Market Access and Regional Specialization in a Ricardian World
(Preliminary and incomplete)

A. Kerem Coşar  Pablo D. Fajgelbaum
U. of Chicago Booth  UCLA

November 2012

Abstract

When trade is costly within countries, international trade leads to concentration of economic activity in locations with good access to foreign markets. Costly trade within countries also makes it harder for remote locations to gain from international trade. We investigate the role of these forces in shaping industry location, employment concentration and the gains from international trade. We develop a model that features Ricardian comparative advantages between countries, coupled with differences in proximity to international markets across locations within a country. In the model, international trade creates a partition between a coastal and an interior region that differ in population density and specialization patterns. We assess the model prediction for industry location across U.S. counties. In tune with the theory, we find that U.S. export-oriented industries are more likely to locate and to employ more workers closer to international ports. We use the model to measure the importance of international trade in concentrating economic activity, and of domestic trade costs in hampering the gains from international trade.
1 Introduction

International trade is an important determinant of the geographic distribution of economic activity within countries. In China, the export growth of the past few decades occurred jointly with movements of rural workers and export oriented industries toward coastal regions (World Bank, 2009). After the U.S.-Vietnamese trade agreement, employment expanded in Vietnamese comparative-advantage industries located closer to major seaports (McCaig and Pavnick, 2012). In the U.S. and Mexico, increased economic integration led to larger manufacturing employment near the border (Hanson, 1996). It is also well known that the distribution of employment is skewed towards coasts: half of the world population lives within 100 kilometers of coastlines or navigable rivers, while 19 out of the 25 largest cities in the world are coastal.\(^1\) While the appeal of coastal sites derives in part from their resources and amenities, a reason for their primacy is that they are well suited for trading with other countries.

These examples showcase the impact of international trade on the regional distribution of economic outcomes. At the same time, they highlight the relevance of costly trade within countries. The larger the domestic trade costs, the stronger the incentives for export oriented industries to concentrate in places with good access to international markets, and the harder for remote locations to gain from trade. In this paper, we study how international trade and the internal geography of countries interact to shape the location of industries, the concentration of employment, and the gains from international trade. For that, we develop a theory of international trade with costly trade within countries and we assess some of its key empirical and quantitative implications.

Our approach features Ricardian comparative advantages across countries coupled with differences in international market access across locations within countries. Locations within a country are arbitrarily arranged in a map and differ in distance to international gates such as seaports, airports or land crossings. Within the country trade is costly, and international shipments must cross through the international gates to reach foreign markets. To produce, each location uses a perfectly mobile resource (workers) and an immobile resource (land). Absolute productivity levels may vary across locations within a country, while relative productivity across industries is the same in all locations but differs between countries. Trade costs lead to concentration in locations with good market access but decreasing returns in production lead to congestion, so that it is not optimal to concentrate production in a single location.

To ultimately quantify the interaction between international and domestic trade costs, our model also includes complementary forces that lead to congestion and to agglomeration. We include key dimensions that have received empirical scrutiny and that can be quantified within our model, such as demand for housing, location-specific amenities and external economies of scale. The model can be fully characterized in their presence, and we use it to study how international trade and internal geography jointly determine regional patterns of production and employment vis-a-vis these other forces.

\(^1\)Authors’ calculation from Harvard CID. The reported number is for 1995.
We first use the model to characterize regional patterns of production and employment in open economy. We find that whenever the economy is not fully specialized in what it exports, two distinct regions necessarily emerge. The equilibrium features regions near international gates that specialize in export-oriented goods, followed by an interior region that is incompletely specialized and does not trade with the rest of the world. International trade causes population density to decline away from the international gates toward the country’s interior. Thus, even though trade costs are uniform across space, international trade generates a partition between a "coastal" and an "interior" region. The boundary between these regions, as well as their shares in employment and output, is endogenous and depends on international and domestic trade costs.

Then, we analyze how changes in trade costs interact with factor movements within the country and with the gains from trade. Reductions in international trade costs lead to migration of mobile factors toward the locations with good international market access. Lower international trade costs also cause the boundary between the coastal and the interior regions to move inland, so that marginal locations switch from autarky to trading with the rest of the world, and the geographic extension of the integrated region increases. As a result, employment density and the share in national income rise in the coastal region relative to the interior region. Reductions in domestic trade costs also cause net migration away from inner locations, but might also cause population density to shrink in some coastal areas.

Finally, we investigate the impact of domestic trade costs on the gains from international trade. Aggregate welfare and real income can be decomposed into a familiar term that captures the gains from trade without domestic geography and a term that captures the effect of domestic trade frictions. The first component depends on the terms of trade, as in a standard Ricardian model. The additional component depends on domestic trade costs, on the size of the trading region, and on the distribution of land, amenities and absolute productivity levels across locations. Since larger domestic frictions cause the trading region to shrink, the gains from international trade decrease with domestic trade costs. In the quantitative section, we measure this complementarity between international and domestic trade costs.

We apply our theory to the U.S. economy. We start by assessing the implications of the model for the location of industries. In the theory, differences in international market access and Ricardian comparative advantages cause industries to arrange across locations based on their export orientation at the national level. Therefore, in the data, we would expect export-oriented industries to be more likely than import-competing ones to locate closer to international gates. We use U.S. data on specialization at the county and national levels to investigate this prediction. We assess how employment varies within industries across districts based on the industry export orientation and on the county distance to its nearest international port. Controlling for industry and county fixed effects we find a positive correlation between industry export orientation and distance to international gates such as seaports, land-crossings or airports. Moving inland from a representative port for 400 miles, employment in export-oriented industries relative to import-competing industries shrinks by between 5% and 25%.
In ongoing work, we calibrate the model to aggregate data from the U.S. The model outcomes depend on some key parameters: domestic trade costs, decreasing returns to scale, international comparative advantages, and sectorial expenditure shares. We obtain these parameters matching features of the data that are independent from the geographic distribution of employment. As natural targets we use, respectively, the share of shipping costs in the total value of shipments, the share of land in production, trade intensity at the country level, and household expenditure shares. Then, we compare the concentration of economic activity in coastal areas predicted by the calibrated model with its empirical counterpart, and we measure the gains from trade at different levels of domestic trade costs.

Since our answers might be sensitive to alternative forces, in a second calibration we also allow for external economies of scale and for amenities that vary systematically with distance to international gates. We set a strength for the external effect within the range estimated in the literature and we treat amenities as a residual, choosing its distribution to match the empirical concentration of employment in areas with good access to international markets. Using the extended calibration, we can evaluate the independent role of international trade vis-a-vis these other forces by comparing actual outcomes to those in a counterfactual autarky scenario.

Relation to the Literature Few papers consider an interaction between international and domestic trade costs. Matsuyama (1999) considers a multi-region extension of Helpman and Krugman (1985). He focuses on home-market effects under different spatial configurations, but does not include factor mobility. In a context with demand linkages, Krugman and Livas-Elizondo (1996) and Behrens et al. (2006) present models where two regions within a country trade with the rest of the world. Henderson (1982) and Rauch (1991) embed system of cities models in open economy frameworks. Rossi-Hansberg (2004) studies the location of industries that differ in relative productivity on a continuous space with externalities. These papers are based on agglomeration forces. In contrast, we study how concentration depends on the interaction between heterogeneous market access within countries and comparative advantages between countries. We focus on these forces in our empirical and quantitative applications.

In neoclassical environments, Bond (1993) and Courant and Deardorff (1993) present models with regional specialization where relative factor endowments may vary across discrete regions within a country. These papers do not include heterogeneity in access to world markets. Venables and Limao (2002) study geographic specialization across regions trading with a central location but do not allow for factor mobility.

More recently, Ramondo et al. (2011) study the gains from trade and ideas diffusion allowing for multiple regions within countries. They do not focus on differences in world market access across locations or on labor mobility within countries, so that domestic trade costs do not interact with the gains from trade. Redding (2012) extends the framework in Eaton and Kortum (2002) with labor mobility within a country to study regional gains from trade. In his analysis, for each good there are independent productivity draws across locations. In contrast, we assume that locations...
share access to the same technologies within a country, so that industries choose their location based on comparative advantages at the national level and on distance to international gates.

Finally, a large literature in urban economics studies determinants of industry location. Holmes and Stevens (2004) offer a summary assessment of the forces determining industry location in the U.S., while Hanson (1998) presents a review centered on the role of international trade. Our explanation for industry location is in line with his view and complements common explanations such as natural advantages or pure agglomeration forces.

Structure of the Paper We start in Section 2 by laying out the model, characterizing the general equilibrium and presenting the comparative statics of population density and welfare with respect to domestic trade costs. In Section 3 we assess the model prediction for regional specialization with U.S. data, and in section 4 we present the quantitative assessment. Section 5 concludes. Proofs are in the appendix.

2 Model

Geography and Trade Costs The country consists of a set of locations arbitrarily arranged on a map. We index locations by \( \ell \), and we assume that only some locations can trade directly with the rest of the world. To be shipped internationally from \( \ell \) a good must cross through a port. As it will be clear below, given the nature of our model only the distance separating each location \( \ell \) from its nearest port matters for the equilibrium. Therefore, we assume without loss of generality that \( \ell \) represents the distance separating each location from its nearest port, and we denote all ports by \( \ell = 0 \). We let \( \ell \) be the maximum maximum distance between a location inside the country and its nearest port.

