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International trade and regional inequality

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Abstract: This paper studies how openness to trade can increase inequality across regions and the spatial concentration of economic activity due to the endogenous sorting of heterogeneous firms and industries across space. I embed selection into exporting and trade due to endowment-driven comparative advantage into a multi-sector economic geography model with heterogeneous firms. The model yields two novel mechanisms through which opening to trade increases the spatial concentration of economic activity, one at the firm level and another at the industry level. Firstly, firms in larger cities are more productive and will expand due to trade-induced within-industry re-allocation. Secondly, sectors located in larger cities are less labour intensive and will expand due to trade-induced across-industry reallocation according to comparative advantage in capital-rich andvanced economies. I test the model predictions using the rise in Chinese import competition vis-à-vis the United States. I find that on average a sector in a large commuting zone (at the 75th percentile of the city size distribution) loses 1.07 percentage points of employment due to the increase in Chinese import competition while the average sector in a small commuting zone (25th percentile) loses 2.09 percentage points, a loss almost twice as large. Decomposing the effect of trade on cities of different sizes I find that 53

Keywords: Globalisation, regional inequality, spatial sorting.

Commerce international et inégalités inter-régionales

Abstract : Cet article étudie l'impact de l'ouverture au commerce international sur l'accroissement des régions résultant de la sélection endogène des firmes et des secteurs sur le territoire. J'étudie ceci en intégrant de la sélection à l'exportation lié aux avantages comparatifs dans un modèle d'économie géographique multisectoriel avec des firmes hétérogènes. Le modèle met en évidence deux nouveaux mécanismes à travers lesquels l'ouverture commerciale augmente la concentration spatiale de l'activité économique. Premièrement, les entreprises des grandes villes sont plus productives et se développeront grâce à la réallocation induite par le commerce au sein d'une industrie. Deuxièmement, les secteurs situés dans les grandes villes nécessitent moins de main-d'œuvre et vont se développer en suivant l'avantage comparatif des économies avancées riches en capital. Je teste les prédictions du modèle en utilisant l'augmentation aux États-Unis de la concurrence due aux importations chinoises. Je trouve qu'en moyenne un secteur d'une grande zone de d'emploi (au 75ème centile de la répartition par taille de ville) perd 1,07 point de pourcentage d'emploi en raison de la concurrence accrue des importations chinoises, tandis que le secteur moyen d'une petite zone d'emploi (25ème centile) perd 2,09 points de pourcentage, une perte presque deux fois plus importante.En décomposant l'effet du commerce sur les villes de différentes tailles, je trouve que 53

Mots-clefs : Mondialisation, Commerce international, inégalités régionales, sélection spatiale.

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1 Introduction

The distributional effects of globalisation have come into renewed public focus in recent years. While the effects of international trade on inequality across heterogeneous workers have been studied extensively (Helpman, 2016), relatively little is known about the effect on heterogeneous regions. Are metropolitan areas like New York City differently affected by trade than countryside towns like Grand Rapids, Michigan? The positive cross-country correlation between changes in openness to trade and regional inequality presented in Figure 1 suggests they might be. Across countries, an increase in openness to trade is associated with an increase in the concentration of economic activity in bigger cities.

This paper microfounds this cross-country correlation using a theoretical model and causal estimates from reduced-form regressions to provide evidence of a causal link from trade integration to increased regional inequality. I develop an open economy model that nests a multi-sector economic geography model with heterogeneous firms. The model proposes two mechanisms through which changes in trade openness affect regional inequality, based on the spatial sorting behaviour of heterogeneous sectors and heterogeneous firms. I validate the mechanisms of the model using the rise in import competition from China vis-à-vis the United States. The regression estimates allow me to quantify the relative importance of the firm- and the industry-level mechanism for the increase in regional inequality. The firm-based mechanism accounts for roughly half of the heterogeneous effect of trade on different regions, while the industry-based mechanism and the interaction of the two account for 27% and 20%, respectively.

The mechanism on the firm level and the mechanism on the industry level both embody stylized facts from research in the fields of international trade and urban economics.

First, the firm-level mechanism builds on recent research in urban economics by Combes et al. (2012) and Gaubert (2018) who provide evidence that, within narrowly defined industries, firms in larger cities are more productive. Research in international trade has shown that opening up to trade leads to a reallocation of market share from less to more productive firms within industries (Pavcnik, 2002, Melitz, 2003). Jointly, these two stylized facts suggest that a given aggregate trade shock translates into a heterogeneous local labour demand shock across different city sizes. Smaller cities host less productive firms that are affected more negatively by a given sectoral trade shock and therefore the city faces a more negative labour demand shock in this sector. This will reallocate employment from smaller to larger cities and thereby increase regional inequality.

Second, the industry-level mechanism builds on recent work by Davis and Dingel (2015) and Gaubert (2018), who provide evidence of systematic spatial sorting of heterogeneous sectors. They find that more skill and more capital-intensive sectors are over-proportionally located in larger cities. Theories of endowment-driven comparative advantage in international trade emphasize trade-induced across-industry reallocation to capital and skill-intensive industries in countries that are abundant in these factors, e.g. advanced economies. Combining these stylized facts suggests that increasing the openness to trade has a differential effect on the sectors that are located in smaller cities relative to those in larger cities. Smaller cities host sectors that are more exposed to import competition while larger cities host those that are more exposed to an export opportunity shock from trade opening. Therefore employment will reallocate from those sectors located in smaller cities to those located in larger cities and thereby increase spatial concentration.

I integrate the multi-sector spatial general equilibrium model from Gaubert (2018) with the international trade model by Bernard et al. (2007) to open a rich economic geography to international trade. The spatial equilibrium of the model features spatial sorting of more productive firms and more capital-intensive sectors into larger cities. In the open economy equilibrium with asymmetric countries, trade occurs both across industries driven by comparative advantage, and within industries driven by firm heterogeneity and love-for-variety utility functions. I study different versions of the model to highlight the effect of the firm-based and the industry-based mechanism separately. Both mechanism can rationalize the cross-country correlation. In a version of the model with symmetric countries and therefore only within-industry trade, the city size distribution in the open economy is more concentrated than in the closed economy in line with the firm-based mechanism outlined above. In a version of the model that only features two sectors that vary in their factor intensity, the city size distribution of the country that is more capital abundant is more concentrated in the open than in the closed economy as suggested by the industry-level mechanism.

I validate the model predictions empirically using the rise in Chinese import competition from 1990 to 2007 as an exogenous trade shock for the United States following Autor et al. (2013) and Acemoglu et al. (2016). In order to bring the model to the data, I exploit the log-linear structure of the equilibrium which makes it amenable to regression analysis. To validate the firm-level mechanism, I derive an equilibrium expression for changes in employment at the city-sector level as a function of changes in import competition. The overall effect can be decomposed into an aggregate and a city-specific effect that depends on the firms located in the city. To validate the industry level mechanism, I show that in the model the city-level trade shock only depends on the sectoral composition of the city and the covariance between sectoral employment and change in import competition. In the empirical analysis I rely heavily on the model structure that implies that city size is a sufficient statistic for both the distribution of firms across different cities within a sector as well as the sectoral composition. I find strong support for the model predictions using the regressions implied by the model structure. Consistent with the firm-level mechanism, I show that conditional on the size of the aggregate trade shock the negative employment effect within a sector is significantly larger in small cities. The previous literature emphasizes variation in the labour supply elasticity across city sizes which could generate an identical pattern for changes in employment. I rule out a supply-based mechanism using regressions on the change in wages as well as the change in employment. The negative effect of import competition on both wages and employment is decreasing in city size, which is inconsistent with the labour supply channel that predicts that the effect on wages increases with city size. Instead it provides strong evidence in favour of the model mechanism, that emphasizes variation in the size of labour demand changes across different city sizes. Consistent with the industry-level mechanism, I find that smaller cities experience a significantly larger trade shock than more populated cities.

