

\[
\varphi_{nj,nj}^{Oj,nj} = \exp \left( V_{nj}^{t+1} \frac{1}{r_{nj}^{t+1}} \frac{\beta}{\vartheta} \right) / \sum_{i=O,n} \exp \left( V_{ij}^{t+1} \frac{1}{r_{ij}^{t+1}} \frac{\beta}{\vartheta} \right), \quad \text{for all } n, j.
\]

(9)

Analogous to the previous example, from (9) 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 equal, there is a higher fraction of firms that choose to locate in \( n' \).11 Of course, in gen-

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10 In particular, note that if we substitute (7) into \( \varphi_{nj,Oj}^{t+1} \), we obtain

\[
\varphi_{nj,Oj}^{t+1} = \left( \frac{\sum_{n'=1}^{N} \exp \left( V_{nj}^{t+1} - r_{nj}^{t+1} \right) \frac{\beta}{\vartheta} \right)}{\sum_{i=O,n} \exp \left( V_{ij}^{t+1} \frac{\beta}{\vartheta} \right)} \right)^{\beta},
\]

and as we can see, \( \varphi_{nj,Oj}^{t+1} \) is impacted by changes economic circumstances in all other locations.

11 More formally, note that

\[
\frac{\partial \varphi_{nj,Oj}^{t+1}}{\partial \left( V_{nj}^{t+1} - r_{nj}^{t+1} \right)} = \frac{\beta}{\vartheta} \varphi_{nj,nj}^{t+1} \varphi_{nj,Oj}^{t+1} \varphi_{Oj,nj}^{t+1} > 0,
\]

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 \( \varphi_{nj,nj}^{t+1} \).
eral 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

$$M_{t+1}^{nj} = M_{t}^{nj} \varphi_{t}^{nj,nj} + M_{t}^{Oj} \varphi_{t}^{Oj,nj}, \text{ for all } n, j,$$

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

The equilibrium conditions (10) and (11) 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.

### 2.1.3 Development of Capital Structures

Capital structure in the economy is used as an input in the production of intermediate goods and by firms 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. We simplify this problem by building on Desmet and Rossi-Hansberg (2014), and Desmet et al. (2016). In particular, 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 improvements to land, similar to Allen and Donaldson (2018). We assume that capital structures depreciate at a rate $\delta$, but new capital structures can be developed. Capitalists do not produce capital, they give their capital and land to developers that use them to produce new capital structures. 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 $\varpi^n_t$ 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 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.

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,

$$V^n_{t,co} \equiv \max_{l^n_{t,co} \geq 0} \left\{ r^n_t \left( k^n_{t-1} (1 - \delta) \right)^{\kappa_n} \left( l^n_{t,co} \right)^{1-\kappa_n} - w^n_{t,co} l^n_{t,co} - \varpi^n_t \right\},$$

where $k^n_{t-1}$, $l^n_{t,co}$ are capital structures and labor demand per unit of land, $w^n_{t,co}$ is wages paid to workers in the construction sector, $\kappa_n$ 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

$$w^n_{t,co} L^n_{t,co} = (1 - \kappa_n) r^n_t K^n_t,$$  \hspace{1cm} (12)

where $L^n_{t,co}$ is the supply of construction workers. The aggregate law of motion of capital structures is given by

$$K^n_t = \left( K^n_{t-1} (1 - \delta) \right)^{\kappa_n} \left( L^n_{t,co} \right)^{1-\kappa_n}.$$  \hspace{1cm} (13)

Note that in our formulation the law of motion of capital accumulation turns out to as in Lucas and Prescott (1971), and Hercowitz and Sampson (1991).
2.2 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 they decide where to supply labor. 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 

\[
C_{nj}^{t} = \prod_{k} (c_{nj,k}^{t})^{\alpha_k},
\]

and \( c_{nj,k}^{t} \) 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 

\[
P_{nt} = \prod_{k=1}^{J} \left( \frac{P_{nk}^{t}}{\alpha_k} \right)^{1/\nu}.
\]

Non-employed households obtain consumption in terms of home production \( b_n > 0 \). As a result, 

\[
C_{i,ne}^{t} = b_n,
\]

where \( C_{i,ne}^{t} \) is the consumption of a non-employed household located in \( i \) 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, mobility frictions \( m_{nj,ik} \) and idiosyncratic preference shocks \( \varepsilon_{ik}^{t} \). We assume that households discount the future at rate \( \beta \geq 0 \), and that \( \varepsilon_{ik}^{t} \) are the realization of a Type-I Extreme value distribution with zero mean and dispersion parameter \( \nu \).

The value function of a worker located in labor market \( n,j \) at time \( t \) is given by

\[
u_{nj}^{t} = \log(C_{nj}^{t}) + \max_{i=1,...,N,k=ne,1,...,J} \left\{ \beta E_t \left[ u_{nj}^{t+1} \right] - m_{nj,ik}^{t} + \varepsilon_{ik}^{t} \right\}.
\]

As mentioned above, workers decide at each moment in time where to locate tomorrow. They can move to any \( i = 1,...,N \), and any \( k = ne,1,...,J \), where \( ne \) means non-employment.\(^{12}\) Let \( U_{nj}^{t+1} = E_t \left[ u_{nj}^{t+1} \right] \) be the expected value of a household from locating in \( n,j \) where the expectations are taken over the realizations of the idiosyncratic shocks. It follows that

\[
U_{nj}^{t} = \log \left( C_{nj}^{t} \right) + \nu \log \left[ \sum_{i=1}^{N} \sum_{k=ne,1}^{J} \exp \left( \beta U_{nj}^{t+1} - m_{nj,ik}^{t+1} \right)^{1/\nu} \right].
\]

\(^{12}\)While we could allow for international migration, in the quantitative model that we take to the data we are going to assume that workers can only move across labor markets within a country and not across countries. With data on international migration of workers we could also include this interesting additional margin.
The fraction of workers that relocate from market $nj$ to market $ik$ is given by

$$
\mu_{t}^{nj,ik} = \frac{\exp \left( \beta U_{t+1}^{ik} - m_{nj,ik}^{t} \right)}{\sum_{n'=1}^{N} \sum_{h=ne,1}^{J} \exp \left( \beta U_{t+1}^{nh} - m_{nj,n'h}^{t} \right)}^{1/\nu},
$$

(15)

and the evolution of labor across markets is given by

$$
L_{t+1}^{nj} = \sum_{i=1}^{N} \sum_{k=ne,1}^{J} \mu_{t}^{ik,nj} L_{t}^{ik}.
$$

(16)

### 2.3 Aggregation and Market Clearing

We denote by $\lambda_{t}^{nj,ij}$ the aggregate bilateral expenditure shares of goods purchased by $ij$ from $nj$. Using (1), (2), and (4) we obtain the following bilateral trade gravity equation

$$
\lambda_{t}^{nj,ij} = \frac{M_{t}^{nj} \left( a_{t}^{nj} \right)^{\sigma_{j}^{-1}} \left( \left( 1 + \tau_{t}^{nj,ij} \right) d_{t}^{nj,ij} x_{t}^{nj} \right)^{1-\sigma_{j}}}{\sum_{h} M_{t}^{hj} \left( a_{t}^{hj} \right)^{\sigma_{j}^{-1}} \left( \left( 1 + \tau_{t}^{hj,ij} \right) d_{t}^{hj,ij} x_{t}^{hj} \right)^{1-\sigma_{j}}}.
$$

(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 $\chi_{t}$; 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 $\iota_{n}$ of the global profits and uses this income, together with the income from land and capital structures, $\varpi_{n} H_{n}$, to consume local goods and to finance the entry of firms.\(^{13}\) Therefore, total income in region $n$ is given by

$$
I_{t}^{n} = \sum_{j=co,1}^{J} w_{t}^{nj} L_{t}^{nj} + t_{t}^{n} \chi_{t} + \varpi_{t}^{n} H_{n} - r_{t}^{n} \sum_{j=1}^{J} M_{t}^{O_{j}} \varphi_{t}^{O_{j} n k} + \sum_{j=1}^{J} \frac{\tau_{t}^{ij,nj}}{1 + \tau_{t}^{ij,nj}} \chi_{t}^{ij,nj} X_{t}^{nj}.
$$

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

\(^{13}\)Differences between the remittances to the global portfolio, and transfers from the global portfolio generate trade imbalances. We will discipline $t_{t}^{n}$ 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.
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

\[
I_t^n = \sum_{j=1}^{J} w_t^{nj} L_t^{nj} + r_t^n K_t^n - r_t^n \sum_{j=1}^{J} M_t^{Oj} \varphi_t^{Oj,nj} + \sum_{j=1}^{J} \frac{\tau_t^{ij,nj}}{1 + \tau_t^{ij,nj}} \lambda_t^{ij,nj} X_t^{nj}, \text{ for all } n. \tag{18}
\]

The total expenditure on goods in sector \( j \) and location \( n \) is given by the expenditure on materials from firms across all other sectors and for consumption, namely

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

where the first term is the demand for sector \( j \) intermediate goods from all sectors, and \( \sum_{i=1}^{N} \left( 1 - \frac{1}{\sigma_k} \right) \lambda_t^{nk,ik} X_t^{ik} \) 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

\[
w_t^{nj} L_t^{nj} = (1 - \xi^n) \gamma^{nj} \sum_{i=1}^{N} \left( 1 - \frac{1}{\sigma_j} \right) \lambda_t^{nj,ij} X_t^{ij}, \text{ for all } n, j, \tag{20}
\]

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

\[
r_t^n K_t^n = \xi^n \sum_{j=1}^{J} \gamma^{nj} \sum_{i=1}^{N} \left( 1 - \frac{1}{\sigma_j} \right) \lambda_t^{nj,ij} X_t^{ij} + r_t^n \sum_{j=1}^{J} M_t^{Oj} \varphi_t^{Oj,nj}, \tag{21}
\]

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.

Before defining the equilibrium in our model, in Appendix A we follow Ossa (2011) and show that the delocation effect from Venables (1987) is also present in a static two country version of the model that we have developed in this section.

### 2.4 Equilibrium

The exogenous state of the economy is determined by the set of constant and time-varying fundamentals \( \Theta_t = \left\{ d_t^{nj,ij}, m_t^{nj,ik}, a_t^{nj} \right\}_{n=1,j,k=1}^{N,J} \). Namely, bilateral non-tariff ( iceberg) trade costs, mobility costs, and productivity across locations and sectors. We de-
fine by $Y_t \equiv \{ \Sigma_{n,j}^N \}_{n,i=1;j=1}^{N,J}$ 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 locations and industries $L_t = \{ L_{nj}^N \}_{n=1;j=co,1}^{N,J}$, the distribution of firms, active and inactive, $M_t = \{ M_{nj}^N, M_{Oj}^N \}_{n=1;j=1}^{N,J}$, and the distribution of capital $K_t = \{ K_n^N \}_{n=1}^N$.

Let us define the equilibrium migration flows at time $t$ by $\mu_t = \{ \mu_{nj,ik}^N \}_{n,j=1;k=ne,co,1}^{N,J}$, the equilibrium firm transition rates at time $t$ by $\varphi_t = \{ \varphi_{nj,nj}^N, \varphi_{nj,Oj}^N, \varphi_{Oj,ij}^N \}_{n,j=1}^{N,J}$, the value function for the workers by $V_t = \{ V_{nj}^N \}_{n=O,1;j=1}^{N,J}$, the value function for the firms by $V_t = \{ V_{nj}^N \}_{n,j=1}^{N,J}$, equilibrium wages by $w_t = \{ w_{nj}^N \}_{n,j=1}^{N,J}$, rental rates by $r_t = \{ r_k^N \}_{n=1}^N$, aggregate and bilateral expenditures $X_t = \{ X_{nj,ij}^N \}_{n,j=1}^{N,J}$ where $X_{nj,ij}^N$ is the expenditure of goods by $ij$ on goods produced by $nj$, that is $X_{nj,ij}^N = \lambda_{nj,ij}^N X_t^i$, and prices by $P_t = \{ P_n^N \}_{n=1}^N$, where $P_n^N$ 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:

**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 $\{ Y_t \}_{t=0}^\infty$, 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, (14-16), the firms dynamic problem, (6-11), the problem of capital structure developers, (12, 13), the static sub-problems of the households and producers at each $t$, using equilibrium conditions (2, 3, 4, 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.