There are two industries, \( i \in \{X, M\} \). International and domestic trade costs are industry specific. The international iceberg cost in industry \( i \) between \( \ell = 0 \) and the rest of the world (RoW) is \( e^{i \theta} \). Within the country, iceberg trade costs are constant per unit of distance. Therefore, the cost of shipping a good for distance \( d \) in industry \( i \) equals \( e^{\tau_i d} \). This implies a cost of international trade equal to \( e^{\tau_i^0 + \tau_i \ell} \) in industry \( i \) from location \( \ell \).

Given this geography, we can interpret each location \( \ell = 0 \) as a seaports, airport, or international land crossing. What is key is that not all locations have the same technology for trading with the RoW. This will drive concentration near points with goods access. Internal geography vanishes when \( \tau_i^0 = 0 \) for both industries.

Endowments There are two factors of production, a perfectly mobile factor and a fixed factor. We refer to the mobile factor as workers, and to the fixed factor as land. We choose units such that the national land endowment equals 1, and we let \( \lambda(\ell) \) be the amount of land available at

\footnote{The analysis can as well accomodate a continuum of industries as in Dornbusch, Fichser and Samuelson (1977). Our results would carry on in that case.}
each location $\ell$. Land is owned by immobile landlords who do not work and who spend their rental income locally. Each location is also endowed with a level of amenities $m(\ell)$.

We let $n$ be the total number of workers in the country, equal to the labor to land ratio at the national level. These workers are mobile across locations $\ell$. We let $n(\ell)$ denote employment density at location $\ell$, which is to be determined in equilibrium.

Preferences. Workers and landlords consume in the same location as they live and they have homothetic preferences on tradeable goods $X$ and $M$. In addition, agents derive utility from consumption of non-tradeables and amenities. Indirect utility of a worker who lives in $\ell$ is a monotone transformation of

$$u(\ell) = m(\ell) \frac{w(\ell)}{E(\ell)},$$

where $w(\ell)$ is the wage at $\ell$, $E(\ell)$ is the cost of living index defined at $\ell$, and $m(\ell)$ is the level of amenities in location $\ell$. Amenities are a free public good that makes locations more attractive to all consumers. For landowners, income equals the level of rents $r(\ell)$ per unit of land and utility is therefore increasing in $m(\ell) r(\ell)/E(\ell)$. Landowners are immobile, but workers decide where to live.

The cost of living at $\ell$ is

$$E(\ell) = E_T(\ell)^{\beta_T} E_N(\ell)^{1-\beta_T},$$

The coefficient $\beta_T$ measures the importance of tradeables in final consumption. The price index of tradeables $E_T(\ell) \equiv E_T(P_X(\ell),P_M(\ell))$ is defined on the price in sectors $X$ and $Y$. We let $p(\ell) \equiv P_X(\ell)/P_M(\ell)$ be the relative price of $X$ in $\ell$. Since preferences are homothetic, there exists an increasing and concave function $e(p(\ell))$ that depends on the relative price of $X$ such that

$$E_T(\ell) = P_M(\ell)e(p(\ell)).$$

In turn, the price of a unit of non-tradeable goods and services is $E_N(\ell)$. To characterize the equilibrium we will need to use consumption of non-tradeables in each location. Demand for non-tradeables per unit of land in location $\ell$ is

$$C_N(\ell) = (1-\beta_T) \frac{Y(\ell)}{E_N(\ell)},$$

where $Y(\ell) \equiv [w(\ell) n(\ell) + r(\ell)] \lambda(\ell)$ is total income in location $\ell$.\footnote{Since each local economy is a small open economy there is no need to specify demand for each tradeable industry to define the equilibrium.}

Technology. Production in sector $i = X, M, N$ requires one unit of land to operate a technology with decreasing returns to scale in labor. We let $n_i(\ell)$ be employment per unit of land in industries $i = X, M$ or in the nontradeable sector $i = N$ at location $\ell$. We can express profits per unit of land
in sector $i$ at $\ell$ as
\[
\pi_i (\ell) = \max_{n_i(\ell)} \left\{ P_i(\ell) q_i (n_i(\ell)) - w(\ell) n_i(\ell) - r (\ell) \right\}. 
\] (4)

The production technology is
\[
q_i (n_i(\ell)) = \frac{n_i(\ell)^{1-\alpha_i}}{\alpha_i (\ell)^{1}}, 
\] (5)

where $a_i (\ell)$ is the unit cost of production in industry $i$ in sector $\ell$ and $\kappa_i \equiv \alpha_i^{-\alpha_i} (1 - \alpha_i)^{-(1-\alpha_i)}$ is just a normalization constant that helps to save notation later. Decreasing returns to scale $1 - \alpha_i$ measure the labor intensity in sector $i$, acting as congestion force. Therefore $\alpha_i$ is the land intensity in $i$. From (5) it follows that the aggregate production function in each sector is Cobb-Douglas.

In the nontradable sector, unit costs $a_N (\ell)$ may vary across locations. The labor intensity $\alpha_N$ represents the importance of services in production of non-tradeables relative to housing, that only uses land.\footnote{It would have been equivalent to include two non-tradeable sectors in consumption, housing (which only uses land) and services (which only uses labor), with consumption weight $\alpha_N$ on services. Our current notation is more compact.} In the tradeable sector, the relative cost of production in industry $X$ is constant across the country:
\[
a_X (\ell) = \frac{a_X (\ell)}{a_M (\ell)} \text{ for all } \ell \in [0, \bar{\ell}]. 
\] (6)

Industry-specific production costs $[a_M (\ell), a_X (\ell)]$ may vary arbitrarily across locations as long as (6) is satisfied. That is, some locations might be more productive than others in every industry, but Ricardian comparative advantages are defined at the country level.\footnote{When we introduce externalities, the level of $[a_M (\ell), a_X (\ell)]$ will depend on population density in each location.} In turn, $a$ differs across countries, creating incentives for international trade. International differences in institutions, recently emphasized as an important determinant of trade and specialization, exemplify a source of comparative advantage that does not vary systematically across locations within countries.

The solution to the firm’s problem yields labor demand per unit of land used by each sector $i$ in location $\ell$,
\[
n_i(\ell) = \frac{1 - \alpha_i}{\alpha_i} \left( \frac{P_i(\ell)}{a_i (\ell) w(\ell)} \right)^{1/\alpha_i} \text{ for } i = X, M, N. \tag{7}
\]

We assume that the labor intensity is the same across tradeable industries: $\alpha_X = \alpha_M = \alpha_T$. Assuming differences in $\alpha_i$ across locations would not change our results. We discuss the implications of differences in $\alpha_i$ across tradeable industries below.\footnote{For quantitative purposes this is an appropriate assumption in the U.S. if the two tradeable sectors are interpreted as export-oriented and import-competing. Given that housing is an important component of nontradeables, we would expect $\alpha_N > \alpha_T$, although we do not impose that ranking for our results. See Section 4.}

Finally, we let $\lambda_i(\ell)$ be land used by each sector $i = X, M, N$.\footnote{For quantitative purposes this is an appropriate assumption in the U.S. if the two tradeable sectors are interpreted as export-oriented and import-competing. Given that housing is an important component of nontradeables, we would expect $\alpha_N > \alpha_T$, although we do not impose that ranking for our results. See Section 4.}

### 2.1 Local Equilibrium

We define can characterize a local equilibrium at each location $\ell$ that takes prices $\{P_X (\ell), P_M (\ell)\}$ and the real wage $u^*$ as given.
Definition 1 A local equilibrium at $\ell$ consists of employment density $n(\ell)$, labor demands $\{n_i(\ell)\}_{i=X,M,N}$, land use $\{\lambda_i(\ell)\}_{i=X,M,N}$, non-tradeable consumption and price $\{C_N(\ell), P_N(\ell)\}$, and factor prices $\{w(\ell), r(\ell)\}$ such that

1. workers maximize utility,
   \[ u(\ell) \leq u^*, \quad = \text{if } n(\ell) > 0, \quad (8) \]
   with demand of non-tradeables $C_N(\ell)$ given by (3);

2. profits are maximized,
   \[ \pi_i(\ell) \leq 0, \quad = \text{if } \lambda_i(\ell) > 0, \quad \text{for } i = X, M, N \quad \text{(9)} \]
   where $\pi_i(\ell)$ is given by (4);

3. land and labor markets clear,
   \[ \sum_{i=X,M,N} \lambda_i(\ell) = \lambda(\ell), \quad \text{(10)} \]
   \[ \sum_{i=X,M,N} \frac{\lambda_i(\ell)}{\lambda(\ell)} n_i(\ell) = n(\ell); \quad \text{(11)} \]

4. the non-tradeable market clears,
   \[ C_N(\ell) = q_N(\ell) \lambda_N(\ell); \quad \text{and} \]

5. trade is balanced.