According to the empirical estimates on average a tradable sector in a commuting zone at the 75th percentile of the city size distribution lost 1.07% of its employment due to the rise in Chinese import competition while one at the 25th percentile lost 2.09%. Decomposing the effect of trade on commuting zones of different sizes I find that 53% of this difference is driven by firm heterogeneity while 27% are driven by across industry heterogeneity and the remaining 20% by their positive interaction. This decomposition allows me to differentiate between the effect of endowment-driven across-industry and within-industry trade on regional inequality. Since the largest share of the effect stems from within-industry trade it is not only trade openness to countries such as China, that differ in their comparative advantage, but also trade among advanced economies that potentially increases regional inequality.

The remainder of this paper is organized as follows. Section 2 discusses the related literature and the contribution of this paper. In section 3, I describe the model that underlies the empirical analysis presented in section 4. Section 5 concludes.

2 Related literature

This paper proposes spatial sorting as a causal mechanism through which increases in international trade affect regional inequality. This relates to a number of literatures in both international trade and economic geography.

There is a small literature that looks at how international trade affects the economic geography within a country going back to Krugman and Elizondo (1996). Recent papers include Fajgelbaum and Redding (2014), who study how an increase in openness leads to higher population densities in areas with higher access to world markets and Coşar and Fajgelbaum (2016) who document that Chinese coastal cities specialize in traded goods relative to more remote locations. This literature focuses on the importance of intra-national trade costs and looks at settings such as Argentina in the late 19th century and China where intra-national trade costs are an important transmission mechanism for the effects of external integration. This paper complements the previous literature and adds to it in three ways. Firstly, it suggests a different mechanism through which international trade effects the economic geography based on the spatial sorting behaviour of heterogeneous firms and industries. Secondly, in my empirical application I look at the economic geography of an advanced economy whose spatial distribution is governed by different forces and arguably more stable than the one of an industrialising country. Thirdly, in contrast to the previous literature that focuses more on long-term macroeconomic development issues I study the effect on regional inequality and thereby link trade to the emerging literature on regional divergence (Giannone, 2017).

Most closely related to this paper is recent work by Brülhart et al. (2015) that studies the heterogeneous effects of trade on different town sizes in Austria after the fall of the Iron Curtain. They find that larger towns tend to have larger wage and smaller employment responses than smaller towns and argue that this is driven by heterogeneity in the labour supply elasticity across different city sizes. While the focus on the heterogeneity across different city sizes is somewhat similar, we differ in the choice of model and focus of the analysis, which makes the two papers complementary. They explicitly do not consider the endogenous sorting of sectors across city sizes and do not allow for variation in the intensity of the trade shock, such that they do not eplore the two mechanisms highlighted in this paper. While the empirical analysis in this paper allows for more heterogeneity in the effect of trade they instead use a more structural approach in order to address the welfare implications. Additionally, they do not address the effects on the overall spatial concentration which is the focus of this paper.

In my empirical analysis, I build on the large literature that studies the effects of trade shocks, especially the rise in Chinese import competition, on employment and other variables in local labour markets (Kovak (2013), Autor et al. (2013)) and on the industry level (Acemoglu et al., 2016). I add to this literature in a number of dimensions. Firstly, in my model I do not treat each commuting zone as an independent small open economy but rather model the economic geography of the country explicitly. This allows me to formalize and empirically highlight the heterogeneity of the effect of import competition across different commuting zones. I also dispense with the assumption of quasi-random industry location and instead let the model guide the endogenous spatial distribution of the import competition shock. Secondly, instead of only focusing on outcomes on the commuting zone level I emphasize the effect on the aggregate spatial distribution of economic activity.

Methodologically, I build on recent empirical and theoretical advances that analyze spatial sorting of heterogeneous firms and sectors in economic geography and urban economics such as Combes et al. (2012), Davis and Dingel (2015) and Gaubert (2018). I contribute to this literature by studying the importance of spatial sorting in the open economy and how it matters for the effects of changes in trade openness. The only paper that jointly models spatial sorting and international trade is contemporaneous work by Garcia et al. (2018). Similar to this paper they also incorporate trade with heterogeneous firms into the spatial equilibrium model developed by Gaubert (2018). They study how omitting the firm decision to export might lead us to underestimate the welfare losses from sub-optimal city sizes due to zoning restrictions, as the lost agglomeration gains could have pushed firms above the Melitz (2003) threshold.

The findings of this paper are also relevant for a number of other literatures.

It adds to the large literature on the distributional effects of trade (see Helpman (2016) for a recent survey), but rather than focusing on heterogeneous effects by skill or gender it focuses on heterogeneity across less and more populated regions. The results could also be relevant for the literature in political economy that tries to understand the regional distribution of the support for populist and especially protectionist policies.

3 Theory

In this section I develop a multi-sector economic geography model with heterogeneous firms following Gaubert (2018) and integrate it with an international trade model featuring firm heterogeneity and comparative advantage (Bernard et al., 2007). Combining a rich economic geography with an international trade model allows me to capture how firm and sector heterogeneity translate an increase in openness into an increase in regional inequality. There are two countries, Home and Foreign ($k = H, F$), where Foreign can either be thought of the rest of the world or a specific country. In the empirical application I will think of Home as the United States and Foreign as China. I do not introduce any heterogeneity in terms of the economic geography of the two countries and therefore can suppress the country superscripts to ease readability when describing the spatial equilibrium.

3.1 Model setup

3.1.1 Preferences

There is a mass of N identical workers that supply one unit of labour inelastically, consume $h(L_c)$ units of housing and $c(L_c)$ units of the tradable consumption index, where L_c denotes the size of the city a given worker decides to locate in.

Workers' preferences are given by:

$$U = \left(\frac{c}{\eta}\right)^{\eta} \left(\frac{h}{1-\eta}\right)^{1-\eta}$$
$$c = \prod_{j=1}^{S} c_j^{\xi_j}$$
$$c_j = \left[\int c_j(i)^{\frac{\sigma_j-1}{\sigma_j}} di\right]^{\frac{\sigma_j}{\sigma_j-1}}$$

where $\sum_{j=1}^{S} \xi_j = 1$. Workers maximize their utility subject to the budget constraint $Pc(L_c) + p_H h(L_c) = w(L_c)$, where P is the CES price index of the tradable consumption bundle (c), p_H is the price of housing and the income is given by the wage $w(L_c)$ given inelastic unit labour supply.

3.1.2 Housing and cities

There is a large number of ex-ante identical potential city sites in each country with an immobile amount of land normalized to one ($\gamma = 1$), that is owned by absentee landowners. There are no trade costs between cities within a country. [1] Housing is immobile and produced according to the following production function:

$$h^S = \gamma^b \left(\frac{\ell}{1-b}\right)^{1-b} \tag{1}$$

Given the structure on housing demand and supply the equilibrium in the housing market implies that the amount of housing consumed in equilibrium is given by:

$$h(L_c) = (1-\eta)(1-b)L_c^{-b} \tag{2}$$

The amount of housing consumed is smaller in larger cities since the increase in housing production is constrained by the fixed amount of land. If we impose spatial equilibrium, i.e. that utility is equalized across space ($V(p_H, P, w) = \bar{U}$) we can derive the equilibrium wage as a function of city size:

$$w(L_c) = \bar{w}((1-\eta)L_c)^{b\frac{1-\eta}{\eta}} \tag{3}$$

1. This assumption is not crucial for any of the results but eases tractability.

where $\bar{w} = \bar{U}^{\frac{1}{\eta}} P$ is taken as numeraire. The wage increases with city size. This acts as a congestion cost that counterbalances the gains in productivity from agglomeration.

3.1.3 Production

The economy consists of a number of tradable sectors indexed by $j = 1, .., S$. Each sector is populated by a mass of firms that differ in their exogenously given raw efficiency (z). Firms compete according to monopolistic competition and each firm produces a unique variety (i) using the following production technology:

$$y_j(z, L_c) = \psi(z, L_c) k^{\alpha_j} \ell^{1-\alpha_j} \tag{4}$$

where the Hicks-neutral productivity shifter ψ depends on the raw efficiency draw of the firm (z) and the city size the firm locates in (L_c). Sectors are also heterogeneous with respect to the factor share (α_j) of inputs capital (k) and labour(ℓ).