### 3 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

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14 Kucheryavyy, Lyn, and Rodriguez-Clare (2019) study the theoretical properties of multi sector models with Marshallian 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.
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.

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 C the derivations and proofs.

3.1 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 $\{\Gamma_t\}_{t=0}^{\infty} \rightarrow \{\Gamma'_t\}_{t=0}^{\infty}$ 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 $v_{t}^{n,j} = \exp(V_t^{n,j})$, $\hat{\pi}_{t}^{n,j} = \exp(\pi_t^{n,j})$, and $\hat{r}_{i+1}^{t} = \exp(r_{i+1}^{t})$. 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 C 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 \( \hat{\Upsilon} = \{\hat{\Upsilon}_t\}_{t=0}^{\infty} \) 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 \( \{\hat{L}_t, \hat{M}_t, \hat{K}_t, \hat{\mu}_{t-1}, \hat{\varphi}_{t-1}, \hat{X}_t\} \), 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 D we present the algorithm that we implement to solve for the baseline economy and the solution to Proposition 2.

### 3.2 Data and Estimation

We 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 sector that we use to discipline the production of new structures described in Section 2.1.3. 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, \( \lambda_{n,j}^{i,j} \) across countries, across U.S. states, and between U.S. states and other coun-
tries in our world; total expenditure by sector and country \( X_{t}^{nj} \), payment to labor and capital \( w_{t}^{nj} L_{t}^{nj} \), the stock of capital and rental rates across countries \( K_{t}^{n} \) and \( r_{t}^{n} \), and the initial profits of a representative firm \( \pi_{t}^{nj} \). We also need to construct the initial distribution of employment in the United States \( L_{t}^{nj} \), the labor mobility rates across U.S. states and sectors \( \mu_{t}^{nj,ik} \), the sectoral distribution of active firms across U.S. 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 \( \gamma_{nj} \), across sectors and locations, the input-output coefficients \( \gamma_{nj,nk} \), the shares of labor in value added \( \xi_{n} \), the share of labor in the production of new structures \( \kappa_{n} \), and the consumption shares \( \alpha_{j} \), and the ownership of profits \( \iota_{n} \).

Finally we also obtain the set of bilateral tariffs \( \tau_{nj,ij} \) and estimates for the value of the elasticities \( \vartheta, \nu, \sigma, \beta \).

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 E.

**Trade and Production Data** We use 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. Trade flows across countries are obtained from the World Input-Output Database (WIOD).\(^{15}\) Production data to discipline the productions functions are obtain from WIOD and data for the individual U.S. states are from the BEA.

**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 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 in each state, 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

\(^{15}\)Please refer to Timmer et al. (2015) and Timmer et al. (2016) for further details.
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 $\varphi_{ij,Oj}^{nj}$ as the number of deaths over the total number of active firms in that sector and location. Consequently, the initial probability of staying in a location for a firm in a given sector is computed as $\varphi_{ij,nj}^{nj} = 1 - \varphi_{ij,Oj}^{nj}$. Finally, we also need to discipline the mass of inactive firms $M_{ij}^{Oj}$, and the probability of entry to a given location for an inactive firm $\varphi_{ij,nj}^{Oj}$. 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 $\varphi_{ij,nj}^{Oj}$ 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 $M_{ij}^{Oj}$ 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>
<thead>
<tr>
<th></th>
<th>Manufacturing</th>
<th>Services</th>
<th>Wholesale and Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>274.8</td>
<td>4,567.8</td>
<td>1,377.6</td>
</tr>
<tr>
<td>U.K.</td>
<td>146.9</td>
<td>1,750.6</td>
<td>412.1</td>
</tr>
<tr>
<td>France</td>
<td>255.5</td>
<td>2,685.7</td>
<td>887.9</td>
</tr>
<tr>
<td>Germany</td>
<td>241.8</td>
<td>2,105.4</td>
<td>638.9</td>
</tr>
<tr>
<td>Spain</td>
<td>185.1</td>
<td>1,978.7</td>
<td>412.1</td>
</tr>
</tbody>
</table>

Source: OECD - SDBS.

Figure 1 presents the number of active firms by sector and across U.S. states at the year 2015 computed from the U.S. Census. What we can observe is that firms are unevenly distributed across space, and across industries. There is more concentration of firms in larger states such as California, Texas, New York and Florida. The distribution is not the same across industries, and the United States has a relatively larger mass of firms in the services and wholesale and retail industries than in the manufacturing industries. One of the goal of the quantitative analysis in the next section is to quantify how this distribution changes with changes in trade policy.
Figure 1: Number of Establishments Across U.S. states (2015)

a) Manufacturing (thousand)

b) Services (thousand)

c) Wholesale and Retail (thousand)

Note: Source U.S. Census.

<table>
<thead>
<tr>
<th></th>
<th>Manufacturing</th>
<th>Services</th>
<th>Wholesale and Retail</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\bar{\phi}_{ij,ij}^{2015}$</td>
<td>93.3%</td>
<td>91.7%</td>
<td>92.6%</td>
</tr>
<tr>
<td>$\bar{\phi}_{ij,Oj}^{2015}$</td>
<td>6.7%</td>
<td>8.3%</td>
<td>7.4%</td>
</tr>
<tr>
<td>$\bar{\phi}_{Oj,USAj}^{2015}$</td>
<td>3.0%</td>
<td>6.1%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

Source: OECD - SDBS. Each $\bar{\phi}$ are the median observations of our sample.

Table 2 shows the median exit/entry/continuation probabilities computed with the data described above. As an example, we also display the probability of entry in the United States in the initial year.

**Capital Stocks and Rental Rates** The stock of capital for each country $K^n_t$ is obtained from the Penn World Tables 9.1. 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 OECD and recover the rental rates across locations as $r_t^n = r_t^n K_t^n / K_t^n$. Our computed rental rates are heterogeneous across locations and in the order of magnitude of 10 percent.

**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.

Unfortunately we do not have information on labor mobility rates across countries and across sectors and regions 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 $w_t^n L_t^n = (1 - \xi_n) \sum_{j=1}^{J} \gamma_{nj} \sum_{i=1}^{N} \frac{(1-1/\sigma_j)}{1+r_t^n \gamma_{nj}} \lambda_t^{nij} X_t^{ij} + (1-\kappa_n) r_t^n K_t^n$ 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**  Finally we need estimates for the values of the elasticities of the model, $\vartheta, \nu, \sigma^j, \beta$. 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, $\nu$, 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 \( \varpi \) following Artuç et al. (2010) at an annual frequency and obtain a value of \( \varpi = 2.02 \).

To estimate the dispersion of idiosyncratic shocks for firms \( \vartheta \), we use our structural model to derive an estimating equation, proceeding as follows (please refer to Appendix F for further details).\(^{16}\) Using equilibrium conditions (6) and (7), we can express the value of active firms relative to the value of inactive firms as

\[
V^{n_j}_t - V^{O_j}_t = \pi^{n_j}_t - \beta r^{n}_{t+1} + \vartheta \log \frac{\varphi^{O,n_j}_t}{\varphi^{n_j}_t}. \tag{22}
\]

Taking the ratio between the fraction of firms that stay in a given location \( \varphi^{n_j,n_j}_t \) and the fraction that exit \( \varphi^{n_j,O_j}_t \) we obtain that

\[
\frac{\varphi^{n_j,n_j}_t}{\varphi^{n_j,O_j}_t} = \exp(\beta V^{n_j}_{t+1} - \beta V^{O_j}_{t+1})^{1/\vartheta}. \tag{23}
\]

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

\[
\log \frac{\varphi^{n_j,n_j}_{t-1}}{\varphi^{n_j,O_j}_{t-1}} + \beta \log \frac{\varphi^{n_j,n_j}_t}{\varphi^{O,j,n_j}_{t}} = \frac{\beta}{\vartheta} \left( \pi^{n_j}_t + \beta r^{n}_{t+1} \right).
\]

We assume that we measure the entry probabilities \( \varphi^{O,j,ij}_t \) 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 \( \varepsilon^{n_j}_t \) that is orthogonal to profits and rental rates. As a result, our empirical equation becomes

\[
y^{n_j}_t = \tilde{C}_t + \frac{\beta}{\vartheta} \left( \pi^{n_j}_t + \beta r^{n}_{t+1} \right) + \varepsilon^{n_j}_t, \tag{24}
\]

where \( y^{n_j}_t \equiv \log \frac{\varphi^{n_j,n_j}_{t+1}}{\varphi^{n_j,O_j}_{t+1}} + \beta \log \frac{\varphi^{n_j,n_j}_{t}}{\varphi^{O,j,n_j}_{t}} \). 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 \( y^{n_j}_t \) 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

\(^{16}\)The resulting estimation described below is in the spirit of the one in CDP used to estimate the household’s idiosyncratic shocks \( \varpi \). 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.
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, 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 spatial evolution of economic activity across countries and regions in the U.S. After that, we use our model to study the spatial effects of commercial policy.

4 The Effects of Commercial Policy on Firm Location

In this Section, we study the impact of protectionism on industrial location, and its welfare consequences. The quantitative model developed in Section 2 can be used to quantify the effects of unilateral, bilateral or multilateral changes in trade policy, either across countries, across regions, or across industries. In the quantitative analysis that follows, we focus on quantifying the effects of unilateral changes in tariffs applied by the United States to other countries, with and without retaliation.

We first take the model to the data for the year 2015 and solve for the baseline economy; that is, the evolution of equilibrium allocations with the current level of tariffs and constant fundamentals going forward. Since the observable initial allocations are not necessarily in steady state, in the baseline economy with constant fundamentals the economies are transitioning to the steady state and in such transition the mass of firms, workers, and capital is changing across space and time until it reaches its long run equilibrium. In appendix G, as an example, we display the evolution of firms in the baseline economy. We then solve for the effects of changes in trade policy relative to the baseline economy. In particular, we study the effects of increases in tariffs applied by the United States in the manufacturing industry to levels of 15% and 25% from an initial average level of about 3%, with and without retaliation.

We consider two retaliation scenarios, one where the United States and the rest of the countries in the world increase tariffs to the same level (to 15% and to 25%), and another where the increase in tariffs between the United States and the rest of countries is of the same magnitude (15 and 25 percentage points). The equilibrium allocations in the counterfactual economy relative to the baseline economy identify the general equilibrium effects of protectionism in our different experiments. In all of these cases

\[17\] At the end of Appendix D we present a figure with a graphical depiction of the solution to the value functions of the baseline economy.
we assume that the changes to trade policy happen at time 1, are unanticipated at time zero, and that at time 1 all agents learn about the change in policy after it happens.

Table 3: Change in the Mass of Firms in the U.S. - Short run (%)

<table>
<thead>
<tr>
<th></th>
<th>U.S. Tariffs to 15%</th>
<th>U.S. Tariffs to 25%</th>
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</thead>
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<tr>
<td></td>
<td>w/o Retal.</td>
<td>Retal. 15%</td>
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<tr>
<td>Manufacturing</td>
<td>0.18%</td>
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</tr>
<tr>
<td>Wholesale &amp; Retail</td>
<td>0.01%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Services</td>
<td>0.02%</td>
<td>0.01%</td>
</tr>
</tbody>
</table>

We start by describing the effects of increased protectionism on the mass of firms in the United States across industries in the short run and long run, results displayed in Table 3. We refer as the short run to the effect on impact with the policy change (first year effects), and the long run as the effects in steady state. We display in the table the effects from the unilateral tariff increases to 15% and 25% and the retaliation scenario where tariffs applied between the United States and the other countries increase to 15% and 25%. The results from the other retaliation scenario are very similar and relegated to Appendix G.

In the short run, we find a small positive location effect from unilateral trade protectionism. In particular, with a unilateral increase in U.S. tariffs to 15%, the mass of firms in the U.S. manufacturing industry increases by 0.18% (about 500 firms) on impact, and by 0.33% (about 900 firms) with the tariff increase to 25%. With retaliation, the mass of manufacturing firms decline in the short run, as retaliation impacts negatively the profitability of all locations on impact. We find little impact on the mass of firms in the services, and wholesale and retail industries in the short run.