Conditions 2 to 5 constitute a small Heckscher-Ohlin economy extended with a non-tradeable sector. In addition, in each local economy $\ell$ the employment density $n(\ell)$ is determined by (8). We let $p_A(\ell)$ be the autarky price in location $\ell$. By this, we mean the price prevailing in the absence of trade with any other location or with the rest of the world, but when labor mobility is allowed across locations.

We first note that $p_A(\ell) = p_A$ is the same in all locations regardless of its fundamentals $\{\ell, m(\ell), \lambda(\ell), \{a_i(\ell)\}_{N,M,X}\}$. For this, labor mobility is key. In the absence of labor mobility, conditions 2 to 4 would imply an autarky price that depends on relative factor endowments. However, (8) implies that the labor density is higher in places with better fundamentals. This offsets factor proportions effects, turning each local economy into a small Ricardian economy. When $\alpha_X = \alpha_M$, as we specialize later on, we simply have that $p_A = a$.

The specialization pattern can be readily characterized based on relative prices. Using (9), location $\ell$ must be fully specialized in $X$ when $p(\ell) > p_A$, and fully specialized in $M$ when $p(\ell) < p_A$. Since $p(\ell)$ is taken as given, a location that trades with either the rest of the world or with other locations is (generically) fully specialized. When $p(\ell)$ coincides with $p_A$, the location might either
export or stay in autarky. This logic also implies that an incompletely specialized location is (generically) in autarky.

To solve for the wage $w(\ell)$ we note that whenever a location is populated, the local labor supply decision (8) must be binding. Together with (7) and the clearing conditions (10) and (11), this gives the equilibrium for population density in a location that is fully specialized in $X$,

$$n(\ell) = \left[ \frac{A}{u^* a_N(\ell)^{1-\beta_T}} \frac{m(\ell) p(\ell) / e_T(p(\ell))}{a_X(\ell)} \right]^{\frac{\beta_T}{\beta_T \alpha_T + (1-\beta_T) \alpha_N}}$$

if $p(\ell) > p_A$,  \hspace{1cm} (12)

where $A$ is a constant that depends on preference and technology parameters. A similar expression holds for autarkic locations or for locations that are fully specialized in $M$.\(^7\)

Expression (12) conveys the various forces that determine the location decision of workers. Agents care about the effect of prices on both their income and on their cost of living. Our assumptions guarantee that agents employed in industry-location pair $(X, \ell)$ enjoy a higher real income when the local relative price of industry $X$ is higher in location $\ell$. That is, the income effect from a higher relative price necessarily offsets any cost-of-living effect.\(^8\) At the same time there are congestion forces, so that agents prefer to avoid places with high employment density. A higher housing share $\gamma_H$ in consumption of non-tradeables or a higher land share $1-\alpha$ in production of tradeables leads to higher congestion. Naturally, agents also prefer locations with more amenities or where absolute productivity is larger.

When $p(\ell) \neq p_A$, locations are fully specialized and necessarily export. In this circumstance $n(\ell)$ increases with the relative price of the exported good. Also, regardless of whether a location trades or is in autarky, an increase in the national real wage $u^*$ keeping relative prices constant causes workers to emigrate from $\ell$.

We summarize the properties of local equilibrium as follows.

**Proposition 1 (Local Equilibrium)** There is a unique local equilibrium where: (i) the autarky price $p_A$ is independent from $\ell$; (ii) location $\ell$ is fully specialized in $X$ when $p(\ell) > p_A$, and fully specialized in $M$ when $p(\ell) < p_A$; (iii) population density $n(\ell)$ is increasing in the relative price of the exported good and decreasing in the real wage $u^*$.

### 2.2 General Equilibrium

We have characterized the local equilibrium independently from a location’s geographic position. We move on to study how market access matters for the employment density and the specialization pattern in general equilibrium. We study a small economy that takes international prices $\{P^*_X, P^*_M\}$

\(^7\)More precisely, $A \equiv \left( \frac{1}{(1-\beta_T)^{\gamma_H} + (1-\alpha)} - 1 \right)^{\beta_T (1-\alpha) + (1-\beta_T) \gamma_H}$. See Appendix for the full derivation of (12).

\(^8\)For this note that $P_X(\ell)/e(\ell) = p(\ell) / e(p(\ell))$ is increasing in the relative price of $X$, while $P_M(\ell)/e(\ell) = 1/e(p(\ell))$ is decreasing in $p(\ell)$. 

9
as given. We let

\[ p^* = \frac{P^*_X}{P^*_M} \]

be the relative price at RoW, and we let

\[ \tau_j \equiv \frac{1}{2} \sum_{i=X,M} \tau^i_j \] for \( j = 0, 1 \)

be the average international and domestic iceberg cost across sectors. We assume that all ports inside the country face the same international price \( p^* \).

No arbitrage implies that for any pair of locations prices satisfy

\[ P_i(\ell)/P_i(\ell') \leq e^{\tau_{i[i\ell']}\ell} \text{ for } i = X, M, \ell, \ell' \in [0, \bar{\ell}] . \] (13)

This condition binds if a good in industry \( i \) is shipped from \( \ell \) to \( \ell' \). A similar condition holds with respect to RoW. Since location \( \ell = 0 \) can trade directly with RoW, (13) implies

\[ e^{-2\tau_0} \leq p(0)/p^* \leq e^{2\tau_0} . \] (14)

The first inequality is binding if the country exports \( X \) to RoW, while the second is if it imports \( X \). Therefore, for any location \( \ell \) we have

\[ e^{-2\tau_\ell} \leq p(\ell)/p(0) \leq e^{2\tau_\ell} , \] (15)

where the first inequality binds if \( \ell \) exports \( X \) to RoW, and second does if \( \ell \) imports \( X \).

We are ready to define the general equilibrium of the economy.

**Definition 2 (General Equilibrium)** An equilibrium in a small economy given international prices \( \{P^*_X, P^*_M\} \) consists of a real wage \( u^* \), local outcomes \( n(\ell), \{n_i(\ell)\}_{i = X,M}, \{\lambda_i(\ell)\}_{i = X,M,S}, c_S(\ell), c_H(\ell), w(\ell), r(\ell) \) and goods prices \( \{P_i(\ell)\}_{i = X,M} \) such that

1. given \( \{P_i(\ell)\}_{i = X,M} \) and \( u^* \), the local outcomes constitute a local equilibrium by Definition 1 for all \( \ell \in [0, \bar{\ell}] \);

2. the real wage \( u^* \) adjusts such that the national labor market clears,

\[ \int_0^{\bar{\ell}} n(\ell) \lambda(\ell) d\ell = n ; \text{ and} \] (16)

3. relative prices \( p(\ell) \) satisfy the no-arbitrage conditions (14) and (15) for all \( \ell \in [0, \bar{\ell}] \).

Since Definition 1 of a local equilibrium includes trade balance for each location, trade must also balance at the national level.
To characterize the regional patterns of specialization, we first note that the no-arbitrage conditions restrict the set of trade flows that can arise in equilibrium. In particular, there are no bilateral trade flows between any pair of locations within the country. This implies that the country is in international autarky if and only if all locations in the country are in autarky and incompletely specialized. This result is a type of spatial impossibility theorem, in the tradition of Starrett (1978). Since all locations share the same relative unit costs, there are no gains from trade within the country.

With this in mind we can characterize the general equilibrium. We can partition locations into the set of those that trade with RoW and those that stay in autarky. If the country exports $X$, then all locations that trade with RoW must also export $X$. It follows that all locations $\ell$ such that $e^{-2(\tau_0 + \tau_1 \ell)}p^* < p_A$ must stay in autarky, for if they specialized in $X$ then the relative price of $X$ would be so low that it would induce specialization in $M$. In the same way, all locations $\ell$ such that $e^{-2(\tau_0 + \tau_1 \ell)}p^* > p_A$ must specialize in $X$, for if they stayed in autarky then the relative price of $M$ would be so high that it would induce domestic consumers to import from abroad, violating the no-arbitrage condition (15).

We conclude that the distance to $\ell = 0$ is the only fundamental difference across locations. This justifies our initial statement that locations may be arbitrarily arranged on a map, as well as our decision to index locations them by their distance to the nearest port.

This reasoning implies that if the country is not in international autarky there must be some boundary $b \in [0, \ell]$ such that all locations $\ell < b$ are fully specialized in the export industry. In turn, all locations $\ell > b$ do not trade with the RoW and stay in autarky. The internal boundary $b$ divides the country between a trading "coastal region" comprising all locations $\ell \in [0, b]$ close to the international gate, and an autarkic "interior region" comprising all locations $\ell \in (b, \ell]$.

Since all locations $\ell \in (b, \ell]$ are in autarky, they are incompletely specialized and their relative price is $p_A = a$. Given this price in the autarkic region and the regional pattern of production, the no-arbitrage conditions (14) and (15) give the price distribution depending on the position of $b$:

$$p(\ell) = \begin{cases} 
p^*e^{-2(\tau_0 + \tau_1 \min[\ell, b])} & \text{if the country is net exporter of } X, \\
p^*e^{2(\tau_0 + \tau_1 \min[\ell, b])} & \text{if the country is net exporter of } M. 
\end{cases}$$

(17)

Using this relative price function we can describe the distribution of employment across locations. When the country trades with RoW, the relative price of the export industry decreases toward the interior. Using (12), we have that employment also decreases as we move away from the port. Therefore, international and domestic trade costs affect the distribution of employment across locations through their impact on the relative price gradient in (17).