Firm entry and location choice Firm entry closely follows the setup in Melitz (2003). Firms initially pay a sunk market entry cost (f_{E_j}) and draw their raw efficiency z from cumulative distribution function $F_j(z)$. After the realization they decide whether to start producing or to exit immediately. If they decide to produce they choose which city size (L_c) to locate in and whether to only produce for the domestic market, paying per period fixed cost f_{P_j}, or to also export paying per period fixed cost f_{X_j}. Firms die with an exogenous probability δ. In order to match the stylized fact that more productive firms are located in larger cities Gaubert (2018) assumes there is a complementarity between raw efficiency (z) and city size (L_c) such that ex-ante more productive firms increase their productivity by more by location in a larger city. I maintain her assumption that $\psi(z, L_c)$ is strictly log-supermodular in city size (L_c) and firm raw efficiency (z), and is twice differentiable:

$$\frac{\partial^2 log\psi(z, L_c)}{\partial L_c \partial z} > 0$$

In order to ensure a unique solution for the location problem of the firm the additional regularity condition that the elasticity of productivity with respect to city size is decreasing has to be imposed.

Firm problem Firm profits can be decomposed into profits from domestic and exporting activity $\pi = \pi^d + \pi^x$. Conditional on entry the firm maximises both domestic and exporting profits such that the firm problem is given by:

$$\max_{k,\ell,p_j^d,p_j^x,L_c,n} \pi_j = (1+T(L_c))(p_j^d \psi_j(z_i,L_c) k^{\alpha_j} \ell^{1-\alpha_j} - w_H(L_c)\ell - \rho_H k - P^H f_{P_j})$$
$$+ n(1+T(L_c))(p_j^x \tau_j^{-1} \psi_j(z_i,L_c) k^{\alpha_j} \ell^{1-\alpha_j} - w_H(L_c)\ell - \rho_H k - P^H f_{X_j})$$

where firms choose optimal factor inputs capital (k) and labour (ℓ), whether to export or not (n), optimal prices for the home market (p_j^d) and the foreign market (p_j^x) (if applicable), and in which city size (L_c) to locate in. $T(L_c)$ is a subsidy proportional to profits paid by city developers to attract firms. Given CES demands and monopolistic competition firms set prices at a constant mark-up over marginal cost. The profit function of a firm that locates in city size L_c is given by:

$$\max_{L_c} \pi_j = \tilde{\kappa}_{1j} \rho_H^{-\tilde{\alpha}_j} (1+T_j(L_c)) \left(\frac{\psi(z,L_c)}{w_H(L_c)^{1-\alpha_j}} \right)^{\sigma_j - 1} R_j^H P_j^{H^{\sigma_j-1}} - (1+T_j(L_c)) P f_{P_j} \tag{5}$$
$$+ n(1+T_j(L_c)) \left[\tilde{\kappa}_{1j} \rho_H^{-\alpha(\sigma_j-1)} \left(\frac{\psi(z,L_c)}{w_H(L_c)^{1-\alpha_j}} \right)^{\sigma_j-1} \tau_j^{1-\sigma_j} R_j^F P_j^{F^{\sigma_j-1}} - P f_{X_j} \right]$$

where $\tilde{\kappa}_{1j} = \frac{((1-\alpha_j)^{1-\alpha_j} \alpha_j^{\alpha_j} (\sigma_j-1))^{\sigma_j-1}}{\sigma_j^{\sigma_j}}$ and $\tilde{\alpha}_j = \alpha_j(\sigma_j - 1)$.

3.1.4 City developers

In order to avoid a coordination failure an agent at the city-level is needed that coordinates firms, workers and land-owners. There is one city-developer per potential site that maximizes profits and opens a city of given size if there is a demand for this city size. City-developers earn income through fully taxing the income of land-owners. They pay a subsidy proportional to profits ($T(L_c)$) in order to attract firms and compete according to perfect competition. They solve the following problem:

$$\max_{\{T_j(L_c)\}_{j \in 1,\ldots,S}} \Pi_{L_c} = b(1-\eta) w(L_c) L_c - \sum_{j=1}^{S} \int_z T_j(L_c) \frac{\pi_j(z,L_c)}{1+T_j^i(L_c)} \mathbb{1}_j(z,L_c) f_j(z) dz \tag{6}$$

where $\pi_H(L_c) = b(1-\eta)L_c w(L_c)$ is the profit earned by the fully taxed landowners and $\mathbb{1}_j(z, L_c)$ is equal to 1 if firm z chooses to locate in this city and 0 otherwise.

3.2 Definition of the spatial equilibrium

The construction of the spatial equilibrium is qualitatively equivalent to the equilibrium in Gaubert (2018). The spatial equilibrium is given by:

(i) workers maximize utility given prices

(ii) utility is equalised across all inhabited cities

(iii) firms maximize profits given factor prices and the aggregate price index

(iv) landowners maximize profits given prices

(v) city developers maximize profits given the wage schedule and the firm problem

(vi) National capital and international goods market clear, and the housing and the labour market in each city clear

(vii) capital is optimally allocated, and

(viii) firms and city developers earn zero profits.

Since the introduction of international trade does not alter the structure of the equilibrium the existence and uniqueness proof in Gaubert (2018) still applies.

3.3 Constructing the spatial equilibrium

3.3.1 Subsidy

As the city developer problems is not affected by international trade it solves the same problem as in Gaubert (2018) such that the same lemma applies:

Lemma 1 ((Lemma 2 in Gaubert (2018))) *In equilibrium, city developers offer and firms take-up a constant subsidy to firms' profit $T_j^* = \frac{b(1-\eta)(1-\alpha_j)(\sigma_j-1)}{1-(1-\eta)(1-b)}$ for firms in sector j, irrespective of city size L_c or firm type z.*

Proof. The proof can be found in appendix C in Gaubert (2018).

3.3.2 Matching function

Whenever there is demand for a given city size, it is profitable for a city developer to open a city of that size. Workers are by the definition of the spatial equilibrium indifferent across locating in different city sizes. Firms are not indifferent across different city sizes as their profits vary with city size. The demand for cities is therefore determined by firms' location decisions. Given the subsidy derived above the variable profit of firms that only serve the domestic market and those that serve both the domestic and the foreign market are given by:

$$\max_{L_c} \pi_j^d = \tilde{\kappa}_{1j} \rho_H^{-\alpha(\sigma_j - 1)} (1 + T_j^*) \left(\frac{\psi(z, L_c)}{w_H(L)^{1-\alpha_j}} \right)^{\sigma_j - 1} R_j^H (P_j^H)^{\sigma_j - 1} \tag{7}$$

$$\max_{L_c} \pi_j^{d,x} = \tilde{\kappa}_{1j} \rho_H^{-\alpha(\sigma_j - 1)} (1 + T_j^*) \left(\frac{\psi(z, L_c)}{w_H(L)^{1-\alpha_j}} \right)^{\sigma_j - 1} \left[R_j^H (P_j^H)^{\sigma_j - 1} + \tau_j^{1-\sigma_j} R_j^F P_j^{F^{\sigma_j - 1}} \right]$$

Note that the resulting first-order conditions only depend on the trade-off between gains from agglomeration ($\psi(z, L_c)$) and congestion costs ($w_H(L_c)$) and is independent of all other general equilibrium quantities. A crucial implication of this separability is that the optimal location decision is the same for exporters and non-exporters. The resulting first order condition that determines the optimal city size to locate in is given by:

$$\frac{\psi_{L_c}(z, L_c) L_c}{\psi(z, L_c)} = (1 - \alpha_j) b \frac{1 - \eta}{\eta}$$

where $\psi_{L_c}(z, L_c) = \partial \psi(z, L_c) / \partial L_c$. This "matching function" ($L_{cj}^*(z)$) implicitly defines L_c as a function of z and therefore matches firms of different productivities to different city sizes for each sector. It accounts for firm and sector heterogeneity and generates spatial sorting across both dimensions. More capital-intensive sectors experience a lower congestion cost which enters scaled by the labour-intensity of production $(1 - \alpha_j)$ and the productivity of more efficient firms grows faster with city size due to the assumed complementarity. As the matching function is unaffected by trade it is the same as in the model by Gaubert (2018) and therefore has the following properties that were derived in that model:

$$L_{cj}^*(z) = \underset{L_c \in \mathcal{L}_c}{\operatorname{argmax}} \, \pi_j^*(z, L_c)$$

The matching function $L_c^*(z)$ is increasing in z such that there is positive assortative matching between firm raw efficiency z and city size L_c and the set of city sizes in equilibrium ($\mathcal{L}$) is efficient (see Gaubert (2018) for a more detailed discussion).