Table 4 shows that the location effect of trade protectionism is bigger in the long run. The mass of manufacturing firms in the United States increases by 2.59% (about 7,100 firms) with the tariff increase to 15% and by 4.66% with the unilateral increase to 25% (about 12,800 firms). We also find a more significant response in the mass of firms in

Table 4: Change in the Mass of Firms in the U.S. - Long Run (%)

<table>
<thead>
<tr>
<th></th>
<th>U.S. Tariffs to 15%</th>
<th>U.S. Tariffs to 25%</th>
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<tr>
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<td>Retal. 15%</td>
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<td>Manufacturing</td>
<td>2.59%</td>
<td>1.43%</td>
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<tr>
<td>Wholesale &amp; Retail</td>
<td>0.27%</td>
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</tr>
<tr>
<td>Services</td>
<td>0.37%</td>
<td>0.25%</td>
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</table>
the services and wholesale and retail industries. For instance, the mass of firms in the services industries increases in the long run by 0.37% with the 15% tariff and to 0.63% with the 25% tariff. As the mass of manufacturing firms increases, they also demand services to produce, creating incentives for the entry of firms in these other industries. Retaliation increases the incentives for firms to stay in the foreign countries, thus we find a smaller increase in the mass of firms in the United States in the long run.

Table 5: Change in the U.S. Price Index and Welfare - Long Run (%)

<table>
<thead>
<tr>
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<th>U.S. Tariffs to 15%</th>
<th>U.S. Tariffs to 25%</th>
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<tr>
<td></td>
<td>w/o Retal.</td>
<td>Retal. 15%</td>
</tr>
<tr>
<td>Price index</td>
<td>4.69%</td>
<td>3.34%</td>
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<tr>
<td>Workers’ welfare</td>
<td>-0.52%</td>
<td>-0.90%</td>
</tr>
<tr>
<td>Real income</td>
<td>-1.04%</td>
<td>-1.30%</td>
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<tr>
<td></td>
<td>7.9%</td>
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</tr>
<tr>
<td></td>
<td>-1.89%</td>
<td>-2.09%</td>
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We now turn to describe the effects of trade protectionism on the U.S. price index, and welfare. Table 5 displays the long-run effects for the different counterfactuals. Starting with the price index, a tariff increase to 15% increases the U.S. price index by 4.7%, and to 25% results in a 7.9% increase in the U.S. price index. The U.S. price index also increases with retaliation. The increase in the U.S. price index highlights the fact that the positive location effect of trade protectionism is not large enough to more than offset the direct price effect on imported varieties, resulting in an overall increase in the price index, a result that contrasts with the price-lowering protection effect in Venables (1987).

Turning to welfare analysis, the second row in the table displays the change in consumption equivalent of workers, which captures the change in real wages taking into account all the transitional dynamics, and the option value of migration in equation (14). We find that trade protectionism reduces welfare of workers by 0.5% with the 15% tariff, and by 0.9% with the 25% tariff. With retaliation, the decline is even bigger, 0.9% and 1.4%, respectively. In our quantitative framework, we have different sources of income beyond wages, such as the income of capitalists, tariff revenues and the profits ownership. The third row computes the change in the present discount value of real income, which is one way to take into account all these income sources. Similar to the welfare of workers, we find that trade protectionism results in a decline in real income; of about 1% with the 15% tariff and of 1.9% with the 25% tariff. Also similar to the change in consumption equivalent, retaliation results in even larger decline in U.S. aggregate real income.

We now turn to describe the disaggregated effects of protectionism across U.S. states.
For expositional purposes, we focus on describing the effects of the tariff increase to 25% with and without retaliation. Since the main messages from our quantitative exercises remain the same with the other experiments, we relegate the results from them to the appendix.

**Figure 2: The Sluggish Effect of Trade Protectionism on Firms in the U.S**

a) Effect of Trade Protectionism  
b) Baseline vs. Economy with 25% tariffs

Figure 2 (first column) displays the evolution of the mass of firms across industries in the United States that lead to the short-run and long-run effects described in tables 3 and 4. In addition to the results described before, we also highlight with these figures that the long-run effects from trade protectionism take time to materialize; for instance, about half of the long-run change in the manufacturing firms is realized in about 15 years. The same conclusion can be seen for the evolution of the mass of firms in the services, and wholesale and retail industries. In Figure 2 (second column), we show the evolution of the manufacturing firms in the United States in the baseline economy, and in the economy with increased unilateral trade protectionism. Importantly, we can see that the positive location effect from trade policy discussed above still is not able to revert the decline in the mass of manufacturing firms computed in the baseline with constant fundamentals.

Figure 3 presents the percentage change in the mass of firms in the U.S. across industries as a consequence of increased unilateral protectionism. The first column shows the short-run effects and the second column shows the long-run effects. In the short run, we see an heterogeneous increase in manufacturing firms across U.S. states. This heterogeneity is shaped by the mechanisms highlighted in our model such as the capital supply and how costly it is, the labor availability at each location, and the exposure to foreign trade. For instance, larger states where there is more capital and labor such
as California, Texas, Illinois, Florida and New York tend to experience a proportionally larger change in the mass of manufacturing firms in the short run. Also, some smaller states in the midwest with relatively low rental rates of structures have a relatively bigger change in the mass of manufacturing firms, relative to their initial mass. On the other hand, there are other states such as Michigan that are relatively capital abundant, yet experiences a small change in the mass of manufacturing firms because of low labor supply (for instance, think about places like Detroit), highlighting the the importance of the interaction between labor market and firm dynamics. Relative to the manufacturing sector, all states have very small changes in the mass of firms in the services and wholesale and retail industries in the short run.

In the long run, we find a more significant increase in the mass of manufacturing firms across states, consistent with the dynamics of firms described in Figure 2. There is also more heterogeneity in the changes across individual states, reflecting the fact that trade policy also creates potential incentives for domestic firms to relocate across space within the United States. We find that relative to their initial mass, states in the midwest and central regions of the United States experience a relatively larger percent increase in the mass of manufacturing firms. These states benefit from the protection from foreign competition, and given that capital is relatively cheaper, they are able to attract firms and labor. In fact, as Figure 4 shows, these states are also the ones that accumulate more capital over time. When we look at the absolute change in the mass of firms across U.S. states displayed in Figure 5 (first column), that is, without controlling by the initial mass of firms in each state, we also find that manufacturing firms, in absolute terms, tend to increase more in states that are relatively intensive in manufacturing, intensity measured as the share of manufacturing firms relative to the total mass of firms in that state (Figure 5, second column).

Overall, these results show that trade protectionism has unequal location effects across space; it tends to benefits some smaller states where it is relatively cheaper to build some capital and attract firms, and also benefits some other states that are relatively more intensive in the manufacturing industry. The remaining question that we answer later on is the price and welfare consequences of this redistribution of economic activity through trade policy. Figure 3 also highlights the more significant increase in the mass of firms in the services and wholesale and retail industries across states, as mentioned above. Finally, we also find that protectionism results in a marginal decline in the non-employment rate of the economy (of about 0.1%).

In the Appendix "Additional Results" we also show the effects on the absolute number of firms across U.S. states.
Figure 3: Effects of Protectionism on the Mass of Firms in the U.S.

a) Manufacturing - Short Run (percent)

b) Services - Short Run (percent)

c) Wholesale & Retail - Short Run (percent)

d) Manufacturing - Long Run (percent)

e) Services - Long Run (percent)

f) Wholesale & Retail - Long Run (percent)
Figure 4 shows the effect on manufacturing firms in other countries. We find that unilateral trade protectionism in the United States negatively affects some important trading partners such as Canada and Mexico, and manufacturing competitors like China.

In terms of prices and welfare, Figure 7 displays the effects on the price index and workers' welfare across individual U.S. states. First, we find a generalized increase in the price index, and a decline in welfare, across all states. Second, as expected, the increase in the price index and fall in welfare tend to be more moderate in those states that have a bigger location effect from trade protectionism. Third, as we can see in the third panel, we find that manufacturing workers located in the states that attract more firms are better off with trade protectionism, while in the rest of the states are worse off. These results highlight that protectionism has distributional consequences, benefiting
a group of workers and hurting others, but these distributional effects occur even within the protected industries, and as mentioned above, also result in generalized average welfare losses across space.

Figure 7: Effects on the Price Index and Workers’ Welfare

a) Price Index Effects (percent)
Finally, Figure 8 displays the short-run and long-run effect of trade protectionism on the manufacturing firms with retaliation, that is, when the other countries also increase tariffs applied to U.S. exports to a level of 25%. In the short run, we find a negative effect in most states, except for those located in the midwest and central regions that attract more firms in the long run. In the long run, there are some states that still are negatively affected such as Tennessee, Nevada, and Washington, but overall we find that retaliation only moderates the increase in manufacturing firms described above.

Figure 8: Effects on Manufacturing Firms with Retaliation

a) Short Run (percent)

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b) Long Run (percent)

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</tr>
<tr>
<td>WV</td>
<td>7.1</td>
</tr>
<tr>
<td>WI</td>
<td>5.8</td>
</tr>
<tr>
<td>WY</td>
<td>7.7</td>
</tr>
</tbody>
</table>

5 Conclusion

Industrial location is the most frequent argument to justify trade protectionism, yet there is little evidence on its quantitative impact. Starting from the new economic geography literature, in particular from Ossa (2011), we depart 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. Our quantitative experiments of U.S. increasing unilaterally tariffs result in positive location effects, that take time to materialize, and is much smaller in the short run than in the long run. We find that as a result of the increase in tariffs the U.S. price index increases. We also find a decline in welfare, and a bigger decline when the rest of the world retaliates to the U.S. tariff increase. The location effect of trade policy is very heterogeneous across space, but the increase in prices and decline in welfare is generalized across all states. After all, our paper highlights the inefficacy of trade protectionism to redistribute aggregate gains from trade through industrial relocation.
References


A  **Delocation Effect in the Two Country Example**

In this section we show how in the stylized version of our model the delocation effect from Venables (1987) is present. We follow Ossa (2011) and show this in the cases of two countries, \( n = 1, 2 \) and two sectors. The manufacturing sector has marginal cost \( x^1 / a^1 \) and uses only labor for production. We assume that wages are normalized across countries and equal to 1 (either by assuming that the non-manufacturing sector is freely tradable sector or by assuming that wage in the short run are fixed due to short run frictions in the labor market). The manufacturing sector is a costly tradable sector. We denote by \( \tau^{12} \) to tariffs applied by country 2 to country 1 and \( d^{12} \) are the iceberg costs. In order for a unit of a good from country 1 to arrive to country 2, \( d^{12} (1 + \tau^{12}) \) have to be shipped. Note that with this assumption there is no tariff revenue generated (as Ossa (2011) explains, this is in order to obtain analytical solutions but it does not change the argument). Let \( q^1 \) be the total production of manufacturing goods in country 1, and \( q^{11} \),
and \( q^{12} \) be the production of the good that is sold to country and 2. The goods market clearing condition in country 1 is given by

\[
q^1 = q^{11} + d^{12} (1 + \tau^{12}) q^{12}, \tag{A.1}
\]

and for country 2

\[
q^2 = q^{22} + d^{21} (1 + \tau^{21}) q^{21}. \]

In this simplified version of the model we assume that the entry cost into market 1 is given by \( r^1 \), that is firms need to have a unit of capital. Firms can freely move across countries, then it follows that

\[
\pi^1 = r^1, \quad \text{and} \quad \pi^2 = r^2,
\]

where \( \pi^1 = \pi^{11} + \pi^{12} \), that is the total profits at home. Using (5), we obtain that

\[
\pi^{11} + \pi^{12} = r^1,
\]

or

\[
p^{11} (q^{11} + d^{12} (1 + \tau^{12}) q^{12}) = \sigma r^1,
\]

and then using the demand of the goods (1), prices (4), and (A.1) we get

\[
q^1 = \sigma - 1 x^1 / a^1 r^1.
\]