To streamline the exposition, we assume from now that decreasing returns are the same in both industries: $\alpha_X = \alpha_M = \alpha$. In our quantitative application, this turns out to be the relevant case for the U.S. In the Appendix we characterize the equilibrium allowing for differences in $\alpha_i$ across sectors. In this case, condition (9) from the local equilibrium implies that the autarky price equals...
unit costs,

\[ p_A = a. \]

We assume that the economy is net exporter of \( X \). Below, we provide conditions such that this is the case. Using (12) in the aggregate labor-market clearing condition (16) we solve for the real wage,

\[
 u^* = A \left[ \frac{1}{n} \int_0^\ell x(\ell) \left( \frac{p(\ell)}{e_T(p(\ell))} \right)^{\frac{\beta_T}{\beta_T \alpha_T + (1 - \beta_T) \alpha_N}} d\ell \right]^{\frac{\beta_T \alpha_T + (1 - \beta_T) \alpha_N}{\beta_T}}. \tag{18}
\]

\( x(\ell) \equiv \lambda(\ell) \left[ m(\ell) / \left( a_X(\ell)^{\beta_T} a_N(\ell)^{1 - \beta_T} \right) \right]^{1 / \left[ \beta_T (1 - \alpha_T) + (1 - \beta_T)(1 - \alpha_N) \right]} \) captures the productivity level as well as the amount of land and amenities available at \( \ell \). Since the relative price function in (17) depends on \( b \), so does the real wage. To find the location of the boundary \( b \) we use continuity of the relative price function:

\[ p(b) \geq p_A, \quad \text{if } b < \ell. \tag{19} \]

When \( p(\ell) > p_A \) then \( b = \ell \), so that the interior region does not exist. The general equilibrium is fully characterized by the pair \( \{ u^*, b \} \) that solves (18) and (19). All other variables follow from these two outcomes.

**Figure 1: Relative Prices and Population Density over Distance**

Figure 1 illustrates the structure of the equilibrium when the economy exports good \( X \) but is not fully specialized. On the horizontal axis, locations are ordered based on distance to their nearest port. In the left panel, we have that the relative price of the exported good descends as we move away from the port until it hits the autarky relative price, and remains constant afterward. The economy is fully specialized in \( X \) in the coastal region, and incompletely specialized in the interior. In the right panel, we plot population density assuming that \( m(\ell) = m \) and \( a_X(\ell) = a \) across locations, so that international trade is the only forces that shapes the distribution of employment density. Population density also declines from away from the port in the coastal region until it...
reaches the interior region.

We summarize our findings so far as follows.

**Proposition 2 (Population and Industry Location in General Equilibrium)** There is a unique small-country equilibrium, where: (i) if the country trades and is not fully specialized, there exists an interior region \((b, \bar{r})\) that is in autarky and incompletely specialized, and a coastal region \([0, b]\) that trades with RoW and specializes in the export-oriented industry; and (ii) if \(m(\ell) = m\) and \(a_X(\ell) = a_X\), the distribution of population is uniform under international autarky and increasing toward international gates if the country trades.

These results demonstrate that international trade drives concentration of economic activity and industry location. In the absence of international trade, there are no differences in specialization patterns across locations. In contrast, when the economy trades but is not fully specialized, two discrete regions emerge: a coastal region surrounding international gates that is densely populated, connected to international markets and specialized in the export-oriented industry; and an interior region that is lowly populated, disconnected from the rest of the world and incompletely specialized.

In our reasoning so far we have assumed a given trade pattern at the national level. Next, we establish the conditions on the parameters that determine the national trade pattern and existence of the interior region.

**Proposition 3 (National Trade Pattern and Existence of Interior Region)** (i) The country exports \(X\) if \(p_A/p^* < e^{-2\tau_0}\); in that case, the interior region exists if and only if \(e^{-2(\tau_0 + \tau_1 \bar{q})} < p_A/p^*\); (ii) the country exports \(M\) if \(e^{2\tau_0} < p_A/p^*\); in that case, the interior region exists if and only if \(p_A/p^* < e^{2(\tau_0 + \tau_1 \bar{q})}\); and (iii) the country is in international autarky if \(e^{-2\tau_0} < p_A/p^* < e^{2\tau_0}\).

The first implication of these results is that domestic trade costs \(\{\tau_1^X, \tau_1^M\}\), while capable of affecting the gains and the volume of international trade, can not affect the pattern or the existence of it. In other words, the conditions that determine when international trade exists as well as the direction of international trade flows are the same as in an environment without domestic geography. The second implication is that, when the country trades, there is an interior region when trade cost \(\{\tau_1, \tau_0\}\) or the extension of land \(\bar{q}\) are sufficiently large, or when comparative advantages, captured by \(p_A/p^*\), are not sufficiently strong.

### 2.3 Impact of Changes in International and Domestic Trade Costs

We use the model to characterize the impact of international and domestic trade costs on the concentration of economic activity and the gains from trade. In the quantitative section we measure the importance of these effects.

Our motivating examples from the introduction show that international trade integration is associated with shifts in economic concentration. In our model, population density varies across locations based on the proximity to the international gate, and population density in the coastal
region relative to the interior region is endogenous. We summarize the impact of trade costs on these outcomes as follows.

**Proposition 4 (Internal Migration)** A reduction in international or in domestic trade costs moves the boundary inland to \( b' > b \) and causes migration from region \([c, \bar{T}]\) into region \([0, c]\) for some \( c \in (b, b')\). A lower \( \tau_0 \) causes population density to increase in \([0, b]\), but a lower \( \tau_1 \) causes population density to decrease at the port.

The direct impact of a reduction in trade costs is that the relative price of the exported industry increases in the coastal region. In the case of a reduction in \( \tau_0 \), the shift is uniform across locations, while a lower \( \tau_1 \) results in a flattening of the slope of relative prices toward the interior. In both cases, the change in prices causes the relative price at \( b \) to be larger than the autarky price \( p_A \), so that locations at the boundary now find it profitable to specialize in export industries and the boundary moves inland.

What are the internal migration patterns associated with these reductions in trade costs? As we show below, a consequence of lower trade costs is an increase in the real wage \( u^* \). Since in the interior relative prices remain constant, this causes labor demand to shrink. As a result, workers migrate away from locations that remain autarkic toward the coast. Relative population density increases in the coastal region.

**Figure 2: Effects of Changes in Domestic and International Trade Costs**

Figure 2 illustrates the effects. The solid black line reproduces the initial equilibrium from Figure 1. The solid red line represents a new equilibrium with lower international trade costs. The price function shifts upward and the intercept increases from \( p(0) \) to \( p_1(0) \), increasing population density at the port from \( n_1(0) \) to \( n_2(0) \). Locations in \([b, b']\) start trading, but the newly specialized locations \([c, b']\) lose population. The dashed blue line shows the effect of a reduction in domestic trade costs. Prices at the port stay constant, but the slope flattens. As a result, population density at the port shrinks from \( n_2(0) \). In relative terms, locations at intermediate distance become relatively more attractive when domestic trade costs decline.
These results reproduce the cases that we highlight in the introduction: as trade costs decline, employment migrates to coastal areas that host comparative-advantage industries. In the quantitative section, we compare the model-generated and empirical values for the coastal density \( n_C \) relative to the national average.

We conclude with the impact of domestic trade costs \( \tau_1 \) on the gains from international trade. First, we can consider two extreme cases. As \( \tau_1 \to \infty \), domestic trade becomes infinitely costly and \( b \to 0 \). In that limit, the country is in international autarky and all locations face the same relative price \( p(\ell) = p_A \). We let \( u^a \) be the real wage in that case. On the other hand, when \( \tau_1 = 0 \) then \( b = \bar{b} \) and all locations face the relative price \( p(\ell) = p(0) \). In that case, the real wage is

\[
\bar{u} = A \left( \frac{p(0)}{p_A} \right)^{\beta_T} \left( \frac{X}{n} \right)^{\beta_T \alpha_T + (1 - \beta_T) \alpha_N}
\]

where \( X = \int_0^\bar{\ell} x(\ell) \, d\ell \) is a measure of the national endowment of land and amenities, as well as of the distribution of absolute productivity levels. As in a standard Ricardian model, the real wage is increasing in the terms of trade. Here, it also depend on the share of tradeables in total expenditures. Congestion forces cause the real wage to decrease with the national labor endowment.