3.3.3 General equilibrium

The general equilibrium has been determined up to the following set of variables: The producitivty cut-offs of entry to the home market (z_j^{kd}) and the export market (z_j^{kd}), where $k \in \{H, F\}$, $m \in \{H, F\}$ and $k \neq m$ denote Home and Foreign and $j = 1, ..., S$ indexes industries, and the sector specific price level (P_j^k); overall expenditure on tradable goods (R^k); the rental rate of capital (ρ_k); and the wage (w_k), where the wage in Home is already pinned down by choosing $\bar{w}$ as the numeraire.

The free entry condition (equation 8) for each sector $j = 1, ..., S$ and country $k \in \{H, F\}$ is given by:

$$\begin{aligned} \big(f_{E_j} + &(1 - F(z_j^{kd}))f_{P_j} + (1 - F(z_j^{kx}))f_{X_j}\big)P^k \\ &= \tilde{\kappa_{1j}}\rho_k^{-\tilde{\alpha}_j}\left[R_j^k(P_j^k)^{\sigma_j - 1}S(z_j^{kd}) + \tau_j^{1-\sigma_j}R_j^m(P_j^m)^{\sigma_j-1}S_j(z_j^{kx})\right] \end{aligned} \tag{8}$$

where f_{E_j} is the units of the final good paid as sunk cost of entry, and z_j^{kd} and z_j^{kx} are the raw efficiency cut-offs for entering the domestic and the export market, respectively.

The zero profit cut-off condition for entering the domestic market (equation 9) and the export market (equation 10) in each sector j and country $k \in \{H, F\}$ are given by:

$$P^k f_{P_j} = \tilde{\kappa_{1j}}\rho_k^{-\tilde{\alpha}_j}R_j^k(P_j^H)^{\sigma_j-1}C_j(z_j^{kd}) \tag{9}$$

$$P^k f_{X_j} = \tilde{\kappa_{1j}}\rho_k^{-\tilde{\alpha}_j}R_j^m(P_j^m)^{\sigma_j-1}\tau_j^{1-\sigma_j}C_j(z_j^{kx}) \tag{10}$$

where $\tilde{\alpha}_j = \alpha_j(\sigma - 1)$.

The goods market clearing condition (equation 11) and the equilibrium price index (equation 12) for each sector j and country $k \in \{H, F\}$ are given by:

$$R_j^k = \tilde{\kappa_{1j}}\rho_k^{-\tilde{\alpha}_j}M_j^k\left[R_j^k(P_j^k)^{\sigma_j-1}S_j(z_j^{kd}) + R_j^m(P_j^m)^{\sigma_j-1}\tau_j^{1-\sigma_j}S_j(z_j^{kx})\right] \tag{11}$$

$$1 = \tilde{\kappa_{1j}}\sigma_j\left[M_j^k S(z_j^{kd}) + \tau_j^{1-\sigma_j}M_j^m S(z_j^{mx})\right](P_j^k)^{\sigma_j-1} \tag{12}$$

The factor market clearing conditions for capital (equation 13) and labour (equation 14) for each country $k \in \{H, F\}$ is given by:

$$\begin{aligned}\bar{K}_k =& \sum_{j=1}^{S} \tilde{\kappa_{1j}} \rho_k^{-\tilde{\alpha}_j} \frac{(\sigma_j - 1)(\alpha_j)}{\rho_k} M_j^k \\ & \times (R_j^k (P_j^k)^{\sigma_j - 1} S_j(z_j^{kd}) + \tau_j^{1-\sigma_j} R_j^m (P_j^m)^{\sigma_j - 1} S_j(z_j^{kx})) \end{aligned} \tag{13}$$

$$\begin{aligned}\bar{N}_k =& (1-b)(1-\eta)\bar{N}_k + \sum_{j=1}^{S} \tilde{\kappa_{1j}} \rho_k^{-\tilde{\alpha}_j} (\sigma_j - 1)(1-\alpha_j) M_j^k \\ & \times (R_j^k (P_j^k)^{\sigma_j - 1} E_j(z_j^{kd}) + \tau_j^{1-\sigma_j} R_j^m (P_j^m)^{\sigma_j - 1} E_j(z_j^{kx})) \end{aligned} \tag{14}$$

where $S(z_j^A), C(z_j^A)$ and $E(z_j^A)$ are normalized values of sectoral sales and employment that are fully determined by the matching function $L_{cj}^*(z)$ for each sector:

$$E_j(z_j^A) = \int_{z_j^A} \mathbb{1}_A(z) \frac{\psi(z, L_{cj}^*(z))^{(\sigma_j - 1)}}{\left[(1-\eta) L_{cj}^*(z)\right]^{\frac{b(1-\eta)(1+(1-\alpha_j)(\sigma_j-1))}{\eta}}} f_j(z) dz$$

$$S_j(z_j^A) = \int_{z_j^A} \mathbb{1}_A(z) \left(\frac{\psi(z, L_{cj}^*(z))}{\left[(1-\eta) L_{cj}^*(z)\right]^{\frac{b(1-\eta)(1-\alpha_j)}{\eta}}} \right)^{\sigma_j - 1} f_j(z) dz$$

$$C_j(z_j^A) = \left(\frac{\psi(z_j^A, L_{cj}^*(z_j^A))}{\left((1-\eta) L_{cj}^*(z_j^A)\right)^{\frac{b(1-\eta)(1-alpha_j)}{\eta}}} \right)^{\sigma_j - 1}$$

where $A = d, x$ distinguishes between the domestic market and the export market and $\mathbb{1}_A(z)$ is equal to one if a firm with raw efficiency level z serves market A. Note that the sector-specific expenditure $R_j^k = \xi_j^k R^k$ is fully determined by R^k.

3.3.4 City size distribution

The equilibrium city size distribution is jointly determined by the matching function as determined by the firm problem and the city developers problem. Given the labour market clearing condition, the population living in a city of size L_c or smaller must equal the labour demand of all firms located in these city sizes and employment in construction:

$$\int_{L_{min}}^{L_c} u f_{L_c}(u) du = \sum_{j=1}^{S} M_j \int_{z_j^*(L_{min})}^{z_j^*(L_c)} \ell_j(z, L_{cj}^*(z)) f(z_j) dz_j + (1-\eta)(1-b) \int_{L_{min}}^{L_c} u f_{L_c}(u) du$$

where $L_{min} = inf(\mathcal{L})$ is the smallest city size in equilibrium. Differentiating this yields the city size density function:

$$f_{L_c}(L_c) = \kappa_4 \frac{\sum_{j=1}^{S} M_j \mathbb{1}_j(L) \ell_j(z_j^*(L_c)) f_j(z_j^*(L_c)) \frac{dz_j^*(L_c)}{dL_c}}{L_c}$$

where $\kappa_4 = \frac{1}{1-(1-\eta)(1-b)}$ and $\mathbb{1}_j(L_c)$ indicates whether firms of sector j are located in city size L_c or not.

3.4 Equilibrium properties

I use this model to study the effects of trade on the spatial concentration of economic activity. To simplify the analysis and to closely identify the mechanisms linking trade openness to regional inequality, I study the effects of within- and across-industry trade separately in different versions of the model.

3.4.1 Within-industry trade

To isolate the effect of within-industry trade on the city size distribution and therefore the spatial concentration of the economy I focus on the symmetric country case which does not feature any across-sector reallocations.