Now substitute this expression on (A.1) and use (1) to obtain

\[
\frac{\sigma - 1}{x^1 / a^1} r^1 = \left( \frac{P^{11}}{P^1} \right)^{-\sigma} X^1 + \theta \left( \frac{P^{12}}{P^2} \right)^{-\sigma} X^2,
\]

where \( X^1, \ X^2 \) are the total expenditure on manufacturing goods (a share of total income in this case) from each country. Using (4) we obtain

\[
\left( \frac{\sigma x^1}{\sigma - 1 a^1} \right)^{\sigma - 1} r^1 = (P^1)^{-\sigma} X^1 + (P^2)^{-\sigma} (d^{12} (1 + \tau^{12}))^{1-\sigma} X^2,
\]

and likewise for country 2,

\[
\left( \frac{\sigma x^2}{\sigma - 1 a^2} \right)^{\sigma - 1} r^2 = (P^1)^{-\sigma} (d^{21} (1 + \tau^{21}))^{1-\sigma} X^1 + (P^2)^{-\sigma} X^2.
\]
Solving for prices we get

\[
(P^1)^{\sigma-1} = \left( \frac{\sigma}{\sigma - 1} \frac{x^1}{a^1} \right)^{\sigma-1} \frac{1}{X^1} \frac{r^1 - (d^{12} (1 + \tau^{12}))^{1-\sigma}}{1 - (d^{12} (1 + \tau^{12}) d^{21} (1 + \tau^{21}))^{1-\sigma}}
\]

\[
(P^2)^{\sigma-1} = \left( \frac{\sigma}{\sigma - 1} \frac{x^2}{a^2} \right)^{\sigma-1} \frac{1}{X^2} \frac{r^2 - (d^{21} (1 + \tau^{21}))^{1-\sigma}}{1 - (d^{21} (1 + \tau^{21}) d^{12} (1 + \tau^{12}))^{1-\sigma}}.
\]

Note that these expressions are identical to Ossa (2011) where instead of fix cost \( f \) we have instead the endogenous \( r^1 \) and \( r^2 \). Finally, note that each country’s price index is monotonically decreasing in its own tariffs,

\[
\frac{\partial P^1}{\partial \tau^1} / (1 + \tau^2) = (1 - \sigma) \frac{(d^{12} (1 + \tau^{12}) d^{21} (1 + \tau^{21}))^{1-\sigma}}{1 - (d^{12} (1 + \tau^{12}) d^{21} (1 + \tau^{21}))^{1-\sigma}} < 0,
\]

\[
\frac{\partial P^2}{\partial \tau^2} / (1 + \tau^1) = (1 - \sigma) \frac{(d^{21} (1 + \tau^{21}) d^{12} (1 + \tau^{12}))^{1-\sigma}}{1 - (d^{21} (1 + \tau^{21}) d^{12} (1 + \tau^{12}))^{1-\sigma}} < 0.
\]

### B Derivations

#### Value Function for the Firm

In this appendix we derive the value functions of the active and inactive firms, equilibrium conditions (6) and (7). For brevity, in what follows we derive in detail equation (6) and highlight that deriving (7) follows the same steps.

Define \( \Xi^n_t = \max \left\{ \beta E \left[ v^n_{i+1} \right] + \varphi \epsilon^{n_j} ; \beta E \left[ v^0_{i+1} \right] + \varphi \epsilon^{O_j} \right\} \), and \( \epsilon^{n_j, O_j} = \frac{\beta (V^n_{i+1} - V^0_{i+1})}{\varphi} \). Recall that \( \epsilon \) are i.i.d. over time an is a realization of a Type-I Extreme Value distribution with zero mean. Then,

\[
\Xi^n_t = \sum_{i=n,O} \int_{-\infty}^{+\infty} \left( \beta V^{ij} + \varphi \epsilon^{ij} \right) f(\epsilon^{ij}) \prod_{m \neq i} F\left( \epsilon^{i,mj} + \epsilon^{ij} \right) d\epsilon^{ij},
\]

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

\[
\Xi^n_t = \sum_{i=n,O} \int_{-\infty}^{+\infty} \left( \beta V^{ij} + \varphi \epsilon^{ij} \right) e^{-\epsilon^{ij} - \gamma - e^{(-\epsilon^{ij} - \gamma)}} \prod_{m \neq i} e^{-e^{(-\epsilon^{i,mj} + \epsilon^{ij}) - \gamma}} d\epsilon^{ij},
\]

where \( \gamma \) is an Euler’s constant. Manipulating this equation, can be expressed as

\[
\Xi^n_t = \sum_{i=n,O} \int_{-\infty}^{+\infty} \left( \beta V^{ij} + \varphi \epsilon^{ij} \right) e^{(-\epsilon^{ij} - \gamma)} e^{(-\epsilon^{ij} - \gamma) \sum_{m=n,O} e^{(-\epsilon^{i,mj})}} d\epsilon^{ij},
\]
Defining $\lambda_t = \log \sum_{m=n,O} e^{(-\epsilon_{ij,mj}^t)}$ and $\zeta_t = \epsilon_{ij}^t + \tilde{\gamma}$ we get

$$\Xi^n_t = \sum_{i=n,O} \int_{-\infty}^{\infty} \left( \beta V_{ij}^t + \varphi (\zeta_t - \tilde{\gamma}) \right) e^{(-\zeta_t - e^{(-\zeta_t - \lambda_t)})} d\zeta_t,$$

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

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

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

$$\Xi^n_t = \varphi \log \sum_{m=n,O} \exp \left( \beta V_{ij}^m \right)^{1/\varphi} \left[ \frac{\sum_{i=n,O} \exp \left( \beta V_{ij}^t \right)^{1/\varphi}}{\sum_{m=n,O} \exp \left( \beta V_{ij}^m \right)^{1/\varphi}} \right],$$

which implies

$$\Xi^n_t = \varphi \log \sum_{m=n,O} \exp \left( \beta V_{ij}^m \right)^{1/\varphi},$$

and therefore

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

**Location Choice Probabilities of the Firms** We now proceed to derive (8). 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 $\varphi_t^{n,j,nj}$ 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,

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

Given our assumption over the idiosyncratic shocks, we obtain that

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

or

$$\varphi_t^{n,j,nj} = \int_{-\infty}^{\infty} \exp (-\epsilon_t^{nj}) \exp \left[ - \exp (-\epsilon_t^{nj} - \tilde{\gamma}) \sum_{m=n,O} \exp (-\epsilon_t^{nj,mj}) \right] \, d\epsilon_t^{nj},$$

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with \( \hat{\epsilon}^{n_j,m_j} = \frac{\beta (V^{n_j}_{t+1} - V^{m_j}_{t+1})}{\varphi} \). Defining \( \lambda_t = \log \sum_{m=n,O} \exp (-\epsilon^{n_j,m_j}_t) \) and \( \zeta_t = \epsilon^{ij}_t + \hat{\gamma} \) we get

\[
\varphi^{n_j,n_j}_t = \exp (-\lambda_t) \int_{-\infty}^{\infty} \exp (- (\zeta_t - \lambda_t) - \exp (- (\zeta_t - \lambda_t))) d\zeta_t,
\]

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

\[
\varphi^{n_j,n_j}_t = \exp (-\lambda_t) \int_{-\infty}^{\infty} \exp (-\tilde{y}_t - \exp (-\tilde{y}_t)) d\tilde{y}_t.
\]

Solving this integral we get

\[
\varphi^{n_j,n_j}_t = \frac{\exp (\beta V^{n_j}_{t+1})^{1/\varphi}}{\sum_{m=n,O} \exp (\beta V^{m_j}_{t+1})^{1/\varphi}}.
\]

C 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

\[
\begin{align*}
\dot{v}^{n_j}_t &= \frac{\dot{w}^{n_j}_t}{\dot{P}^{n}_t} \left( \varphi^{n_j,n_j}_{t-1} \left( \hat{v}^{n_j}_{t+1} \right)^{\beta/\vartheta} + \varphi^{n_j,Oj}_{t-1} \left( \hat{v}^{Oj}_{t+1} \right)^{\beta/\vartheta} \right)^{\vartheta}, \\
\dot{v}^{Oj}_t &= \left( \sum_{j=1}^{N} \varphi^{Oj,ij}_{t-1} \left( \hat{v}^{ij}_{t+1} / \hat{r}^{i}_{t+1} \right)^{\beta/\vartheta} \right)^{\vartheta}, \\
\dot{u}^{n_j}_t &= \left( \frac{\dot{u}^{n_j}_t}{\dot{P}^{n}_t} \right) \left( \sum_{i=1}^{N} \sum_{k=ne,1}^{J} \mu_{t-1}^{n_j,ik} \left( \hat{u}^{ik}_{t+1} \right)^{\beta/\nu} \right)^{\nu}, \\
\varphi^{n_j,n_j}_t &= \frac{\varphi^{n_j,n_j}_{t-1} \left( \hat{v}^{n_j}_{t+1} \right)^{\beta/\vartheta} + \varphi^{n_j,Oj}_{t-1} \left( \hat{v}^{Oj}_{t+1} \right)^{\beta/\vartheta}}{\varphi^{n_j,n_j}_{t-1} \left( \hat{v}^{n_j}_{t+1} \right)^{\beta/\vartheta} + \varphi^{n_j,Oj}_{t-1} \left( \hat{v}^{Oj}_{t+1} \right)^{\beta/\vartheta}},
\end{align*}
\]
\[
\varphi_{t,nj}^{O_j,nj} = \frac{\varphi_{t-1}^{O_j,nj}(\hat{v}_{t+1}^{n})^{\beta/\vartheta}}{\sum_{i=1}^{N} \varphi_{t-1}^{O_j,i}(\hat{v}_{t+1}^{i})^{\beta/\vartheta}}, \tag{C.5}
\]
\[
\mu_{t,ik}^{n_j} = \frac{\mu_{t-1}^{n_j,ik}(\hat{u}_{t+1})^{\beta/\nu}}{\sum_{i=1}^{N} \mu_{t-1}^{n_j,ik}(\hat{u}_{t+1})^{\beta/\nu}}, \tag{C.6}
\]

Together with (10), (11), (13), (16), and the equilibrium conditions (2), (3), (4), (17), (12), (18), (19), (20), and (21) in time differences for all \( n, i, j, \) and \( k \). As we can see, conditional on data \( \{L_0, M_0, K_0, \varphi_{-1}, X_0\} \) we can solve for the allocations at each \( t \) without information on the level of \( \Theta_t = \{d_{t,j,j}, m_{n,j,ik}, a_{t,j,n}^{n_j}\}^N_{n=1;j,j,k=1}. \)

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

\[
\hat{v}_{t}^{n_j} = \hat{v}_{t}^{n_j}(\varphi_{t-1}^{n_j, n_j}(\hat{v}_{t+1}^{n})^{\beta/\vartheta} + \varphi_{t-1}^{O_j,n_j}(\hat{v}_{t+1}^{O_j})^{\beta/\vartheta})^{\vartheta}, \tag{C.7}
\]
\[
\hat{v}_{t}^{O_j} = \left( \sum_{i=1}^{N} \varphi_{t-1}^{O_j,i}(\hat{v}_{t+1}^{i})^{\beta/\vartheta} \right)^{\vartheta}, \tag{C.8}
\]
\[
\hat{u}_{t}^{n_j} = \left( \hat{u}_{t}^{n_j}/\hat{F}_{t}^{n} \right) \left( \sum_{i=1}^{N} \sum_{k=1}^{J} \mu_{t-1}^{n_j,ik}(\hat{u}_{t+1}^{ik})^{\beta/\nu} \right)^{\nu}, \tag{C.9}
\]
\[
\varphi_{t}^{n_j,n_j} = \frac{\varphi_{t-1}^{n_j,n_j}(\hat{v}_{t+1}^{n})^{\beta/\vartheta}}{\varphi_{t-1}^{n_j,n_j}(\hat{v}_{t+1}^{n})^{\beta/\vartheta} + \varphi_{t-1}^{O_j,n_j}(\hat{v}_{t+1}^{O_j})^{\beta/\vartheta}}, \tag{C.10}
\]
\[
\varphi_{t}^{O_j,n_j} = \frac{\varphi_{t-1}^{O_j,n_j}(\hat{v}_{t+1}^{O_j})^{\beta/\vartheta}}{\sum_{i=1}^{N} \varphi_{t-1}^{O_j,i}(\hat{v}_{t+1}^{i})^{\beta/\vartheta}}, \tag{C.11}
\]
\[
\mu_{t}^{n_j,ik} = \frac{\mu_{t-1}^{n_j,ik}(\hat{v}_{t+1}^{ik})^{\beta/\nu}}{\sum_{i=1}^{N} \mu_{t-1}^{n_j,ik}(\hat{v}_{t+1}^{ik})^{\beta/\nu}}, \tag{C.12}
\]
\[
M_{t}^{n_j} = M_{t-1}^{n_j} \varphi_{t-1}^{n_j,n_j} + M_{t-1}^{O_j} \varphi_{t-1}^{O_j,n_j}, \tag{C.13}
\]
\[
M'Oj_t = \sum_{i=1}^{N} M'_{t-1} \varphi'_{t-1} Oj_i,
\]
\[
\hat{K}_t^n = \left( \hat{K}_t^{n-1} \right)^\kappa_n \left( \hat{L}_t \right)^{1-\kappa_n},
\]
\[
L'^{nj}_t = \sum_{i=1}^{N} \sum_{k=e,1}^{J} \mu'^{nk, nj}_t L'^{nk}_{t-1},
\]

Together with equilibrium conditions (2), (3), (4), (17), (12), (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 \( \Theta_t = \{d^{n,ij}_t, m^{n,ik}_t, a^{nj}_t\}_{n,i=1;j,k=1}^{N,J} \).