Using the solution for the real wage \( u^* \) from (18), the actual gains of moving from autarky to trade can be decomposed as follows,\(^9\)

\[
\frac{u^*}{u^a} = \Omega(b; \tau_1) \ast \frac{\bar{u}}{u^a}.
\]

where

\[
\Omega(b; \tau_1) = \left\{ \int_0^\bar{\ell} \frac{x(\ell) \left[ \frac{p(\ell)}{p(0)} \right]}{X \left[ \frac{p(0)}{p_A} \right]} \left( \frac{X}{p_A} \right)^{\beta_T \alpha_T + (1 - \beta_T) \alpha_N} \, d\ell \right\}^{\beta_T \alpha_T + (1 - \beta_T) \alpha_N},
\]

and the potential gains of moving from autarky to international trade are

\[
\frac{\bar{u}}{u^a} = \left( \frac{p(0)}{p_A} \right)^{\beta_T}.
\]

The actual gains from trade, \( u^*/u^a \), equal the potential gains from trade without domestic trade costs, \( \bar{u}/u^a \), adjusted by \( \Omega(\tau_1, b) \). This function captures the impact of internal geography on the gains from trade. It is a weighted average of the losses caused by domestic trade costs in each location. The weights across locations are correspond to their productivity as well as their land and amenities shares, as caputed by \( x_0(\ell) \). The location specific losses from domestic trade costs are captured by the reduction in the terms of trade. \( \Omega(\tau_1, b) \) is strictly below 1 as long as

\(^9\)There are two factors of production in this model. For the perfectly mobile factor (labor), the real income \( u^* \) is equalized across locations, while for the fixed factor (land), the real return \( r(\ell)/E(\ell) \) depends on location. In what follows, we focus our analysis on \( u^* \). However, our production technology implies that the average real return to land, \( \int_0^\bar{\ell} (r(\ell)/E(\ell)) \, d\ell \), is proportional to \( u^* \). Therefore, our statements about the real wage also apply to aggregate welfare and to aggregate income deflated at local prices.
$\tau_1 > 0$, and it equals 1 if $\tau_1 = 0$. In the quantitative section we will measure the magnitude of each component in (20).

How do the gains from trade depend on domestic trade costs? Intuitively, the larger the size of the export-oriented region, the more a country should benefit from trade. Since $\tau_1$ causes the export oriented region to shrink, we should expect the gains from trade to decrease with domestic trade costs. A lower $\tau_1$ makes exporting profitable for locations further away from the port, allowing economic activity to spread out and mitigate the congestion forces in dense coastal areas.

To formalize this, we define the elasticity of the consumer price index,

$$\varepsilon(p) = \frac{d e_T(p)/e_T(p)}{dp/p},$$

and we also define the share of location $\ell$ in total employment,

$$s(\ell) = \frac{n(\ell) \lambda(\ell)}{n}.$$

Using these definitions, we have the following result for the change in welfare when there is a change in the environment. We let $\widehat{z}$ represent the proportional change in variable $z$ when there is a change in the environment.

**Proposition 5 (Gains from International Trade)** Consider a shock to $p^*$, $\tau_0$ or $\tau_1$. Then, the change in the real wage is

$$\widehat{u}^* = \beta_T \int_0^b [1 - \varepsilon(p(\ell)))] s(\ell) \widehat{p}(\ell) d\ell. \quad (22)$$

Therefore, (i) the change in the real wage caused by a terms of trade improvement of $\widehat{p}$ is bounded above by the employment share in export-oriented locations,

$$\frac{\widehat{u}^*}{\widehat{p}} < \int_0^b s(\ell) d\ell;$$

and (ii) the gains from trade are decreasing with domestic trade costs $\tau_1$,

$$\frac{d(u^*/u^o)}{d\tau_1} < 0.$$

Expression (22) describes the aggregate gains from a reduction in trade costs, either domestic or international, as function of the relative price change faced by export-oriented locations weighted by their population shares $s(\ell)$. Reductions in domestic or international trade costs cause the relative price of the exported good to increase. This has a positive effect on revenues and a negative effect on the cost of living. The latter is captured by the price-index elasticity $\varepsilon(p(\ell))$, and mitigates the total gains. In this context, (i) shows that the gains from an improvement in the terms of trade, caused by either lower $\tau_0$ or larger $p^*$, are bounded above by the share of employment in
export-oriented regions. In turn, (ii) shows that the gains from international trade are decreasing in domestic trade costs. Larger $\tau_1$ causes relative export prices to shrink faster toward the interior, reducing the gains from trade.

2.4 Extensions

Sectorial Differences in Labor Intensity

Economies of Scale

Urban economists emphasize that agglomeration forces play an important role for the concentration of economic activity. Therefore, we include a simple form of external economies of scale. We include this effect in some of our quantitative exercises where we set the strength of the externality to match the estimates from the empirical literature. We introduce the externality in a tractable way that does not affect the structure of the equilibrium. We model a general urbanization economy whereby productivity in all tradeable industries depends on population density:

$$a_i(\ell) = a_i n(\ell)^{-\zeta} \text{ for } i = X, M.$$ (23)

In more populated locations the level of productivity is higher. So far, we allowed $a_i(\ell)$ for $i = X, M$ to vary across locations subject to (6). Here, $a_X(\ell)$ and $a_M(\ell)$ vary endogenously but are still consistent with (6).10

3 Specialization Patterns across U.S. Regions

The model predicts that regions with favorable access to world markets trade more with the rest of the world. A more specific prediction arising from comparative advantages is that export-oriented industries at the national level are more likely to locate and to employ more workers in regions with better access to international markets. In what follows, we use data at the U.S. state or county level to assess export-orientation and specialization across U.S. regions.

The first challenge in mapping the model to the data is to build a location-specific measure of market access. For each of 48 continental states and 3108 counties, we proxy market access by the shortest distance to international trade gateways. There are 288 international ports (airports, seaports or land crossings) in the mainland for U.S. goods trade. We use data on trade volume by customs district to identify the 49 largest ports that account for 90% of total U.S. trade. These ports are located in 38 different counties.11 For each U.S. state and county, we then calculate the great-circle distance between its population center and the population center of the nearest county where one of these 49 ports is located. We also compute an alternative measure that drops the

---

10This generic formulation of the external effect can be derived from different microfoundations. For example, they are equivalent to assuming economies to scale at the firm level as in Krugman (1980) in a non-tradeable intermediate input used with same intensity in both $X$ and $M$. See Abdel-Rahman and Fujita (1990).

11See Figure 5 in the Data Appendix for a map of port locations.
three inland airports.\textsuperscript{12} We defer a more detailed description of the distance measure to the data appendix and report summary statistics in Table 1. There is considerable variation in distance to the nearest port at both levels of geographical aggregation.

Table 1: Summary Statistics of the Distance Measure (miles)

<table>
<thead>
<tr>
<th>States</th>
<th>Baseline (49 ports)</th>
<th>Excluding airports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>158</td>
<td>198</td>
</tr>
<tr>
<td>St. Deviation</td>
<td>114</td>
<td>154</td>
</tr>
<tr>
<td>Median</td>
<td>140</td>
<td>145</td>
</tr>
<tr>
<td>Maximum</td>
<td>500</td>
<td>560</td>
</tr>
<tr>
<td>Minimum</td>
<td>15</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Counties</th>
<th>Baseline (49 ports)</th>
<th>Excluding airports</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>194</td>
<td>233</td>
</tr>
<tr>
<td>St. Deviation</td>
<td>121</td>
<td>145</td>
</tr>
<tr>
<td>Median</td>
<td>175</td>
<td>215</td>
</tr>
<tr>
<td>Maximum</td>
<td>571</td>
<td>637</td>
</tr>
<tr>
<td>Minimum</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

In the model, the coastal region trades a positive share of its total value added, while the interior region does not trade. Therefore, the share of trade in regional GDP decreases with distance to the international gates. Equivalently, the model predicts that the share of employment in export-oriented activities declines with distance. These measures are readily available at the state level, and we plot them against state distance in the two panels of Figure 3. Both export intensity and employment in export oriented goods decline with distance. The correlation coefficient between each of these measures and distance is negative and statistically significant. The left panel implies that a reduction in distance to international gates from 400 miles to less 100 miles results in a three-fold increase in the export to value added ratio at the state level.

To further investigate the mechanism, we consider whether this increase in export participation indeed reflects industry composition as our theory predicts. As a preliminary inspection, Figure 4 plots the export/output ratios for 85 manufacturing industries in the 4-digit North American Industry Classification System (NAICS) against the average industry distance to ports. Industry distance is a weighted average of county distance, where the weights correspond to the shares of employment across counties within each industry.\textsuperscript{13} The figure shows that, on average, industries with higher export/output ratios at the national level locate closer to ports. Table 3 in the data appendix lists these industries and reports their distances and export/output ratios.

For a more systematic analysis, we estimate the following equation using county-level data:

\[
\ln(e_{ic}) = \psi_i + \psi_c + \theta \times \ln(dist_c) \times \text{TradeBalance}_i + \varepsilon_{ic};
\]

where \(e_{ic}\) is employment of industry \(i\) at county \(c\), \(dist_c\) is the measure of market access by county, \(\text{TradeBalance}_i\) is the export orientation of industry \(i\) which equals one if the trade balance of

\textsuperscript{12}The three inland airports in the data are Atlanta, Dallas and Salt Lake City. They account for 3.6\% of total trade.