Proposition 1 *If both countries are symmetric, the city size distribution in the open economy first-order stochastically dominates the city size distribution in the closed economy.*

In the symmetric country case trade only happens within industries such that it does not induce any across-industry reallocations. Across firms within an industry trade induces a reallocation of market share and employment from less to more productive firms as in the standard Melitz model. Note that given the log-supermodularity of productivity and optimal firm behaviour the real productivity (productivity net of congestion cost) increases with city size. Hence, the reallocation from less to more productive firms implies a reallocation from small to larger cities for each sector j. The less productive firms that exit and shrink are located in smaller cities and the more productive firms that expand employment are located in larger cities. This spatial reallocation leads to a higher spatial concentration of sectoral employment in larger cities, in fact the spatial distribution of employment in sector j in the open economy first-order stochastically dominates the distribution of employment in the closed economy. Since this holds for all sectors the overall city size distribution shifts to the right. [2]

3.4.2 Across-industry trade

To isolate the effects of across industry trade it is useful to put some bounds on the heterogeneity in the model. In particular, I analyse a version of the model withouth firm heterogeneity, which shuts down any interactions between firm and sector heterogeneity but does not affect the basic intuition.

Proposition 2 *In a two sector version of the model with no heterogeneity in raw-efficiencies, if the other country is relatively labour-abundant, then the city size distribution in the open economy first-order stochastically dominates the city size distribution in the closed economy.*

Opening up to trade implies a fall in the relative price of capital from cost minimization and factor market clearing. This leads to a rise in the share of both factors employed in the capital intensive industry. Since factor endowments remain unchanged employment in the capital-intensive sector increases while employment in the labour-intensive sector decreases. In spatial equilibrium more capital-intensive sectors are located in larger cities, as they are less affected by the congestion cost which is scaled by the labour intensity of production. In this version of the model the distribution of employment across city size in the capital-intensive sector first-order stochastically dominates the distribution in the labour-intensive sector. Hence, the reallocation of employment to the capital-intensive sector implies a reallocation of employment to the larger cities such that the distribution of population in the open economy first-order stochastically dominates the distribution in the closed economy. Therefore endowment-driven across-industry trade leads to spatial concentration in countries that have a comparative advantage in capital-intensive industries. [3]

A similar logic applies if we think about a world that uses unskilled and skilled labour in production rather than capital and labour. In this world it is sensible to assume that advanced economies have a comparative advantage in industries that use skilled labour intensively. Empirically, these are located in larger cities (Davis and Dingel, 2015) and in the model they would locate in larger cities if

2. A more detailed discussion can be found in the online appendix.
3. A more detailed discussion can be found in the online apendix.

the relative price of skilled labour decreases with city size which is in line with empirical evidence (Bernard et al., 2008). Alternatively, this location pattern could be modelled based on differences in the gains from agglomeration between high- and low-skilled labour as done by Davis and Dingel (2015) rather than differences in relative wages. However, the model based on relative factor prices is isomorphic to the one based on differences in the strength of agglomeration with respect to trade-induced across-industry reallocations.

3.4.3 Linking the model to increases in Chinese import competition

So far we have highlighted how an increase in either within or across industry trade increases the spatial concentration of economic activity in simplified versions of the model. Hence, the model can replicate the cross-country evidence from figure 1 and provides two different potential mechanisms to microfound the aggregate correlation. In order to test these two model mechanisms and evaluate them quantitatively I map the model equations into a regression framework. I estimate the derived equations using the exogenous increase in import competition in China vis-à-vis the United States.

Within-industry trade The sorting of heterogeneous firms in the same industry across space determines how an aggregate trade shock translates into a labour demand shock at the local level. In the model employment in sector j in city size c is given by:

$$L_{cj} = \tilde{\kappa}_{2j} \rho^{-\tilde{\alpha}_j} M_j^k \left(E_j^{kd}(\underline{z}_{cj}^k, \overline{z}_{cj}^k)(P_j^k)^{\sigma_j - 1} R_j^k + \tau_j^{1-\sigma_j} E_j^{kx}(\underline{z}_{cj}^k, \overline{z}_{cj}^k)(P_j^m)^{\sigma_j - 1} R_j^m \right) \tag{15}$$

where $\underline{z}_{cj}^k$ and $\overline{z}_{cj}^k$ denote the smallest and the largest level of raw efficiency draws that make a firm in sector j locate in city size L_c. Log-linearising the equation above implicitly yields:

$$\hat{L}_{cj} = h_{cj}(\hat{\rho}, \hat{M}_j^H, \hat{B}_j^H \hat{\underline{z}}_{cj}^{Hd}(L_c), \hat{\overline{z}}_{cj}^{Hd}(L_c), \hat{B}_j^F \hat{\underline{z}}_{cj}^{Hx}(L_c), \hat{\overline{z}}_{cj}^{Hx}(L_c) \tag{16}$$

where I am able to write $\hat{z}$ as a function of L_c rather than z due to the one-to-one mapping implied be the matching function which implies that city size is a sufficient statistic for the productivity level of firms within a city:

Equation (16) implies that the employment effects of an aggregate trade shock are heterogeneous across city sizes. In order to map this equation to the change in import competition I will have to assume that any change in sector aggregates are only related to changes in import competition. This is a fundamental assumption but implied by the idea that the import competition shock is exogenous. Since the city-size-specific term captures entry and exit of firms due to trade-induced shifts in the cut-off this amplifies the negative aggregate effect of an import competition shock for smaller cities where the firms that are close to the productivity cut-off are located. Therefore the model predicts that the employment effect of a given trade shock is smaller in larger cities.

Note that in this paper I use a broad definition of the firm. In particular I do not take a stance on whether the heterogeneity in productivity across firms within a sector captures heterogeneity across firms or across different plants within a firm, or across different tasks within or across firms.

Across-industry trade The extent to which a region is affected by an increase in Chinese import competition depends on the sectoral composition of its employment which is determined by the spatial sorting of heterogeneous sectors. The average exposure of a tradable sector located in city size c to Chinese import competition is given by:

$$\Delta Imp_c = \sum_j \frac{L_{cj}}{\bar{L}_c} \Delta Imp_j$$

where ΔImp_j is the change in imports relative to initial domestic absorption. L_{cj} is the employment in sector j in city size c and $\bar{L}_c$ is the overall employment or population in city size c. The model expressions for L_{cj} and $\bar{L}_c$ can be used to generate a model prediction for the variation in the average exposure to the import competition shock across different locations:

$$\Delta Imp_c = \sum_j \frac{L_{cj}(L_c, \alpha_j)}{\bar{L}_c(L_c)} \Delta Imp_j(\alpha_j) \tag{17}$$

where we have assumed that the intensity of the import competition shock systematically decreases with the capital-intensity of an industry, which follows quite naturally from the fact that China is a labour-abundant country. Since L_{cj} is a function of both L_c and α_j the variation of ΔImp_c is driven by the sorting of industries across different city sizes in the model.

4 Empirics

4.1 Data

I test the prediction of the model on data from the United States using the increase in import competition from China between 1991 and 2007 as an exogenous shock. In my empirical strategy, as well as the data and definitions used, I closely follow the previous literature (Autor et al., 2013, Acemoglu et al., 2016). Throughout the paper I present results estimated on the stacked sub-periods 1991 to 1999 and 1999 to 2007.

Trade data I use the data on sectoral trade flows that were used and provided by Acemoglu et al. (2016) and Feenstra et al. (2017). They provide trade flows for 392 manufacturing and industries at the 4-digit SIC code level. The data of trade flows was originally downloaded form comtrade and subsequently transformed into real 2007 dollars.[4]

Employment data To get data on the employment of industry j in commuting zone c I follow the approach by Autor et al. (2013). I obtain data on local industry composition in 1991, 1999 and 2007 from the County Business Patterns (CBP). The CBP provides information on employment, payroll and firm-size distribution by county and industry. In order to avoid disclosure some establishments are not identified at the most disaggregated level and sometimes employment is only reported as an interval rather than a number. I use the algorithm developed by Autor et al. (2013) to impute employment by county and 4-digit SIC code. I then aggregate this data to the commuting zone level using cross-walks provided by David Dorn.[5] The detailed procedure of the algorithm is outlined in the online appendix in Autor et al. (2013). This gives a panel of observations at the industry-commuting zone level for 722 commuting zones and 392 industries for two periods.