### C.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 \( n_j \) (14) in changes are given by

\[
\dot{u}^{H,nj}_{t+1} = \left( \frac{\dot{u}^{nj}_{t+1}}{\dot{P}_{t+1}} \right)^{1/\nu} \left[ \sum_i \sum_k \mu^{nj,ik}_t \left( \dot{u}^{H,ik}_{t+2} \right)^\beta \right]
\]

2. The fraction of workers that move from labor market \( n_j \) to \( ik \) (15) in changes is given by

\[
\mu_{t+1}^{nj,ik} = \frac{\mu_{t}^{nj,ik} \left( \dot{u}^{H,ik}_{t+2} \right)^\beta}{\sum_{m} \mu_{t}^{nj,mh} \left( \dot{u}^{H,mh}_{t+2} \right)^\beta}
\]

3. The law as motion of employment are given by

\[
L'^{nj}_{t+1} = \sum_{i} \sum_{k} \mu'^{ik,nj}_t L'^{ik}_t
\]

4. The value of active firms (6) and inactive firms (7) in changes are given by

\[
\dot{v}^{nj}_{t+1} = \left( e^{\exp(\pi^{nj}_{t+1} - \pi^{nj}_t)} \right)^{1/\beta} \left\{ \varphi^{n,j,nj}_{t+1} \left( \dot{v}^{nj}_{t+2} \right)^\beta + \left( 1 - \varphi^{n,j,nj}_t \right) \left( \dot{v}^{Oj}_t \right)^\beta \right\}
\]

\[
\dot{v}^{Oj}_{t+1} = \sum_{i} e^{\exp(r^{i}_{t+1} - r^{i}_t )^{3/\vartheta}}
\]
where we have used the transformation \( \dot{a}_{t+1}^a = \exp(V_{t+1}^a - V_t^a)^{1/\theta} \).

5. The probability choices in changes are given by

\[
\varphi_{t+1}^{n_j,n_j} = \frac{\varphi_t^{n_j,n_j}(\dot{a}_{t+2}^a)^\beta}{\varphi_t^{n_j,n_j}(\dot{a}_{t+2}^a)^\beta + \varphi_t^{n_j,O}(\dot{a}_{t+2}^O)^\beta}
\]

(C.22)

\[
\varphi_{t+1}^{n_j,O} = 1 - \varphi_{t+1}^{n_j,n_j}
\]

(C.23)

\[
\varphi_{t+1}^{O,O} = \frac{\varphi_t^{O,O}(\dot{a}_{t+2}^O)^\beta}{\sum_i \varphi_t^{O,O}(\dot{a}_{t+2}^O)^\beta}
\]

(C.24)

6. The law of motion of firms

\[
M_{t+1}^{n_j} = M_t^{n_j} \varphi_t^{n_j,n_j} + M_t^{O_j} \varphi_t^{O_j,n_j}, \text{ for all } n, j
\]

(C.25)

\[
M_{t+1}^{O_j} = \sum_i M_i^{ij} \varphi_t^{ij,O_j}.
\]

(C.26)

C.2 Deriving the Static Sub-problem in Changes

The sectoral price index (2) in changes is given by:

\[
\dot{P}_{t+1}^{n_j} = \frac{1}{P_{t}^{n_j}} \left( \sum_i \dot{M}_{t+1}^{ij} M_t^{ij} \left( \dot{P}_{t+1}^{ij} P_t^{ij} \right)^{1-\sigma_j} \right)^{1/(1-\sigma_j)}
\]

Notice that \( \lambda_{t}^{n_j,ij} = M_t^{n_j} \frac{p_{t}^{n_j,ij} q_{t}^{n_j,ij}}{x_{t}^{ij}} = M_t^{n_j} \left( \frac{p_{t}^{n_j,ij}}{p_t^{ij}} \right)^{1-\sigma_j} \). Hence,

\[
\dot{P}_{t+1}^{n_j} = \left( \sum_i \lambda_{t}^{n_j,ij} M_{t+1}^{ij} \left( \dot{P}_{t+1}^{ij} \right)^{1-\sigma_j} \right)^{1/(1-\sigma_j)}
\]

The price of sector-\( j \) intermediate goods produced in \( i \) and sold in \( n \) (4) in changes is given by:

\[
\frac{p_{t+1}^{n_j,ij}}{p_{t}^{n_j,ij}} = \frac{\sigma_j}{\sigma_j-1} \frac{(1+\tau_{t+1}^{n_j,ij})}{a^{n_j}} \left( \frac{d^{n_j,ij} x_{t+1}^{n_j}}{a^{n_j}} \right)^{1-\sigma_j}
\]

Hence,

\[
\dot{P}_{t+1}^{ij,n_j} = (1 + \tau_{t+1}^{ij,n_j}) \dot{x}_{t+1}^{ij}
\]
The cost of the input bundle in $ij$ (3) in changes is given by:

$$x_{nj}^{t+1} = B^{nj} \left[ \left( w_{nt}^{n_j} \right)^{1-\xi^n} \left( \tilde{r}_{t+1}^{n_j} \right)^{\xi^n} \right] \gamma_{nj}^{t} \prod_k \left( P_{nt}^{nk} \right)^{\gamma_{nj,nk}}$$

Hence

$$x_{nj}^{t+1} = \left[ \left( \tilde{w}_{t+1}^{n_j} \right)^{1-\xi^n} \left( \tilde{r}_{t+1}^{n_j} \right)^{\xi^n} \right] \gamma_{nj}^{t} \prod_k \left( \tilde{P}_{t+1}^{nk} \right)^{\gamma_{nj,nk}}$$

The profit function (5) in changes is given by:

$$\pi_{nj,ij}^{t+1} = \frac{\left( 1+\tau_{ij}^{n_j,ij} \right) \lambda_{ij}^{n_j,ij} \sigma_j^{t+1} \left( \dot{X}_{ij}^{t+1} \right)}{\sigma_j^{t+1} \left( 1+\tau_{ij}^{n_j,ij} \right)}$$

Hence,

$$\dot{\pi}_{nj,ij}^{t+1} = \left( 1+\tau_{ij}^{n_j,ij} \right) \left( \dot{X}_{ij}^{t+1} \right)$$

Total profits in $nj$ at $t+1$ (5) can be expressed as:

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

Using the fact that $\pi_{nj}^{t+1} = \frac{\lambda_{ij}^{n_j,ij} \sigma_j^{t+1} \left( \dot{X}_{ij}^{t+1} \right)}{\sigma_j^{t+1} \left( 1+\tau_{ij}^{n_j,ij} \right)}$ we have

$$\pi_{nj}^{t+1} = \sum_{i=1}^{N} \lambda_{ij}^{n_j,ij} \dot{X}_{ij}^{t+1}$$

The change in the stock of capital structures is given by

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

where $L_{nt+1}^{k,n}$ 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 (12) we get

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

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

\[ \dot{K}^n_{t+1} = (\dot{K}^n_t) \left( \frac{\dot{\gamma}^n_t}{\dot{w}^n_t} \right)^{1-\kappa_n} \]

for \( n \) other than the United States.

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

\[ \lambda^{n,j,ij}_{t+1} = M^{n,j}_{t+1} \frac{\dot{\rho}^{n,j,ij}_{t+1} \dot{q}^{n,j,ij}_{t+1}}{\dot{X}^{ij}_{t+1}} \]

which can be re-expressed as

\[ \dot{\lambda}^{n,j,ij}_{t+1} = M^{n,j}_{t+1} \frac{\dot{\rho}^{n,j,ij}_{t+1} \dot{q}^{n,j,ij}_{t+1}}{\dot{X}^{ij}_{t+1}} \left( 1 + \tau^{n,j,ij}_{t+1} \right) \left( \dot{P}^{ij}_{t+1} \right)^{1-\sigma_j} \]

Hence

\[ \dot{\lambda}^{n,j,ij}_{t+1} = M^{n,j}_{t+1} \left( 1 + \tau^{n,j,ij}_{t+1} \right) \left( \dot{P}^{ij}_{t+1} \right)^{1-\sigma_j} \left( \dot{P}^{ij}_{t+1} \right)^{\sigma_j-1} \]

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

\[ I^n_{t+1} = \sum_k w^{n,k}_{t+1} L^{n,k}_{t+1} \frac{\dot{L}^{n,k}_{t+1}}{w^{n,k}_{t+1} L^{n,k}_{t+1}} + \dot{w}^n_t \dot{K}^n_t + \dot{r}^n_t \dot{r}^n_t K^n_t \]

\[ + \dot{r}^n_t \dot{\chi}_{t+1} - \sum_k r^{n,k}_{t+1} M^{O,k}_{t+1} \dot{\gamma}^{n,k}_{t+1} + \sum_j \sum_k \tau^{n,j,ij}_{t+1} \dot{X}^{n,j}_{t+1} \frac{\dot{X}^{n,j}_{t+1}}{(1 + \tau^{n,j,ij}_{t+1})} \]

where \( \chi_{t+1} = \sum_{n=1}^N \sum_{j=1}^J M^{n,j}_{t+1} \dot{\gamma}^{n,j}_{t+1} \)

\[ X^{n,j}_{t+1} = \sum_k \gamma^{n,k,ij}_{n,j} \sum_{i=1}^N \frac{(\sigma_k - 1)\lambda^{n,k,ik}_{t+1} X^{i,k}_{t+1}}{\sigma_k \left( 1 + \tau^{n,k,ik}_{t+1} \right)} + \alpha^j I^n_{t+1} \]

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

\[ \dot{w}^{n,j}_{t+1} L^{n,j}_{t+1} = (1 - \xi^n) \sum_{i=1}^N \frac{(\sigma_j - 1)\lambda^{n,j,ij}_{t+1} X^{i,j}_{t+1}}{\sigma_j \left( 1 + \tau^{n,j,ij}_{t+1} \right)} \]

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\[ n_{t+1}^n \dot{K}_{t+1} n_t^r = \sum_{j=1}^J \xi_n^{n_j} \gamma n_j^N \sum_{i=1}^N (\sigma_j - 1) \lambda n_{t+1} n_j^i X n_{t+1}^{ij} + \sum_{j=1}^J n_t^r M_{n+1} O j n_j + o_{n+1} n_j \]

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

\[ \dot{w}_t^n \dot{L}_t^n w_t^n L_t^n = \sum_{j=1}^J (1 - \xi_n^{n_j}) \lambda n_{t+1} n_j^i X n_{t+1}^{ij} + (1 - \kappa_n^r) n_t^r K_t^r \]

C.3 Deriving the Households’ Dynamic Problem in Changes

We now 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 \( n_j \) in changes are derived using the following steps (analogous for the case of the firm’s problem). We have that

\[ U_t^{n_j} = \log(\dot{w}_t^{n_j}/P_t^{n}) + \nu \log \left[ \sum_{i=1}^N \sum_{k=1}^J \exp \left( \beta U_{i+1}^{t+1} - m_n^{n_j,i,k} \right)^{1/\nu} \right] \]

In time differences we get

\[ U_{t+1}^{n_j} - U_t^{n_j} = \log(\dot{w}_{t+1}^{n_j}/\dot{P}_{t+1}^{n}) + \nu \log \left[ \sum_{i=1}^N \sum_{k=1}^J \exp \left( \beta U_{i+1}^{t+1} - m_n^{n_j,i,k} \right)^{1/\nu} \right] \]

which can be re-expressed as

\[ U_{t+1}^{H,n_j} - U_t^{n_j} = \log(\dot{w}_{t+1}^{n_j}/\dot{P}_{t+1}^{n}) + \nu \log \left[ \sum_{i=1}^N \sum_{k=1}^J \exp \left( \beta U_{i+1}^{t+1} - m_n^{n_j,i,k} \right)^{1/\nu} \right] \]

and using the definition of \( \mu^{n_j,i,k}_t \) we get

\[ U_{t+1}^{n_j} - U_t^{n_j} = \log(\dot{w}_{t+1}^{n_j}/\dot{P}_{t+1}^{n}) + \nu \log \left[ \sum_{i} \sum_{k} \mu^{n_j,i,k}_t \exp \left( \beta U_{i+1}^{t+1} - \beta U_{i+1}^{t+1} \right)^{1/\nu} \right] \]
\[ \hat{u}_{nt+1}^{n_j} = \left( \hat{w}_{nt+1}^{n_j} + \hat{\beta}_{nt+1}^{n_j} \right)^{1/\nu} \left[ \sum_i \sum_k \mu_t^{n_j,ik} \exp \left( \hat{u}_{kt+2}^{ik} \right)^\beta \right], \]