\textsuperscript{13}I.e., letting \(s_{ic}\) denote the share of industry \(i\)'s employment located in county \(c\), then industry distance is \(\bar{d}_i = \sum_c s_{ic} d_{ic}\), where \(d_{ic}\) is county \(c\)'s distance to the nearest port and \(\sum_c s_{ic} = 1\). Therefore, the larger is \(\bar{d}_i\), the farther away industry \(i\) locates from ports.
industry $i$ is positive (i.e. exports $>$ imports), and zero otherwise. Finally, $(\psi_i, \psi_c)$ are industry and county fixed effects. In the model, industry $X$ has positive trade balance, while industry $M$ has negative trade balance. Therefore our model predicts that $\theta < 0$. That is, industries with positive trade balance are more likely to locate closer to ports.

Employment and U.S. trade data are both available in the same NAICS classification system at the county level from the Bureau of Labor Statistics (BLS) and the Census Bureau Foreign Trade Division, respectively. The Quarterly Census on Employment and Wages (QCEW), published by the Bureau of Labor Statistics (BLS) reports county-level employment at various levels of industry aggregation. We use employment at 85 manufacturing industries (4-digit NAICS) in 3108 counties at year 2003. At the trade side, $TradeBalance_i$ equals one if average industry exports exceed average imports over 1997 – 2000. Out of the 85 industries, 27 have positive net exports over this time period (see Table 3 in the data appendix).

In using county-level employment data, we face data disclosure limitations. The QCEW suppresses certain district-industry cells to protect the identities of a few large employers in the area. These undisclosed cells can be distinguished from true zeros in each industry-county. In the regression, we either drop them as missing observations or we fill in a uniform number imputed from the difference between total employment in our data and aggregate manufacturing employment at the national level. We use 2003 employment levels due to the relatively high coverage compared to other years for which data is available: disclosed cells make up 60% of U.S. manufacturing employment. Table 2 reports the results.
Figure 4: Export Intensity and Average Distance to Ports Across U.S. Industries

Notes: The vertical axis uses industry export data from the Census Bureau Foreign Trade Division together with output data from the NBER-CES database. There are 85 manufacturing industries at four-digit NAICS classification. All data is averages over 2001-2005. Table 3 in the data appendix reports the industries and their export/output ratios. See the text for the definition of the distance measure in the horizontal axis. The fitted line uses industries’ employment as weights.

Each specification yields a significant negative slope for the interaction term, confirming the model prediction that $\theta < 0$. To get a sense of magnitudes, moving toward the nearest port by one standard deviation of the distance distribution (121 miles) increases employment in export oriented industries by between 1.6% and 9% relative to import competing industries. If we consider the extremes of the distance distribution, moving inland from a representative port for 400 miles, a value close to the 90th percentile of the distribution of distance, causes relative employment in export-oriented industries to shrink by between 5% and 25%.

This negative correlation between industry proximity to ports and export status suggests that domestic trade costs and international comparative advantages may play a role in the location of industries. While other forces might also be driving this correlation, we see this result as a first-pass motivating evidence in support of the theory. We now move on to quantifying the effect of domestic trade costs on the concentration of economic activity and the gains from trade using the model.
Table 2: Distance to Ports and Industry Employment Across Counties

<table>
<thead>
<tr>
<th>Dependent variable: $\ln(\text{emp})$</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\ln(\text{dist}) \times \text{TradeBalance}$</td>
<td>-0.0164**</td>
<td>-0.0130*</td>
<td>-0.0614***</td>
<td>-0.0540***</td>
</tr>
<tr>
<td>(0.00785)</td>
<td>(0.00770)</td>
<td>(0.00761)</td>
<td>(0.00736)</td>
<td></td>
</tr>
<tr>
<td>Distance measure</td>
<td>Baseline</td>
<td>Excl. airports</td>
<td>Baseline</td>
<td>Excl. airports</td>
</tr>
<tr>
<td>Undisclosed observations</td>
<td>Imputed</td>
<td>Imputed</td>
<td>Dropped</td>
<td>Dropped</td>
</tr>
<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>County fixed effects</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>N</td>
<td>259590</td>
<td>259590</td>
<td>207498</td>
<td>207498</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.419</td>
<td>0.419</td>
<td>0.564</td>
<td>0.564</td>
</tr>
</tbody>
</table>

Notes: In this table, we report the results from a linear regression of log employment at industry-county level to county and industry fixed effects, and the interaction of county distance to ports and a binary variable that equals one if the industry exports exceed its imports. The sample contains 3108 counties and 85 manufacturing industries at four-digit NAICS classification. See the text and the data appendix for the explanation of variables. Eicker-Huber-White robust standard errors in parentheses. ** Significant at 1 percent level. *** Significant at 5 percent level. * Significant at 10 percent level.

4 Quantitative Analysis

We propose a quantitative methodology to measure the impact of market access and comparative advantages. We first discipline the parameters of the model matching features of the data related to international trade. Then, we compare the model prediction for the concentration of employment with its empirical counterpart, and we compute the counter-factual gains from trade under alternative levels of domestic trade costs.

WORK IN PROGRESS

5 Conclusion

We developed and quantified a theory to characterize the interaction between international trade and the geographic distribution of economic activity within countries. We presented a framework that combines standard forces in international trade with a geographic dimension within countries. Locations within countries differ in access to international markets and congestion forces deter economic activity from concentrating in a single point.

We find that whenever an open economy is not fully specialized in what it exports, two distinct regions necessarily emerge: a specialized, high-population density region close to the port that trades internationally; and a low-population density region in the interior that stays in austerity. Even though space is continuous and trade costs are uniform, heterogeneous access to world markets is sufficient to generate a dual economy. The model is consistent with three basic facts: economic activity concentrates in areas with good access to international markets; international trade integration is correlated with migration toward these areas; and comparative-advantage industries locate in these regions. I also implies that the gains from international trade are larger when domestic trade costs are smaller.

We empirically assessed the main model prediction for industry location. Using U.S. data on
specialization at the county level, we found that U.S. export-oriented industries at the national level are more likely to locate and to employ more workers in places situated at lower distance from international gates such as seaports, airports or land crossings. Finally, in ongoing work, we calibrate the model to U.S. data to measure the importance of international trade in concentrating economic activity in coastal areas, as well as the importance of domestic trade costs in hampering the gains from trade. Our counterfactuals using the baseline model indicate that international trade can account for a non-trivial part of the concentration in coastal regions of the U.S., and that domestic trade costs, despite being small, severely reduce the gains from trade.
References


### A Proofs and Derivations

#### Proof of Proposition 1

(i) Profit maximization implies that $\pi_i(\ell) = (P_i(\ell)/a_i)^{1/(1-\alpha_i)} w(\ell)^{-\alpha_i/(1-\alpha_i)}$. Therefore, (9) implies that $\pi_X(\ell) \geq \pi_M(\ell) \iff p(\ell) \leq a$ and $\pi_X(\ell) \leq \pi_M(\ell) \iff p(\ell) \leq a$. Since autarkic locations must consume, $\lambda_i(\ell) > 0$ for $i = X, M$ and therefore (9) implies that $\pi_X(\ell) = \pi_M(\ell) \iff p(\ell) = p_A = a$. (ii) and (iii) follow from (12).

#### Proof of Proposition 2

First, we note that there are no bilateral trade flows between any pair of locations within the country. To see why, suppose that there is bilateral trade between locations $\ell_X, \ell_M$ at distance $\delta > 0$. If $\ell_X$ is the X-exporting location in the pair, the Proposition 1 implies that $p(\ell_M) \leq p_A \leq p(\ell_X)$, so that the relative price of X is larger higher in the X-exporting location. At the same time, domestic trade costs imply that the relative price of X is strictly larger in the X-importing location, as implied by (13), a contradiction. Therefore, the country is in international autarky if and only if all locations in the country are in autarky and incompletely specialized.

Since in international autarky there is no trade between locations within the country, in that case $\lambda_i(\ell) > 0$ for $i = X, M$ and $p(\ell) = p_A$ for all $\ell$. This implies that $n(\ell) = n$ and $w(\ell) = w$ in all locations. If the country is net exporter of $X$ then $n(\ell)$ is given by 12. Since $p'(\ell) < 0$ and $p/e(p)$ is decreasing with $p$, $n'(\ell) < 0$. If the economy is net exporter of $M$, then $p'(\ell) > 0$ so that $n'(\ell) < 0$. If the country is net exporter of $X$, all locations that trade with RoW must produce $X$. (15) implies that $e^{-2(\tau_0+\tau_1\ell)}p^* \leq p(\ell)$. Therefore, all locations $\ell$ such that $e^{-2(\tau_0+\tau_1\ell)}p^* > p_A$ specialize in $X$. Since the country is not fully specialized, there must be autarkic locations. If $e^{-2(\tau_0+\tau_1\ell)}p^* < p_A$ then specialization $X$ is not feasible, and the location must stay in autarky. Therefore, there must exist $b < \ell$ such $e^{-2(\tau_0+\tau_1b)}p^* = p_A$.