While the main regressions are run on the industry-commuting zone level, for some robustness checks that require wage data not available on the industry-

4. A more detailed discussion on the preparation of the trade data can be found in Acemoglu et al. (2016).

5. These cross-walks can be found at www.ddorn.net/data.htm

commuting zone level I use data at the commuting zone level provided by Autor et al. (2013). This dataset consists of commuting zone specific import competition shocks, and changes in wages and employment for the periods 1990 to 2000 and 2000 to 2007.

4.2 Estimation

4.2.1 Within-industry trade and firm heterogeneity

To test the model predictions I estimate an empirical counterpart to equation (16) for which I assume that the city-size specific part of the effect is linear in population size ($g(\Delta Imp_j, L_c) = \Delta Imp_{jt} \times L_{ct}$) which yields the following estimation equation:

$$\Delta L_{cjt} = \beta_0 + \beta_1 \Delta Imp_{jt} + \beta_2 L_{ct} + \beta_3 \left[\Delta Imp_{jt} \times L_{ct}\right] + \epsilon_{cjt} \tag{18}$$

where ΔL_{cjt} is the log change in employment in commuting zone c in sector j in period t multiplied by 100. ΔImp_{jt} denotes the change in imports from China in sector j and L_{ct} denotes the population in commuting zone c at the beginning of period t. The regressions are weighted by initial employment in each industry-commuting zone cell and standard errors are clustered at the three digit SIC level. The intuition outlined above predicts that $\beta_1 < 0$ and $\beta_3 > 0$. I estimate these equations using a 2SLS approach instrumenting endogenous trade flows from China to the US ($\Delta Imp_{jt}^{US,Ch}$) with trade flows from China to other advanced economies ($\Delta Imp_{jt}^{Ot,Ch}$) as in Acemoglu et al. (2016). The variables are defined as follows:

$$\begin{aligned} \Delta Imp_{jt}^{US,Ch} &= \frac{\Delta M_{jt}^{US,Ch}}{Y_{j91} + M_{j91} - E_{j91}} \\ \Delta Imp_{jt}^{Ot,Ch} &= \frac{\Delta M_{jt}^{Ot,Ch}}{Y_{j88} + M_{j88} - E_{j88}} \end{aligned}$$

Import flows (ΔM_{jt}) are normalized by apparent consumption (production (Y) plus imports (M) minus exports (E)) at the beginning of the period, and before the period for the instrument, to avoid introducing any endogeneity through anticipation effects.

Results The main results are presented in Table 1. [6]. The first column corroborates that the aggregate effect of an import competition shock is still negative when splitting industries into industry-commuting zone cells. Including the interaction term in column 2 yields an estimate of 1.23 which is statistically significant at the 1% level. The theory linked to this regression emphasises a within-industry mechanism such that I try to remove as much across-industry variation from the regression as possible and my favourite specification includes four digit sector fixed effects (columns 3 and 4). The resulting coefficients are highly statistically significant and the point estimate is 0.94 when including regional fixed effects. So a one percentage point rise in industry import penetration reduces industry level employment by around three percentage points in a commuting zone with a population of a log point above the mean, while it reduces it by four percentage points in a mean-sized commuting zone. To study the robustness of this effect I introduce more granular fixed effects in table 2. The magnitude of the coefficients varies according to the identifying variation but they remain significant when including different set of fixed effects up to (four digit industry $\times$ region $\times$ time) fixed effects.

While this evidence is in line with the predictions of the model that an import competition shock translates into a more negative labour demand shock in less populated commuting zones because of the spatial sorting of heterogeneous firms, it is also consistent with other mechanisms. The most apparent alternative explanation is based on variation in the labour supply elasticity across different city sizes as identified by Brülhart et al. (2015) for border towns in Austria. The empirical pattern of relative changes in employment could be generated from a uniform labour demand shock across city sizes if the labour supply elasticity was decreasing with city size. While the demand and the supply-driven explanations have identical implications for changes in employment, they have different implications for wages. A supply-driven model suggests that the effect of an import competition shock on wages would be less negative in smaller cities and more negative in larger cities. The demand driven mechanism in my model on the other hand predicts that the effect on wages should also be smaller in bigger cities or equal across city sizes depending on the elasticity of labour supply, which is constant across city sizes.

I use these differentiating predictions on changes in the wage in order to empirically rule out the labour supply driven explanation. Unfortunately, I cannot

6. The corresponding first stage regressions can be found in Table 6 and 7

use the CBP data to do this as, due to the omissions in the data, I cannot obtain a credible average wage on the sector-commuting zone level. Instead, I rely on the wage data from the Census Integrated Public Use Micro Samples (Ruggles et al., 2017) to generate an average wage on the commuting zone level. Since census data is not available for every year before 2000 I adjust the periods to 1990 - 2000 and 2000 - 2007. In particular, I use the dataset developed by Autor et al. (2013) that provide changes in employment and wages at the commuting zone level as well changes in Chinese import competition shocks at the commuting zone level, which are defined as follows:

$$\Delta Imp_{ct}^{US} = \sum_j \frac{L_{cjt}}{L_{ct}} \frac{\Delta M_{jt}^{US,Ch}}{L_{jt}}$$

$$\Delta Imp_{ct}^{Ot} = \sum_j \frac{L_{cjt}}{L_{ct}} \frac{\Delta M_{jt}^{Ot,Ch}}{L_{jt-1}}$$

I run their baseline regression augmented with an interaction term between the import competition shock and the initial population in the commuting zone:

$$\Delta y_{ct} = \beta_0 + \beta_1 \Delta Imp_{ct}^{US} + \beta_2 L_{ct} + \beta_3 \left[\Delta Imp_{ct} \times L_{ct}\right] + \beta_4 \mathbf{X} + \varepsilon_{1cjt} \tag{19}$$

Since there is not sufficient variation in the logged population variable to identify both first stages separately, I estimate equation (19) using a control function approach as well as using 2SLS. The results are qualitatively the same for both estimation procedures.

The main results based on the control function approach are presented in Table 3.[7] The regressions on employment corroborate the earlier findings that the employment effect of an import competition shock are larger in smaller cities even when reducing the amount of identifying variation by aggregating across industries. The regressions on changes in the average wage suggest that the effect on wages only varies marginally with city size and if anything the effect is less negative in larger cities. This is in line with the labour demand driven mechanism suggested by the model and evidence against a supply-based explanation.

7. The results using a 2SLS approach using either log population or absolute population as interaction can be found in table 8 and 9. The results are in line with those from the control function approach.

4.2.2 Across-industry trade and comparative advantage

The spatial sorting of sectors across regions, driven by the factor intensity of their input use, affects the spatial distribution of the import competition shock. The theoretical model suggests that initial population size is a sufficient statistic for the factor intensity of the sectoral composition. This motivates the following regression:

$$\Delta I\hat{m}p_{ct}^{US,Ch} = \beta_0 + \beta_1 L_{ct} + \gamma \mathbf{X}_{ct} + \epsilon_{ct} \tag{20}$$

where $\Delta I\hat{m}p_{ct}$ is a measure of changes in import competition, L_{ct} is the log population size of commuting zone c at the beginning of the period and $\mathbf{X}_{ct}$ is a vector of control variables. Following Acemoglu et al. (2016) I define the commuting-zone-level trade exposure and its instrument as follows:

$$\Delta Imp_{ct}^{US,Ch} = \sum_j \frac{L_{cjt}}{L_{ct}} \Delta Imp_{jt}^{US,Ch}$$
$$\Delta Imp_{ct}^{Ot,Ch} = \sum_j \frac{L_{cjt}}{L_{ct}} \Delta Imp_{jt}^{Ot,Ch}$$

The main results are reported in Table 4. Columns 1 and 2 present results using the instrument for commuting-zone-specific trade shocks as dependent variable while columns 3 and 4 present results for predicted import exposure from the following regression:

$$\Delta Imp_{ct}^{US,Ch} = \alpha_t + \Delta Imp_{ct}^{Ot,Ch} + \epsilon_{ct}$$

The results are highly statistically significant across all specifications and indicate that regions with larger initial population experience a smaller exposure to Chinese import competition. My preferred specification, which uses predicted imports and a full set of region fixed effects (column 4), indicates that with each additional population log point the experienced import competition shock decreases by 0.06 which is roughly ten percent of the mean for the period 1991 to 1999 and roughly five percent for the period 1999 to 2007. A commuting zone at the 25th percentile of the initial population distribution experiences a shock that is 0.06 units larger than the mean shock and a commuting zone that is at the 75th percentile experiences a shock that is 0.07 units smaller, such that the difference between the two is 0.13

units, roughly 20% of the mean change in Chinese import competition.