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

The fraction of workers that move from labor market \( n_j \) to \( ik \) (15) is given by

\[ \mu_t^{n_j,ik} = \frac{\exp(\beta U_{t+1}^{ik} - m_t^{n_j,ik})^{1/\nu}}{\sum_m \exp(\beta U_{t+1}^{mh} - m_t^{n_j,mh})^{1/\nu}}, \]

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

\[ \mu_t^{n_j,ik} = \frac{\exp(\beta U_{t+2}^{ik} - m_t^{n_j,ik})^{1/\nu} \exp(\beta U_{t+1}^{ik} - m_t^{n_j,ik})^{1/\nu}}{\sum_m \exp(\beta U_{t+2}^{mh} - m_t^{n_j,mh})^{1/\nu}} \frac{\sum_m \exp(\beta U_{t+1}^{mh} - m_t^{n_j,mh})^{1/\nu}}{\sum_m \exp(\beta U_{t+1}^{mh} - m_t^{n_j,mh})^{1/\nu}} \]

Hence

\[ \mu_t^{n_j,ik} = \frac{\mu_t^{n_j,ik} \exp(\beta U_{t+2}^{ik} - \beta U_{t+1}^{ik})^{1/\nu}}{\sum_m \mu_t^{n_j,mh} \exp(\beta U_{t+2}^{mh} - \beta U_{t+1}^{mh})^{1/\nu}}, \]

or

\[ \mu_t^{n_j,ik} = \frac{\mu_t^{n_j,ik} \left( \hat{u}_{kt+2}^{ik} \right)^{\beta}}{\sum_m \sum_{mh} \mu_t^{n_j,mh} \left( \hat{u}_{kt+2}^{mh} \right)^{\beta}}. \]

### C.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 (6) is given by

\[ V_{nt}^{n_j} = \pi_t^{n_j} + \vartheta \log \left\{ \exp(\beta V_{t+1}^{n_j})^{1/\vartheta} + \exp(\beta V_{t+1}^{Oj})^{1/\vartheta} \right\} \]

In time differences we have that

\[ V_{t+1}^{n_j} - V_{nt}^{n_j} = \pi_{t+1}^{n_j} - \pi_t^{n_j} + \vartheta \log \left\{ \exp(\beta V_{t+2}^{n_j})^{1/\vartheta} + \exp(\beta V_{t+2}^{Oj})^{1/\vartheta} \right\} \]

or

\[ \exp(\beta V_{t+1}^{n_j})^{1/\vartheta} + \exp(\beta V_{t+1}^{Oj})^{1/\vartheta} \]
respectively we have

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

which can be expressed as

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

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

Using the fact that \( \varphi_{t+1}^{nj,nj} = \frac{\exp(\beta V_{t+1}^{nj} + 2)}{\exp(\beta V_{t+1}^{nj} + 1)} \) we get

\[
V_{t+1}^{nj} - V_t^{nj} = \pi_{t+1}^{nj} - \pi_t^{nj} \\
+ \vartheta \log \left\{ \varphi_t^{nj,nj} \exp(\beta V_{t+1}^{nj} - \beta V_{t+1}^{Oj})^{1/\vartheta} + (1 - \varphi_t^{nj,nj}) \right\} \]

And therefore

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

The value of inactive firms (7) 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

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

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

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

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which can be re-written as

\[ V_{Oj}^{t+1} - V_O^t = \partial \log \sum_i e^{((\beta V_{ij}^t - \beta r_{i+2}^t) - (\beta V_{ij}^{t+2} - \beta r_{i+2}^{t+1}))^{1/\theta}} e^{(\beta V_{ij}^t - \beta r_{i+1}^t)^{1/\theta}} \]

and using (9) we get

\[ V_{Oj}^{t+1} - V_O^t = \partial \log \sum_i \varphi_{t}^{Oj,ij} e^{((\beta V_{ij}^t - \beta r_{i+2}^t) - (\beta V_{ij}^{t+2} - \beta r_{i+2}^{t+1}))^{1/\theta}} \]

and using the transformation introduced above we get

\[ \hat{v}_{Oj}^{t+1} = \sum_i \varphi_{t}^{Oj,ij} \left( \frac{\hat{u}_{ij}^t}{\hat{u}_{ij}^{t+2}} \right)^{\beta} \]

where \( \hat{u}_{ij}^{t+1} = \exp(V_{ij}^{t+1} - V_{ij}^t)^{1/\theta} \).

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

\[ \varphi_{t}^{nj,nj} = \frac{e^{(\beta V_{nj}^t)^{1/\theta}}}{e^{(\beta V_{nj}^{t+1})^{1/\theta}} + e^{(\beta V_{Oj}^{t+1})^{1/\theta}}} \]

which can be re-written as

\[ \varphi_{t+1}^{nj,nj} = \frac{e^{(\beta V_{nj}^{t+1})^{1/\theta}} e^{(\beta V_{nj}^{t+2})^{1/\theta}}}{e^{(\beta V_{nj}^{t+1})^{1/\theta}} + e^{(\beta V_{Oj}^{t+1})^{1/\theta}}} \]

which can be expressed as

\[ \varphi_{t+1}^{nj,nj} = \frac{e^{(\beta V_{nj}^{t+1})^{1/\theta}} e^{(\beta V_{nj}^{t+2} - \beta V_{nj}^{t+1})^{1/\theta}}}{e^{(\beta V_{nj}^{t+1})^{1/\theta}} + e^{(\beta V_{Oj}^{t+1})^{1/\theta}}} \]

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

\[ \varphi_{t+1}^{nj,nj} = \frac{\varphi_{t}^{nj,nj} e^{(\beta V_{nj}^{t+1})^{1/\theta}}}{\varphi_{t}^{nj,nj} e^{(\beta V_{nj}^{t+2} - \beta V_{nj}^{t+1})^{1/\theta}} + \varphi_{t}^{nj,Oj} e^{(\beta V_{Oj}^{t+1})^{1/\theta}}} \]

or

\[ \varphi_{t+1}^{nj,nj} = \frac{\varphi_{t}^{nj,nj} (\hat{u}_{ij}^{t+2})^{\beta}}{\varphi_{t}^{nj,nj} (\hat{u}_{ij}^{t+2})^{\beta} + \varphi_{t}^{nj,Oj} (\hat{u}_{ij}^{t+2})^{\beta}} \]
It immediately follows that

\[ \varphi_{t+1}^{n_j, O_j} = 1 - \varphi_{t+1}^{n_j, n_j} \]

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

\[ \varphi_{t}^{O_j, n_j} = \frac{\exp(\beta V_{t+1}^{n_j} - r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - r_{t+1}^{n_i})^{1/\theta}} \]

which following the same steps as before can be expressed as

\[ \varphi_{t+1}^{O_j, n_j} = \frac{\exp(\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+2}^{n_i} - \beta r_{t+2}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - r_{t+1}^{n_i})^{1/\theta}} \]

and therefore

\[ \varphi_{t+1}^{O_j, n_j} = \varphi_{t}^{O_j, n_j} \exp((\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j}) - (\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j}))^{1/\theta} \]

\[ \sum_i \varphi_{t+1}^{O_j, i} \exp((\beta V_{t+2}^{i} - \beta r_{t+2}^{i}) - (\beta V_{t+1}^{i} - \beta r_{t+1}^{i}))^{1/\theta} \]

or

\[ \varphi_{t+1}^{O_j, n_j} = \varphi_{t}^{O_j, n_j} \exp((\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j}) - (\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j}))^{1/\theta} \]

\[ \sum_i \varphi_{t+1}^{O_j, i} \exp((\beta V_{t+2}^{i} - \beta r_{t+2}^{i}) - (\beta V_{t+1}^{i} - \beta r_{t+1}^{i}))^{1/\theta} \]

\[ \times \frac{\exp(\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+2}^{n_i} - \beta r_{t+2}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - r_{t+1}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - \beta r_{t+1}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+2}^{n_i} - \beta r_{t+2}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - \beta r_{t+1}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+2}^{n_i} - \beta r_{t+2}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - \beta r_{t+1}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+2}^{n_j} - \beta r_{t+2}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+2}^{n_i} - \beta r_{t+2}^{n_i})^{1/\theta}} \]

\[ \times \frac{\exp(\beta V_{t+1}^{n_j} - \beta r_{t+1}^{n_j})^{1/\theta}}{\sum_i \exp(\beta V_{t+1}^{n_i} - \beta r_{t+1}^{n_i})^{1/\theta}} \]

C.5 Solving for Unexpected Change in Trade Policy at \( t = 1 \)

C.5.1 Household’s Problem

We start first by indexing variables according to the sequence of policy \( \Upsilon \) or to the change in policy \( \Upsilon' \).

Consider the values at \( t = 0 \),

\[ U_{0}^{n_j} (\Upsilon) = \log(w_{0}^{n_j} (\Upsilon) / P_{0}^{n} (\Upsilon)) + \nu \log \left[ \sum_{i=1}^{N} \sum_{k=ne,1}^{J} \exp \left( \beta U_{1}^{i,k} (\Upsilon) - m_{n_j,i,k}^{n} \right)^{1/\nu} \right] \]

and labor market flows

\[ \mu_{0}^{n_j,i,k} (\Upsilon) = \frac{\exp(\beta U_{1}^{i,k} (\Upsilon) - m_{n_j,i,k}^{n})^{1/\nu}}{\sum_{m} \sum_{h} \exp(\beta U_{1}^{m,h} (\Upsilon) - m_{n_j,m,h}^{n})^{1/\nu}} \]
and at \( t = 1 \) after the change in policy

\[
U_{1}^{n_j} (\mathcal{Y}') - U_{0}^{n_j} (\mathcal{Y}) = \log \left( \frac{w_{1}^{n_j} (\mathcal{Y}')}{w_{0}^{n_j} (\mathcal{Y})} \times \exp \left( \frac{\beta U_{2}^{ik} (\mathcal{Y}') - m_{\nu, i, k}}{\nu} \right) \right) + \log \left[ \sum_{i=1}^{N} \sum_{k=ne, 1}^{J} \exp \left( \frac{\beta U_{2}^{ik} (\mathcal{Y}') - m_{\nu, i, k}}{\nu} \right) \right],
\]

Taking the time difference we get

\[
\mu_{1}^{n_j, i, k} (\mathcal{Y}') = \frac{\exp (\beta U_{2}^{ik} (\mathcal{Y}') - m_{\nu, i, k})^{1/\nu}}{\sum_{m} \sum_{h} \exp (\beta U_{2}^{mh} (\mathcal{Y}') - m_{\nu, i, mh})^{1/\nu}}.
\]

Using our notation, we get at \( t = 1 \),

\[
\hat{U}_{1}^{n_j} = \frac{\hat{w}_{1}^{n_j}}{P_{1}} \left[ \sum_{i=1}^{N} \sum_{k=ne, 1}^{J} \hat{\mu}_{0}^{n_j, i, k} (\hat{u}_{2}^{ik})^{\beta/\nu} \right]^{\nu},
\]
\[ \mu_{nj,ik}^{1} = \frac{\tilde{\mu}_{nj,ik}^{0}(\tilde{u}^{ik}_{2})^{\beta/\nu}}{\sum_{m} \sum_{h} \tilde{\mu}_{nj,mh}^{0}(\tilde{u}^{mh}_{2})^{\beta/\nu}}, \]

where

\[ \tilde{\mu}_{nj,ik}^{0} = \mu_{nj,ik}^{1}(\tilde{u}^{ik}_{1})^{\beta/\nu}. \]