#### Proof of Proposition 3

(i) and (ii) If $p_A/p^* < e^{-2\tau_0}$ but the country is in international autarky or exports $M$ then the no-arbitrage conditions (14) and (15) are violated. In that case, equilibrium condition (19) implies that $b < \ell \iff p_A/p^* > e^{2(\tau_0+\tau_1\ell)}$. Similar reasoning applies when the country exports $X$. If $e^{-2\tau_0} < p_A/p^* < e^{2\tau_0}$ but the country exports $X$ or $M$ then the no-arbitrage conditions (14) and (15) are violated.

#### Proof of Proposition 5

From the labor market clearing condition (16) and the condition (19) for the boundary, any change in prices that is not caused by changes in $\{\ell, \lambda(\ell), n\}$ implies:

$$\int_0^{\ell} \frac{dn(\ell)}{n(\ell)} s(\ell) d\ell = 0. \quad (25)$$

When the economy is net exporter of $X$, we have from (12) that

$$\frac{dn(\ell)}{n(\ell)} = \frac{1}{\beta_T (1-\alpha) + (1-\beta_T) \gamma_H} \left[ \beta_T \left( \frac{dp(\ell)}{p(\ell)} - \frac{de(p(\ell))}{e(p(\ell))} \right) - \frac{du^*}{u^*} \right] \quad (26)$$

26
Using the definition of $\varepsilon(p)$ and (26) in (25) we have:

$$\frac{du^*}{u^*} = \beta_T \int_0^T [1 - \varepsilon(p(\ell))] s(\ell) \frac{dp(\ell)}{p(\ell)} d\ell$$

For (i), we have that an increase in the terms of trade imply $dp(\ell)/p(\ell) = p^*$ for all $\ell \in [0,b]$. Then, (22) gives:

$$\frac{\hat{u}^*}{\hat{p}} = \beta_T \int_0^b [1 - \varepsilon(p(\ell))] s(\ell) d\ell < \int_0^b s(\ell) d\ell.$$

where $\int_0^b s(\ell) d\ell$ is the share of employment in export-oriented locations. For (ii), we have that $d\tau_1 > 0$ implies $dp(\ell)/p(\ell) = -\ell d\tau_1 < 0$ for all $\ell \in [0,b]$ so $d(u^*/u^a)/d\tau_1 < 0$. 

27
B  Data Appendix

B.1  Construction of the distance measure

[ To be Completed ]

Figure 5: Top U.S. Ports by Export Share

Notes: The dots represent the locations of the top 49 U.S. trade gateways. Red dots are inland airports (Atlanta, Dallas and Salt Lake City) that are excluded in the alternative distance measure.
### Table 3: List of NAICS Manufacturing Industries Used in Section 3