4.2.3 Quantifying the results

We have shown that both mechanisms suggested by the model are supported by the data. First, within a manufacturing industry the trade shock reduces employment (and wages) more in smaller commuting zones as suggested by the firm-level mechanism. Second, the trade shock is larger in less populated commuting zones, as suggested by the industry-level mechanism. To understand whether the two proposed mechanisms are not only statistically significant but also economically meaningful and therefore contributed to the increase in regional inequality I estimate both the overall effect and the relative importance of the two mechanisms. In order to quantify the extent of regional heterogeneity in the effect of the import competition shock I compare the changes in employment due to the shock in a small commuting zone (defined as at the 25th percentile of the population distribution; with a log population of -0.99) and a large commuting zone (75th percentile; 1.04). I isolate the exogenous part of the increase in imports by multiplying the increase in import competition with the partial R^2 from the first stage that is driven by the instrument, which is equal to 0.52 (following Acemoglu et al., 2016). Under the assumptions that the instrument is valid and that there is no measurement error this provides a consistent estimate of the contribution of increases in Chinese productivity to import penetration.

Firm-level mechanism To obtain a quantitative estimate for the effect of firm sorting I assume that both commuting zones are hit by an average increase in Chinese import competitions but the effect of this increase differs according to the estimates from table 1. I use the estimates from my preferred specification that include fixed effects at the four digit industry level as well as for census regions (column 7). The change in industry employment using these estimates for big and small commuting zones are given by:

$$\begin{aligned}\Delta L_{75th,j} &= -3.99 \times \Delta\overline{Imp}_j \times R^2_{FS} + 0.94 \times \Delta\overline{Imp}_j \times R^2_{FS} \times L_{75th} = -0.85 \\ \Delta L_{25th,j} &= -3.99 \times \Delta\overline{Imp}_j \times R^2_{FS} + 0.94 \times \Delta\overline{Imp}_j \times R^2_{FS} \times L_{25th} = -1.39\end{aligned}$$

When accounting for firm sorting, employment in a tradable sector decreases by 0.85 log points on average in a large commuting zone and by 1.39 log points in a small commuting zone, a difference of 0.54 log points.

Industry-level mechanism To isolate the effect of sector sorting I ignore the heterogeneity in the employment effect of a given trade shock highlighted by the firm-level mechanism.

Instead I take the estimated coefficient for the mean-sized commuting zone and allow for differences in exposure to the import competition shock across large and small commuting zones. The import competition shock in the mean-sized commuting zone is 0.53. According to the results from Table 4 the magnitude of the import competition shock decreases by 0.06 for each log population point, which yields the following shocks for large and small commuting zones:

$$\Delta L_{75th,j} = -3.99 \times (\Delta Imp_{75th,j} \times R^2_{FS}) = -3.99 \times (0.73 - (0.06 \times 1.04)) \times 0.52 = -1.42$$
$$\Delta L_{25th,j} = -3.99 \times (\Delta Imp_{25th,j} \times R^2_{FS}) = -3.99 \times (0.73 - (0.06 \times (-0.99))) \times 0.52 = -1.70$$

When accounting for the differences in the exposure to the import competition shock across city sizes, on average employment in a tradable sector decreases by 1.42 log points in a large commuting and 1.70 in a small commuting zone.

The combined effect To get an overall estimate for the heterogeneous employment effects across big and and small commuting zones I combine the effects of heterogeneous firm and sector sorting in space. The overall effect combines the predicted import competition shock that an average sector experiences conditional on its location, as well as the effect of this shock on employment conditional on location. This leads to the following equation:

$$\begin{aligned}
\Delta L_{75th,j} =& -3.99 \times (\Delta Imp_{75th,j} \times R^2_{FS}) + 0.94 \times (\Delta Imp_{75th,j} \times R^2_{FS}) \times L_{75th} \\
=&(-3.99 \times 0.67 + 0.94 \times 0.67 \times 1.04) \times 0.52 = -1.07 \\
\Delta L_{25th,j} =& -3.99 \times \Delta Imp_{25th,j} \times R^2_{FS} + 0.94 \times \Delta Imp_{25th,j} \times R^2_{FS} \times L_{25th} \\
=&(-3.99) \times 0.79 + 0.94 \times 0.79 \times (-0.99) = -2.09
\end{aligned}$$

Overall the change in employment in an average tradable industry due to Chinese import competition is equal to 1.07 percentage points in a large commuting zone and 2.09 percentage points in a small commuting zone. So on average a small commuting zone loses almost twice as much of its tradable employment from the rise in Chinese import competition. Decomposing this difference into the different mechanisms 53% of this difference is due to firm sorting, 27% due to sector sorting and the remaining 20% due to the interaction of both effects.

5 Conclusion

This paper documented a positive correlation between international economic integration and regional inequality within advanced economies. To microfound this aggregate correlation I propose an economic geography model of spatial sorting of heterogeneous firms and heterogeneous sectors across different city sizes that features an open economy equilibrium with trade due to firm heterogeneity and endowment-driven comparative advantage. The model provides two mechanisms that microfound the aggregate correlation, one on the firm level and one on the industry level. Firstly, within-industry trade reallocates market share and employment from less to more productive firms, since these more productive firms benefit more from agglomeration externalities, they are relatively located in larger cities. Hence, in the model this reallocation increases spatial concentration. Secondly, specialization due to endowment-driven comparative advantage increases employment in capital and skill-intensive sectors for advanced economies. Capital-intensive sectors are relatively located more in larger cities as the relative price of capital to labour decreases with city size. Hence, in the model this reallocation increases spatial concentration.

I test the model predictions from these mechanisms empirically using the rise in Chinese import competition for the United States. I find strong support for both mechanisms. Firstly, a given industry-level import competition shock has a more negative employment effect in smaller relative to larger commuting zones, consistent with the firm-level mechanism proposed by the model. I rule out alternative explanations such as varying labour supply elasticities across different city sizes. Secondly, commuting-zone-specific trade shocks are smaller in more populated commuting zones, consistent with the industry-level mechanism proposed by the model. Overall, on average an industry in a large commuting zone (at the 75th percentile of the city size distribution) loses 1.07 percentage points of employment due to the increased Chinese import competition while the average industry in a small commuting zone (25th percentile) loses 2.09 percentage points.

I use the reduced-form estimates to compare the quantitative importance of these two mechanisms for the 2.39 log points difference in the employment effect between an average manufacturing sector in a large and a small commuting zone. The majority of this difference (53%) is driven by firm heterogeneity while 27% is due to sector sorting and the remaining 20% is due to the positive interaction of both effects. Since the largest share of the regional heterogeneity stems from within-industry trade, this suggests that the effect of trade on regional inequality does not only come from trading with countries, such as China, that differ in their comparative advantage, but also European countries with whom most US trade happens within industries.

An additional implication of the model that could be explored in future more structural work is that we overestimate the welfare effects of trade as long as we ignore its spatial implications. Estimating the gains from trade based on changes in tradables production and productivity alone does not account for the welfare losses due to the increase in congestion costs caused by increased spatial concentration.

This paper has provided causal evidence for two different theoretical mechanisms that international integration increases regional inequality and spatial concentration in advanced economies. While the previous literature has provided ample evidence for important distributional effects of trade across different skill groups, regional heterogeneity has been much less studied. These findings have important policy implications as they provide an additional margin for redistribution if the government aims to redistribute the aggregate gains from trade.