For all other \( t > 1 \)

\[ \hat{u}_{nj}^{t+1} = \frac{\hat{u}_{nj}^{t}}{P_{n}^{t}} \left[ \sum_{i=1}^{N} \sum_{k=1}^{J} \mu_{nj,ik}^{t+1} \hat{u}_{ik}^{t+1} \right]^{\nu}, \]

\[ \mu_{nj,ik}^{t} = \frac{\mu_{nj,ik}^{t+1} \hat{u}_{nj}^{t+1} \hat{u}_{nj}^{t+1}}{\sum_{m} \sum_{h} \mu_{nj,mh}^{t+1} \hat{u}_{mh}^{t+1}}. \]

### C.5.2 Firm's Problem

We start first by indexing variables according to the sequence of policy \( \Upsilon \) or to the change in policy \( \Upsilon' \).

\[ V_{nj}^{0}(\Upsilon) = \pi_{nj}^{0}(\Upsilon) + \vartheta \log \left\{ \sum_{h=n,O} \exp \left( V_{1}^{hj}(\Upsilon) \right)^{\beta/\vartheta} \right\}, \]

and

\[ \varphi_{nj,hj}^{0}(\Upsilon) = \frac{\exp \left( V_{1}^{hj}(\Upsilon) \right)^{\beta/\vartheta}}{\sum_{i=n,O} \exp \left( V_{1}^{ij}(\Upsilon) \right)^{\beta/\vartheta}}, \]

where \( h = n, O \). Under the change in policy,

\[ V_{nj}^{1}(\Upsilon') = \pi_{nj}^{1}(\Upsilon') + \vartheta \log \left\{ \sum_{h=n,O} \exp \left( V_{2}^{hj}(\Upsilon') \right)^{\beta/\vartheta} \right\}, \]

and

\[ \varphi_{nj,hj}^{1}(\Upsilon') = \frac{\exp \left( V_{2}^{hj}(\Upsilon') \right)^{\beta/\vartheta}}{\sum_{i=n,O} \exp \left( V_{2}^{ij}(\Upsilon') \right)^{\beta/\vartheta}}, \]

then, in time differences we get

\[ V_{nj}^{1}(\Upsilon') - V_{nj}^{0}(\Upsilon) = \pi_{nj}^{1}(\Upsilon') - \pi_{nj}^{0}(\Upsilon) + \vartheta \log \left\{ \frac{\sum_{h=n,O} \exp \left( V_{2}^{hj}(\Upsilon') \right)^{\beta/\vartheta}}{\sum_{h=n,O} \exp \left( V_{1}^{hj}(\Upsilon) \right)^{\beta/\vartheta}} \right\} \]
\begin{align*}
\varphi^{n,j,h}_1 (\mathcal{Y}') &= \frac{\varphi^{n,j,h}_2 (\mathcal{Y}') \exp \left( \frac{V^{n,j}_1 (\mathcal{Y}')}{V^{n,j}_2 (\mathcal{Y}') - V^{n,j}_1 (\mathcal{Y}') \beta/\vartheta} \right) \exp \left( \frac{V^{h,j}_1 (\mathcal{Y}')}{V^{h,j}_2 (\mathcal{Y}') - V^{h,j}_1 (\mathcal{Y}') \beta/\vartheta} \right)}{\sum_{i=n,\varnothing} \varphi^{n,j,i}_0 (\mathcal{Y}) \exp \left( \frac{V^{n,j,i}_1 (\mathcal{Y})}{V^{n,j,i}_2 (\mathcal{Y})} \right) \exp \left( \frac{V^{h,j}_1 (\mathcal{Y})}{V^{h,j}_2 (\mathcal{Y}) - V^{h,j}_1 (\mathcal{Y}) \beta/\vartheta} \right)}
\end{align*}

Similarly,
\begin{align*}
V^{O,j}_1 (\mathcal{Y}) &= 0 + \vartheta \log \left\{ \sum_i \exp \left( \frac{V^{i,j}_1 (\mathcal{Y}) - r^1_1 (\mathcal{Y})}{V^{i,j}_1 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \beta/\vartheta} \right) \right\},
\end{align*}

\begin{align*}
\varphi^{O,j,n}_0 (\mathcal{Y}) &= \frac{\exp \left( V^{n,j}_1 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \right) \beta/\vartheta}{\sum_i \exp \left( V^{i,j}_1 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \beta/\vartheta \right)},
\end{align*}

\begin{align*}
V^{O,j}_0 (\mathcal{Y}') &= 0 + \vartheta \log \left\{ \sum_i \exp \left( \frac{V^{i,j}_2 (\mathcal{Y}) - r^1_1 (\mathcal{Y})}{V^{i,j}_2 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \beta/\vartheta} \right) \right\},
\end{align*}

\begin{align*}
\varphi^{O,j,n}_1 (\mathcal{Y}') &= \frac{\exp \left( V^{n,j}_2 (\mathcal{Y}) - r^1_2 (\mathcal{Y}) \right) \beta/\vartheta}{\sum_i \exp \left( V^{i,j}_2 (\mathcal{Y}) - r^1_2 (\mathcal{Y}) \beta/\vartheta \right)},
\end{align*}

then
\begin{align*}
\varphi^{O,j}_1 (\mathcal{Y}') - \varphi^{O,j}_0 (\mathcal{Y}) &= \vartheta \log \left\{ \frac{\sum_i \exp \left( V^{i,j}_2 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \right) \beta/\vartheta}{\sum_i \exp \left( V^{i,j}_1 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \beta/\vartheta \right)} \right\},
\end{align*}

finally
\begin{align*}
\varphi^{O,j}_1 (\mathcal{Y}) - \varphi^{O,j}_0 (\mathcal{Y}) &= \vartheta \log \left\{ \sum_{i=1}^N \varphi^{O,j,i}_0 (\mathcal{Y}) \exp \left( \frac{V^{i,j}_1 (\mathcal{Y})}{V^{i,j}_2 (\mathcal{Y})} \right) \frac{\exp \left( V^{i,j}_2 (\mathcal{Y}) - V^{i,j}_1 (\mathcal{Y}) \right) \beta/\vartheta}{\exp \left( r^1_2 (\mathcal{Y}) - r^1_1 (\mathcal{Y}) \right) \beta/\vartheta} \right\}.
\end{align*}
and

\[ \varphi_{Oj,nj}^0 (Y') = \frac{\varphi_{Oj,nj}^0 (Y') \exp \left( \frac{V_{nj}^0 (Y')} {V_{nj}^1 (Y')} \right)^{\beta/\vartheta} \exp \left( \frac{V_{nj}^0 (Y') - V_{nj}^1 (Y')} {r_{nj}^0 (Y') - r_{nj}^1 (Y')} \right)^{\beta/\vartheta}} {\sum_i \varphi_{i,nj}^0 (Y') \exp \left( \frac{V_{ij}^0 (Y')} {V_{ij}^1 (Y')} \right)^{\beta/\vartheta} \exp \left( \frac{V_{ij}^0 (Y') - V_{ij}^1 (Y')} {r_{ij}^0 (Y') - r_{ij}^1 (Y')} \right)^{\beta/\vartheta}}. \]

Using our notation, for \( t = 1 \)

\[ \hat{v}_1^{Oj} = \left( \sum_{i=1}^N \varphi_{i,nj}^0 \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta} \right)^{\theta}, \]

\[ \varphi_{Oj,hj}^1 = \frac{\varphi_{Oj,hj}^0 \left( \frac{\hat{v}_h^j} {\hat{v}_h^{j+1}} \right)^{\beta/\vartheta}} {\sum_{i=1}^N \varphi_{i,nj}^0 \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta}}. \]

where

\[ \hat{v}_1^{nj} = \frac{\hat{w}_1^{nj}} {\sum_{h=n,0} \varphi_{h,nj}^0 \left( \frac{\hat{v}_h^j} {\hat{v}_h^{j+1}} \right)^{\beta/\vartheta}}, \]

\[ \varphi_{nj,hj}^1 = \frac{\varphi_{nj,hj}^0 \left( \frac{\hat{v}_h^j} {\hat{v}_h^{j+1}} \right)^{\beta/\vartheta}} {\sum_{i=n,0} \varphi_{i,nj}^0 \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta}}. \]

for \( h = n, O. \)

for all \( t > 1 \)

\[ \hat{v}_t^{Oj} = \left( \sum_{i=1}^N \varphi_{i,nj}^0 \varphi_{t-1,nj}^{Oj,nj} \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta} \right)^{\theta}, \]

\[ \varphi_{t,nj}^{Oj,nj} = \frac{\varphi_{t-1,nj}^{Oj,nj} \left( \frac{\hat{v}_t^{nj}} {\hat{v}_t^{nj+1}} \right)^{\beta/\vartheta}} {\sum_{i=1}^N \varphi_{i,nj}^0 \varphi_{t-1,nj}^{Oj,nj} \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta}}. \]

\[ \hat{v}_t^{nj} = \frac{\hat{w}_t^{nj}} {\sum_{h=n,0} \varphi_{h,nj}^0 \varphi_{t-1,nj}^{nj,hj} \left( \frac{\hat{v}_h^j} {\hat{v}_h^{j+1}} \right)^{\beta/\vartheta}}, \]

\[ \varphi_{t,nj}^{nj,hj} = \frac{\varphi_{t-1,nj}^{nj,hj} \left( \frac{\hat{v}_h^j} {\hat{v}_h^{j+1}} \right)^{\beta/\vartheta}} {\sum_{i=n,0} \varphi_{h,nj}^0 \varphi_{t-1,nj}^{nj,hj} \left( \frac{\hat{v}_i^{nj}} {\hat{v}_i^{nj+1}} \right)^{\beta/\vartheta}}. \]
D 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 \( L_t^{nj}, L_t^{Oj} \), 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 \( \varphi_t^{Oj,nj} \).

1. Guess a path for the change in wages \( \dot{w}_t^{nj} \) and the change in the rental rate \( \dot{r}_t^n \).

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

\[
\dot{P}_t^{nj} = \left( \sum_i \lambda_t^{ij,nj} M_t^{ij} \left( \dot{P}_t^{ij,nj} \right)^{1/(1-\sigma)} \right)^{(1-\sigma_j)/(1-\sigma)}
\]

\[
\dot{P}_t^{ij,nj} = (1 + \dot{\lambda}_t^{ij,nj}) \dot{x}_t^{ij}
\]

\[
\dot{x}_t^{nj} = \left[ (\dot{w}_t^{nj})^{1-\xi_n} (\dot{r}_t^n)^{\xi_n} \right] \prod_k \left( \dot{P}_t^{nk} \right)^{\gamma_{nj,nk}}
\]

3. Solve for the bilateral expenditure shares using

\[
\dot{\lambda}_t^{nj,ij} = M_t^{nj} \left( (1 + \dot{\lambda}_t^{nj,ij}) \dot{x}_t^{nj} \right)^{1-\sigma_j} \left( \dot{P}_t^{nj} \right)^{\sigma - 1}
\]

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

\[
\dot{K}_t^n = (\dot{K}_t^n)^{\kappa_n} (\dot{K}_t^{k,n})^{1-\kappa_n}
\]

and for the other countries using

\[
\dot{K}_t^n = (\dot{K}_t^n) \left( \frac{\dot{r}_t^n}{\dot{w}_t^{nj}} \right)^{\frac{1-\kappa_n}{\kappa_n}}
\]

5. Solve for total expenditure using

\[
I_{t+1}^n = \sum_k \dot{w}_t^{nk} \dot{L}_t^{nk} + \dot{w}_t^n L_t^n + \dot{r}_t^n \dot{K}_t^n + \lambda_t^n + \sum_k \dot{r}_t^{nk} M_{t+1}^{O,k} \varphi_t^{O,k,nk} + \sum_j \frac{\dot{\tau}_t^{ij,nj} \dot{X}_t^{nj}}{1 + \dot{\tau}_t^{ij,nj}}
\]
where \( \chi_{t+1} = \sum_n \sum_j M_{t+1}^{nj} \pi_{t+1}^{nj} = \sum_n \sum_i \sum_j \frac{\lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_j (1 + \tau_{t+1}^{nk,ik})} \)

\[
X_{t+1}^{nj} = \sum_k \gamma_k \sum_i (\sigma_i - 1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij} + \alpha^j I_{t+1}^n
\]

Note that total expenditure is solved as a fixed point

6. Solve for changes in profits using

\[
\dot{\pi}_{t+1} = \left(1 + \dot{P}_{t+1}^{ij}\right) - \sigma_j \dot{X}_{t+1}^{ij}
\]

Solve for total profits using

\[
\pi_{t+1}^{nj} = \sum_i \frac{\lambda_t^{nj,ij} X_t^{ij}}{\sigma_j (1 + \tau_{t+1}^{nj,ij})}
\]