<table>
<thead>
<tr>
<th>NAICS code</th>
<th>Industry</th>
<th>Trade Balance</th>
<th>EXP/Q</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>3361</td>
<td>MOTOR VEHICLES</td>
<td>0</td>
<td>0.104</td>
<td>73</td>
</tr>
<tr>
<td>3117</td>
<td>SEAFOOD PRODUCTS PREPARED, CANNED AND PACKAGED</td>
<td>0</td>
<td>0.044</td>
<td>83</td>
</tr>
<tr>
<td>3342</td>
<td>ELECTRONIC COMPONENTS</td>
<td>0</td>
<td>0.191</td>
<td>83</td>
</tr>
<tr>
<td>3254</td>
<td>PHARMACEUTICALS AND MEDICINES</td>
<td>0</td>
<td>0.129</td>
<td>84</td>
</tr>
<tr>
<td>3344</td>
<td>SEMICONDUCTORS AND OTHER ELECTRONIC COMPONENTS</td>
<td>0</td>
<td>0.453</td>
<td>96</td>
</tr>
<tr>
<td>3311</td>
<td>IRON AND STEEL AND Ferroalloy</td>
<td>0</td>
<td>0.095</td>
<td>98</td>
</tr>
<tr>
<td>3366</td>
<td>SHIPS AND BOATS</td>
<td>1</td>
<td>0.843</td>
<td>102</td>
</tr>
<tr>
<td>3345</td>
<td>NAVIGATIONAL, MEASURING, ELECTROMEDICAL, AND CONTROL INSTRUMENTS</td>
<td>1</td>
<td>0.277</td>
<td>103</td>
</tr>
<tr>
<td>3343</td>
<td>AUDIO AND VIDEO EQUIPMENT</td>
<td>0</td>
<td>0.626</td>
<td>104</td>
</tr>
<tr>
<td>3364</td>
<td>AEROSPACE PRODUCTS AND PARTS</td>
<td>1</td>
<td>0.432</td>
<td>105</td>
</tr>
<tr>
<td>3314</td>
<td>NONFERROUS METAL (EXCEPT ALUMINUM) AND PROCESSING</td>
<td>0</td>
<td>0.386</td>
<td>105</td>
</tr>
<tr>
<td>3334</td>
<td>COMPUTER EQUIPMENT</td>
<td>0</td>
<td>0.452</td>
<td>105</td>
</tr>
<tr>
<td>3152</td>
<td>APPAREL</td>
<td>0</td>
<td>0.126</td>
<td>106</td>
</tr>
<tr>
<td>3356</td>
<td>TEXTILES, CLOTHING, AND DYEING</td>
<td>1</td>
<td>0.095</td>
<td>107</td>
</tr>
<tr>
<td>3246</td>
<td>MAGNETIC AND OPTICAL MEDIA</td>
<td>0</td>
<td>0.252</td>
<td>107</td>
</tr>
<tr>
<td>3321</td>
<td>CROWNS, CLOSURES, SEALS AND OTHER PACKING ACCESSORIES</td>
<td>1</td>
<td>0.011</td>
<td>109</td>
</tr>
<tr>
<td>3363</td>
<td>MOTOR VEHICLE PARTS</td>
<td>0</td>
<td>0.213</td>
<td>110</td>
</tr>
<tr>
<td>3251</td>
<td>BASIC CHEMICALS</td>
<td>1</td>
<td>0.237</td>
<td>111</td>
</tr>
<tr>
<td>3359</td>
<td>ELECTRICAL EQUIPMENT AND COMPONENTS, NESOI</td>
<td>1</td>
<td>0.240</td>
<td>111</td>
</tr>
<tr>
<td>3372</td>
<td>STEEL PRODUCTS FROM PURCHASED STEEL</td>
<td>0</td>
<td>0.013</td>
<td>112</td>
</tr>
<tr>
<td>3355</td>
<td>PAINTS, COATINGS, AND ADHESIVES</td>
<td>1</td>
<td>0.077</td>
<td>113</td>
</tr>
<tr>
<td>3241</td>
<td>PETROLEUM AND COAL PRODUCTS</td>
<td>0</td>
<td>0.039</td>
<td>115</td>
</tr>
<tr>
<td>3352</td>
<td>RESIN, SYNTHETIC RUBBER, &amp; ARTIFICIAL &amp; SYNTHETIC FIBERS &amp; FILAMENT</td>
<td>1</td>
<td>0.254</td>
<td>117</td>
</tr>
<tr>
<td>3261</td>
<td>PLASTICS PRODUCTS</td>
<td>1</td>
<td>0.080</td>
<td>117</td>
</tr>
<tr>
<td>3351</td>
<td>ELECTRIC LIGHTING EQUIPMENT</td>
<td>0</td>
<td>0.124</td>
<td>117</td>
</tr>
<tr>
<td>3113</td>
<td>SUGAR AND CONFECTIONERY PRODUCTS</td>
<td>0</td>
<td>0.041</td>
<td>118</td>
</tr>
<tr>
<td>3118</td>
<td>BAKERY AND TORTILLA PRODUCTS</td>
<td>0</td>
<td>0.013</td>
<td>118</td>
</tr>
<tr>
<td>3391</td>
<td>MEDICAL EQUIPMENT AND SUPPLIES</td>
<td>1</td>
<td>0.184</td>
<td>118</td>
</tr>
<tr>
<td>3379</td>
<td>FURNITURE RELATED PRODUCTS, NESOI</td>
<td>0</td>
<td>0.012</td>
<td>119</td>
</tr>
<tr>
<td>3353</td>
<td>ELECTRICAL EQUIPMENT</td>
<td>0</td>
<td>0.227</td>
<td>119</td>
</tr>
<tr>
<td>3122</td>
<td>TOBACCO PRODUCTS</td>
<td>1</td>
<td>0.002</td>
<td>119</td>
</tr>
<tr>
<td>3352</td>
<td>HOUSEHOLD APPLIANCES AND MISCELLANEOUS MACHINES, NESOI</td>
<td>0</td>
<td>0.157</td>
<td>119</td>
</tr>
<tr>
<td>3272</td>
<td>GLASS AND GLASS PRODUCTS</td>
<td>0</td>
<td>0.175</td>
<td>120</td>
</tr>
<tr>
<td>3399</td>
<td>MISCELLANEOUS MANUFACTURED COMMODITIES</td>
<td>0</td>
<td>0.229</td>
<td>121</td>
</tr>
<tr>
<td>3365</td>
<td>RAILROAD ROLLING STOCK</td>
<td>0</td>
<td>0.136</td>
<td>122</td>
</tr>
<tr>
<td>3333</td>
<td>COMMERCIAL AND SERVICE INDUSTRY MACHINERY</td>
<td>0</td>
<td>0.302</td>
<td>122</td>
</tr>
<tr>
<td>3119</td>
<td>FOODS, NESOI</td>
<td>1</td>
<td>0.062</td>
<td>122</td>
</tr>
<tr>
<td>3335</td>
<td>METAL WORKING MACHINERY</td>
<td>0</td>
<td>0.092</td>
<td>123</td>
</tr>
<tr>
<td>3336</td>
<td>ENGINES, TURBINES, AND POWER TRANSMISSION EQUIPMENT</td>
<td>1</td>
<td>0.354</td>
<td>124</td>
</tr>
<tr>
<td>3231</td>
<td>PRINTED MATTER AND RELATED PRODUCT, NESOI</td>
<td>1</td>
<td>0.049</td>
<td>124</td>
</tr>
<tr>
<td>3325</td>
<td>HARDWARE</td>
<td>0</td>
<td>0.152</td>
<td>126</td>
</tr>
<tr>
<td>3315</td>
<td>FOUNDRIES</td>
<td>0</td>
<td>0.016</td>
<td>126</td>
</tr>
<tr>
<td>3352</td>
<td>INDUSTRIAL MACHINERY</td>
<td>0</td>
<td>0.280</td>
<td>127</td>
</tr>
<tr>
<td>3326</td>
<td>SPRINGS AND WIRE PRODUCTS</td>
<td>0</td>
<td>0.093</td>
<td>127</td>
</tr>
<tr>
<td>3114</td>
<td>FRUIT AND VEGETABLE PRESERVES AND SPECIALTY FOODS</td>
<td>0</td>
<td>0.057</td>
<td>127</td>
</tr>
<tr>
<td>3327</td>
<td>BOLTS, NUTS, SCREWS, RIVETS, WASHERS AND OTHER TURNED PRODUCTS</td>
<td>0</td>
<td>0.035</td>
<td>127</td>
</tr>
<tr>
<td>3329</td>
<td>OTHER FABRICATED METAL PRODUCTS</td>
<td>0</td>
<td>0.225</td>
<td>129</td>
</tr>
<tr>
<td>3333</td>
<td>FINISHED AND COATED TEXTILE FABRICS</td>
<td>1</td>
<td>0.046</td>
<td>129</td>
</tr>
<tr>
<td>3274</td>
<td>LIME AND GYPSUM PRODUCTS</td>
<td>0</td>
<td>0.139</td>
<td>129</td>
</tr>
<tr>
<td>3332</td>
<td>FABRICS</td>
<td>0</td>
<td>0.186</td>
<td>129</td>
</tr>
<tr>
<td>3259</td>
<td>OTHER CHEMICAL PRODUCTS AND PREPARATIONS</td>
<td>1</td>
<td>0.151</td>
<td>130</td>
</tr>
<tr>
<td>3323</td>
<td>ARCHITECTURAL AND STRUCTURAL METALS</td>
<td>0</td>
<td>0.161</td>
<td>130</td>
</tr>
<tr>
<td>3314</td>
<td>TEXTILE FURNISHINGS</td>
<td>0</td>
<td>0.061</td>
<td>130</td>
</tr>
<tr>
<td>3313</td>
<td>ALUMINA AND ALUMINUM AND PROCESSING</td>
<td>0</td>
<td>0.133</td>
<td>131</td>
</tr>
<tr>
<td>3339</td>
<td>OTHER GENERAL PURPOSE MACHINERY</td>
<td>1</td>
<td>0.338</td>
<td>131</td>
</tr>
<tr>
<td>3322</td>
<td>CUTLERY AND HANDTOOLS</td>
<td>0</td>
<td>0.137</td>
<td>131</td>
</tr>
<tr>
<td>3262</td>
<td>RUBBER PRODUCTS</td>
<td>0</td>
<td>0.141</td>
<td>132</td>
</tr>
<tr>
<td>3222</td>
<td>CONVERTED PAPER PRODUCTS</td>
<td>1</td>
<td>0.063</td>
<td>132</td>
</tr>
<tr>
<td>3362</td>
<td>FOOTWEAR</td>
<td>0</td>
<td>0.146</td>
<td>133</td>
</tr>
<tr>
<td>3359</td>
<td>APPAREL ACCESSORIES</td>
<td>0</td>
<td>0.354</td>
<td>134</td>
</tr>
<tr>
<td>3151</td>
<td>KNIT APPAREL</td>
<td>0</td>
<td>0.050</td>
<td>134</td>
</tr>
<tr>
<td>3313</td>
<td>FIBERS, YARNS, AND THREADS</td>
<td>0</td>
<td>0.052</td>
<td>135</td>
</tr>
<tr>
<td>3321</td>
<td>BEVERAGES</td>
<td>0</td>
<td>0.027</td>
<td>136</td>
</tr>
<tr>
<td>3372</td>
<td>OFFICE FURNITURE (INCLUDING FIXTURES)</td>
<td>0</td>
<td>0.049</td>
<td>137</td>
</tr>
<tr>
<td>3324</td>
<td>BOILERS, TANKS, AND SHIPPING CONTAINERS</td>
<td>1</td>
<td>0.081</td>
<td>137</td>
</tr>
<tr>
<td>3279</td>
<td>OTHER NONMETALLIC MINERAL PRODUCTS</td>
<td>0</td>
<td>0.098</td>
<td>137</td>
</tr>
<tr>
<td>3334</td>
<td>VENTILATION, HEATING, AIR-CONDITIONING ETC EQUIPMENT</td>
<td>1</td>
<td>0.170</td>
<td>137</td>
</tr>
<tr>
<td>3271</td>
<td>CLAY AND REFRACTORY PRODUCTS</td>
<td>0</td>
<td>0.136</td>
<td>139</td>
</tr>
<tr>
<td>3221</td>
<td>PULP, PAPER, AND PAPERBOARD MILL PRODUCTS</td>
<td>0</td>
<td>0.127</td>
<td>140</td>
</tr>
<tr>
<td>3161</td>
<td>LEATHER AND HIDE TANNING</td>
<td>0</td>
<td>0.406</td>
<td>140</td>
</tr>
<tr>
<td>3169</td>
<td>OTHER LEATHER PRODUCTS</td>
<td>0</td>
<td>0.291</td>
<td>143</td>
</tr>
<tr>
<td>3115</td>
<td>DAIRY PRODUCTS</td>
<td>0</td>
<td>0.183</td>
<td>143</td>
</tr>
<tr>
<td>3369</td>
<td>TRANSPORTATION EQUIPMENT, NESOI</td>
<td>0</td>
<td>0.170</td>
<td>144</td>
</tr>
<tr>
<td>3149</td>
<td>OTHER TEXTILE PRODUCTS</td>
<td>0</td>
<td>0.085</td>
<td>147</td>
</tr>
<tr>
<td>3362</td>
<td>MOTOR VEHICLE BODIES AND TRAILERS</td>
<td>1</td>
<td>0.057</td>
<td>154</td>
</tr>
<tr>
<td>3219</td>
<td>OTHER WOOD PRODUCTS</td>
<td>0</td>
<td>0.021</td>
<td>157</td>
</tr>
<tr>
<td>3371</td>
<td>HOUSEHOLD AND INSTITUTIONAL FURNITURE AND KITCHEN CABINETS</td>
<td>0</td>
<td>0.086</td>
<td>157</td>
</tr>
<tr>
<td>3311</td>
<td>AGRICULTURE AND CONSTRUCTION MACHINERY</td>
<td>1</td>
<td>0.351</td>
<td>158</td>
</tr>
<tr>
<td>3273</td>
<td>CEMENT AND CONCRETE PRODUCTS</td>
<td>0</td>
<td>0.054</td>
<td>158</td>
</tr>
<tr>
<td>3253</td>
<td>PESTICIDES, FERTILIZERS AND OTHER AGRICULTURAL CHEMICALS</td>
<td>1</td>
<td>0.216</td>
<td>161</td>
</tr>
<tr>
<td>3212</td>
<td>VENEER, PLYWOOD, AND ENGINEERED WOOD PRODUCTS</td>
<td>0</td>
<td>0.080</td>
<td>167</td>
</tr>
<tr>
<td>3211</td>
<td>SAWMILL AND WOOD PRODUCTS</td>
<td>0</td>
<td>0.095</td>
<td>170</td>
</tr>
<tr>
<td>3116</td>
<td>MEAT PRODUCTS AND MEAT PACKAGING PRODUCTS</td>
<td>1</td>
<td>0.079</td>
<td>172</td>
</tr>
<tr>
<td>3112</td>
<td>GRAIN AND OILSEED MILLING PRODUCTS</td>
<td>1</td>
<td>0.012</td>
<td>173</td>
</tr>
<tr>
<td>3111</td>
<td>ANIMAL FOODS</td>
<td>1</td>
<td>0.054</td>
<td>190</td>
</tr>
</tbody>
</table>

Notes: Trade balance equals one if exports exceed imports over 1997-2000, and zero otherwise. (EXP/Q) is export/output ratio.