Alternatively solve total profits as

\[
\pi_{t+1}^{nj} = \sum_i \frac{\lambda_t^{nj,ij} X_t^{ij}}{\sigma_j (1 + \tau_{t+1}^{nj,ij})}
\]

7. Solve for the market clearings using

\[
\dot{w}_{t+1}^{nj} \dot{L}_{t+1}^{nj} w_t^{nj} L_t^{nj} = (1 - \xi^n) \gamma^{nj} \sum_i \frac{(\sigma_i - 1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_j (1 + \tau_{t+1}^{nj,ij})}
\]

\[
\dot{K}_{t+1}^{nj} \dot{K}_{t+1}^n K_t^n = \sum_j \xi^n \gamma^{nj} \sum_i \frac{(\sigma_i - 1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_j (1 + \tau_{t+1}^{nj,ij})} + \sum_j \dot{r}_{t+1}^n M_{t+1}^{Oj} \phi_{t+1}^{Oj,nj}
\]

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

\[
\dot{w}_{t+1}^{nj} \dot{L}_{t+1}^{nj} w_t^{nj} L_t^{nj} = \sum_j (1 - \xi^n) \gamma^{nj} \sum_i \frac{(\sigma_i - 1) \lambda_{t+1}^{nj,ij} X_{t+1}^{ij}}{\sigma_j (1 + \tau_{t+1}^{nj,ij})} + (1 - \kappa_n) \dot{r}_{t+1}^n K_{t+1}^n
\]

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 $\dot{v}_{nj}^{t+1}, \dot{v}_{Oj}^{t+1}, \dot{u}_{H,nj}^{t+1}$

2. Solve for the probability choices by firms and gross flows of households $\phi_{nj,nj}^{t+1}, \phi_{nj,Oj}^{t+1}, \phi_{Oj,nj}^{t+1}$

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

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

5. Construct the path of profits $\pi_{t+1}^{nj}$ and 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 $\dot{v}_{nj}^{t+1}, \dot{v}_{Oj}^{t+1}, \dot{u}_{H,nj}^{t+1}$ using the path of profits, real wages, and rental rates from the temporary equilibrium until reach convergence.
E 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 $\lambda_{nj,ij}$ 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 us to recover sectoral bilateral trade flows and total expenditure, and therefore construct the bilateral trade shares $\lambda_{nj,ij}^t$.

**Inter-regional Bilateral Trade Flows** Imports and exports between the 50 U.S. states and 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 adjustments 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 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 \( \gamma_{nj} \). The share of labor in value added \( \xi_n \) 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

\[
M_{nj}^\pi \tau^n_t = \frac{1}{\sigma_j} \sum_{i} \lambda_{nj,ij}^n X_{ij}^t.
\]

As explained in Section 2.3, 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 \( D_n^t \), that is,

\[
i^n = \frac{1}{\sigma_j} \frac{\sum_{i=1}^{N} \lambda_{nj,ij}^n X_{ij}^t - D_n^t}{\chi_t}.
\]

The final consumption shares \( \alpha_j \) are also computed using the equilibrium conditions of the model. In particular

\[
\alpha_j = \frac{\sum_{n=1}^{N} X_{nj}^n - \sum_{n=1}^{N} \sum_{k=1}^{J} \gamma_{nk,nj}^n \left( \frac{1 - 1/\sigma_k}{1 + \tau_{nk,ik}^n} \right) X_{ij}^t}{\sum_{n=1}^{N} \ell_t^n}.
\]

**The Initial Distribution of Firms and Location Choice Probabilities** We compute \( M_{nj}^v \) 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 \( M_{nj}^v \) 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).

**F 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 (6). Adding and subtracting the continuation value to this equation we obtain

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

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

$$V_{nj}^{t} = \pi_{nj}^{t} + \beta V_{nj}^{t+1} - \vartheta \log \varphi_{t}^{nj,nj}.$$ 

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

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

Taking differences with the corresponding value of active firms we get

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

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 $V_{nj}^{t} - V_{Oj}^{t}$ , in particular

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

and therefore we have that

$$\log \frac{\varphi_{t-1}^{nj,nj}}{\varphi_{t-1}^{nj,Oj}} + \beta \log \frac{\varphi_{t}^{nj,nj}}{\varphi_{t}^{O,j,nj}} = \frac{\beta}{\vartheta} (\pi_{nj}^{t} + \beta r_{t+1}^{n}).$$

As discussed in the main text, we assume the entry probabilities $\varphi_{t}^{O,j,i}$ 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 $\varepsilon_{t}^{nj}$ that is orthogonal to profits and rental rates, that is, $\tilde{\varphi}_{t}^{O,j,i} = \varphi_{t}^{O,i} (C_{t} + \varepsilon_{t}^{nj})$. Hence, our estimating equation becomes

$$y_{nj}^{t} = C_{t} + \frac{\beta}{\vartheta} (\pi_{nj}^{t} + \beta r_{t+1}^{n}) + \varepsilon_{t}^{nj}.$$
where \( y_{nt} = \log \frac{\phi_{nj,nj}}{\phi_{j-1,j-1}} + \beta \log \frac{\phi_{nj,nj}}{\phi_{Oj,ij}} \).

### G Additional Results

In this appendix we present in more detail additional counterfactual results. Before doing so, we present as an example, the evolution of manufacturing firms in the baseline economy.

**The Baseline Economy**  As an example to illustrate how the baseline economy with constant fundamentals evolves over time, Figure G.1a shows the evolution of manufacturing firms in the United States in the baseline economy, and Figure G.1b presents the long-run changes in manufacturing firms across individuals U.S. states.

#### Figure G.1: Example of the Baseline Economy

- **a)** Evolution of Manuf. Firms in the U.S.
- **b)** Change in Manuf. Firms (number)

**Unilateral tariff increase to 25%**  In this section, we present additional results from a unilateral increase in tariffs applied to the United States to 25%. Figure G.2 presents the absolute change in the number of firms across U.S. states in the short and long run.
Figure G.2: Effects of protectionism on the mass of firms in the U.S. with 25% Tariffs

- **a) Manufacturing - Short Run (number)**
- **b) Services - Short Run (number)**
- **c) Wholesale & Retail - Short Run (number)**
- **d) Manufacturing - Long Run (number)**
- **e) Services - Long Run (number)**
- **f) Wholesale & Retail - Long Run (number)**
**Unilateral tariff increase to 15%**  We now report the results of a unilateral tariff increase to 15% applied by the United States to other countries. Figure G.3 displays the evolution of the mass of firms in the United States in the short run and in the long run. Figure G.4 shows the percentage change in the mass of firms across individual U.S. states and industries in the short run and long run. Figure G.5 shows the absolute change in the number of firms across industries and U.S. states in the short run and long run. Figure G.6 shows the long-run effect on manufacturing firms in other countries, and Figure G.7 displays the effects on the U.S. price index and welfare.
Figure G.4: Effects of Protectionism on the Mass of Firms in the U.S. with 15% Tariffs

a) Manufacturing - Short Run (percent)

b) Services - Short Run (percent)

c) Wholesale & Retail - Short Run (percent)

d) Manufacturing - Long Run (percent)

e) Services - Long Run (percent)

f) Wholesale & Retail - Long Run (percent)
Figure G.5: Effects of Protectionism on the Mass of Firms in the U.S. with 15% Tariffs

a) Manufacturing - Short Run (number)
Tariff increase to 25% with retaliation  We now present additional results for the counterfactual in which the United States increase tariffs to other countries to a level of 25% and the other countries retaliate with an increase to the same level in their tariffs applied to the United States.

Figure G.8 shows the percentage change in the mass of firms across individual U.S. states and industries in the short run and long run. Figure G.9 shows the absolute change in the number of firms across industries and U.S. states in the short run and long run. Figure G.10 displays the effects on the U.S. price index and welfare.
Figure G.8: Effects on the Mass of Firms in the U.S. with 25% Tariffs Retaliation

- **a) Manufacturing - Short Run (percent)**
- **b) Services - Short Run (percent)**
- **c) Wholesale & Retail - Short Run (percent)**
- **d) Manufacturing - Long Run (percent)**
- **e) Services - Long Run (percent)**
- **f) Wholesale & Retail - Long Run (percent)**
Figure G.9: Effects on the Mass Firms in the U.S. with 25% Tariffs Retaliation

a) Manufacturing - Short Run (number)

b) Services - Short Run (number)

c) Wholesale & Retail - Short Run (number)

d) Manufacturing - Long Run (number)

e) Services - Long Run (number)

f) Wholesale & Retail - Long Run (number)
Figure G.10: Effects on the Price Index and Workers’ Welfare with 25% Tariffs Retaliation

Tariff increase to 15% with retaliation  In this section, we present additional results for the counterfactual in which the United States increase tariffs to other countries to a level of 15% and the other countries retaliate with an increase to the same level in the tariffs applied to the United States.

Figure G.11 shows the percentage change in the mass of firms across individual U.S. states and industries in the short run and long run. Figure G.12, shows the absolute change in the number of firms across industries and U.S. states in the short run and long run. Figure G.13 displays the effects on the U.S. price index and welfare.
Figure G.11: Effects on the Mass of Firms in the U.S. with 15% Tariffs Retaliation

a) Manufacturing - Short Run (percent)

b) Services - Short Run (percent)

c) Wholesale & Retail - Short Run (percent)

d) Manufacturing - Short Run (percent)

e) Services - Long Run (percent)

f) Wholesale & Retail - Long Run (percent)
Figure G.12: Effects on the Mass of Firms in the U.S. with 15% Tariffs Retaliation

a) Manufacturing - Short Run (number)

b) Services - Short Run (number)

c) Wholesale & Retail - Short Run (number)

d) Manufacturing - Long Run (number)

e) Services - Long Run (number)

f) Wholesale & Retail - Long Run (number)
**Figure G.13: Effects on the Price Index and Workers’ Welfare with 15% Tariffs Retaliation**

### a) Price Index Effects (percent)

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### Tariff increase by 25 ppts with retaliation

In this section, we present additional results for the counterfactual in which the United States increase tariffs to other countries by 25 percentage points and the other countries retaliate with the same increase in the tariffs applied to the United States.

Figure G.14 shows the percentage change in the mass of firms across individual U.S. states and industries in the short run and long run. Figure G.15, shows the absolute change in the number of firms across industries and U.S. states in the short run and long run. Figure G.16 displays the effects on the U.S. price index and welfare.
Figure G.14: Effects on the Mass of Firms in the U.S. with 25% Tariffs Retaliation

a) Manufacturing - Short Run (percent)

b) Services - Short Run (percent)

c) Wholesale & Retail - Short Run (percent)

d) Manufacturing - Long Run (percent)

e) Services - Long Run (percent)

f) Wholesale & Retail - Long Run (percent)
Figure G.15: Effects on the Mass of Firms in the U.S. with 25% Tariffs Retaliation

a) Manufacturing - Short Run (number)

b) Services - Short Run (number)

c) Wholesale & Retail - Short Run (number)

d) Manufacturing - Long Run (number)

e) Services - Long Run (number)

f) Wholesale & Retail - Long Run (number)
**Tariff increase by 15 ppts with retaliation**  In this section, we present additional results for the counterfactual in which the United States increase tariffs to other countries by 15 percentage points and the other countries retaliate with the same increase in the tariffs applied to the United States.

Figure G.17 shows the percentage change in the mass of firms across individual U.S. states and industries in the short run and long run. Figure G.18, shows the absolute change in the number of firms across industries and U.S. states in the short run and long run. Figure G.19 displays the effects on the U.S. price index and welfare.
Figure G.17: Effects on the Mass of Firms in the U.S. with 15% Tariffs Retaliation

- Manufacturing - Short Run (percent)
- Services - Short Run (percent)
- Wholesale & Retail - Short Run (percent)
- Manufacturing - Long Run (percent)
- Services - Long Run (percent)
- Wholesale & Retail - Long Run (percent)
Figure G.18: Effects on the Mass of Firms in the U.S. with 15% Tariffs Retaliation

a) Manufacturing - Short Run (number)

b) Services - Short Run (number)

c) Wholesale & Retail - Short Run (number)

d) Manufacturing - Long Run (number)

e) Services - Long Run (number)

f) Wholesale & Retail - Long Run (number)
Figure G.19: Effects on the Price Index and Workers’ Welfare with 15% Tariffs Retaliation

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