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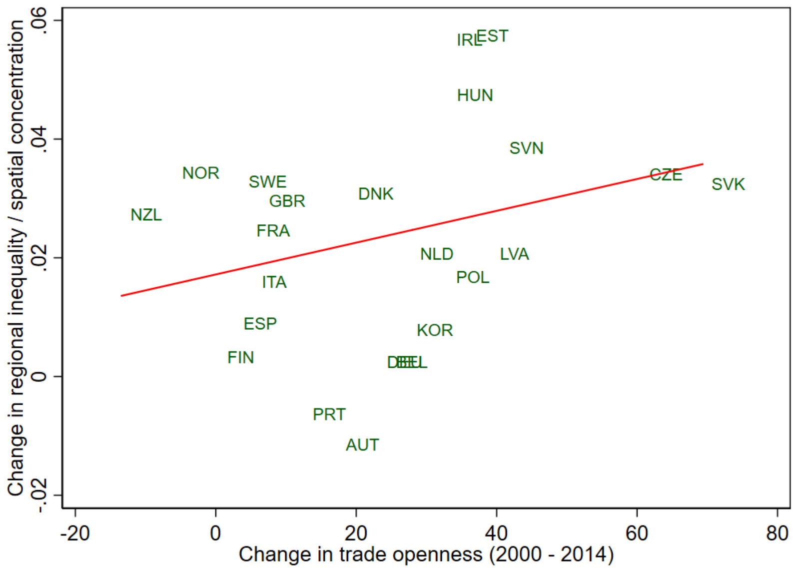
A Tables and figures

Figure 1 – Cross country correlation between openness and regional inequality



Plots the correlation between change in trade openness and change in regional inequalities between 2000 and 2014 for 26 advanced economies. Change in openness is defined as the change in the ratio of imports plus exports to GDP. Change in regional inequality is defined as the change in the regional Gini coefficient. Data is from the Regions and Cities database of the OECD.

Table 1 – Firm-level mechanism: Imports from China and changes in manufacturing employment across different city sizes within an industry

	ΔL_{cj}	ΔL_{cj}	ΔL_{cj}	ΔL_{cj}
$\Delta Imp_j^{US,Ch}$	-2.77***	-6.20***	-4.03***	-3.99***
	(0.836)	(1.736)	(1.271)	(1.257)
$\Delta Imp_j^{US,Ch} \times ln(pop_c)$		1.23***	0.96***	0.94***
		(0.364)	(0.274)	(0.268)
$ln(pop_c)$		1.08***	1.35***	1.30***
		(0.245)	(0.218)	(0.208)
Time FE	Yes	Yes	Yes	Yes
Region FE	No	No	No	Yes
Industry FE (4d)	No	No	Yes	Yes
Observations	129116	129116	129116	129116
Pseudo R^2	0.02	0.04	0.20	0.20
AP F-statistic ΔImp	99.63	69.87	73.64	73.75
AP F-statistic IA	.	125.06	106.49	106.30

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for ten sub-sectors within manufacturing and eight census regions. Regressions are weighted by initial employment in each sector-commuting zone cell. The sample includes 392 manufacturing industries in 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 2 – Firm-level mechanism: Additional specifications using more granular fixed effects

	ΔL_{cj}	ΔL_{cj}	ΔL_{cj}
$\Delta Imp_j^{US,Ch}$		-3.26***	
		(0.336)	
$\Delta Imp_j^{US,Ch} \times ln(pop_c)$	0.92***	0.66***	0.64***
	(0.098)	(0.083)	(0.082)
$ln(pop_c)$	1.31***	1.44***	1.43***
	(0.093)	(0.085)	(0.082)
Level of FE	Ind-Time, Reg	Ind-Reg, Time	Ind-Reg-Time
Observations	129116	129078	128939
Pseudo R^2	0.04	0.04	0.02
AP F-statistic ΔImp	.	1954	.
AP F-statistic IA	1348	1092	2513

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for ten sub-sectors within manufacturing and eight census regions. Regressions are weighted by initial employment in each sector-commuting zone cell. The sample includes 392 manufacturing industries in 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 3 – WAGE AND EMPLOYMENT REGRESSIONS ON THE COMMUTING ZONE LEVEL

	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c
$\Delta Imp_c^{US,Ch}$	-0.7***	-0.7***	-4.5**	-1.3	-4.7**	-1.7	-3.9**	-1.7
	(0.10)	(0.24)	(1.93)	(1.25)	(2.10)	(1.26)	(1.71)	(1.59)
$\Delta Imp_c^{US,Ch} \times ln(pop_c)$			0.3**	0.1	0.3*	0.1	0.3*	0.1
			(0.15)	(0.11)	(0.17)	(0.11)	(0.14)	(0.14)
$ln(pop_c)$	-0.2**	-0.3	-0.8***	-0.4	-0.8***	-0.2	-1.0**	-0.8
	(0.09)	(0.16)	(0.30)	(0.35)	(0.28)	(0.34)	(0.40)	(0.74)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	Yes	Yes	Yes	Yes
Additional controls	No	No	No	No	No	No	Yes	Yes
FS residual	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1444	1444	1444	1444	1444	1444	1444	1444
Pseudo R^2	0.13	0.50	0.19	0.50	0.22	0.54	0.41	0.58

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions are estimated using the control function approach include fixed effects for eight census regions. Regressions are weighted by initial employment in each commuting zone. The sample includes 722 commuting zones for the periods 1990 - 2000 and 2000 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Additional controls for the sectoral and demographic composition are included in some specifications. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4 – Industry-level mechanism: Average exposure to import competition and initial population levels.

	Reduced form		Predicted imports	
	$\Delta Imp_{ct}^{Ot,Ch}$	$\Delta Imp_{ct}^{Ot,Ch}$	$\Delta \hat{Imp}_{ct}^{US,Ch}$	$\Delta \hat{Imp}_{ct}^{US,Ch}$
$ln(pop_c)$	-0.06***	-0.08***	-0.05***	-0.06***
	(0.021)	(0.020)	(0.017)	(0.017)
$\mathbb{1}_{1991-1999}$	0.48***	0.87***	0.56***	0.87***
	(0.045)	(0.099)	(0.037)	(0.081)
$\mathbb{1}_{1999-2007}$	1.21***	1.60***	1.17***	1.49***
	(0.049)	(0.100)	(0.040)	(0.082)
Region FE	No	Yes	No	Yes
Observations	1444	1444	1444	1444
Pseudo R^2	0.70	0.73	0.78	0.81

Note: Robust standard errors clustered at the commuting zone level in parenthesis. Regional fixed effects for eight regions within the US. Regressions are weighted by initial employment in each commuting zone. The sample includes 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that the constants represent the mean trade shocks for different time periods. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 5 – Cross country correlation between trade openness and regional inequality/spatial concentration

	Regional inequality	
	Unweighted	Weighted by population
Openness	0.03***	0.04**
	(0.011)	(0.021)
Year FE	Yes	Yes
Country FE	Yes	Yes
Observations	359	351
Pseudo R^2	0.95	0.91

Note: Robust standard errors clustered by country and year in parenthesis. The sample is an unbalanced panel of 26 countries for the period 1999 to 2014. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 6 – First stage regressions of the trade shock coefficient corresponding to table 1

	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$	$\Delta Imp_j^{US,Ch}$
$\Delta Imp_j^{Ot,Ch}$	1.22***	1.13***	1.11***	1.11***	1.21***	1.21***	1.21***
	(0.123)	(0.137)	(0.135)	(0.134)	(0.103)	(0.142)	(0.142)
$\Delta Imp_j^{Ot,Ch}$ $\times log(pop_c)$		0.03	0.03	0.03	0.02	0.02*	0.02*
		(0.022)	(0.021)	(0.021)	(0.011)	(0.009)	(0.009)
$ln(pop_c)$		-0.01	-0.00	0.01	-0.00	-0.00	-0.00
		(0.008)	(0.008)	(0.011)	(0.005)	(0.003)	(0.003)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sub-sector FE	No	No	Yes	Yes	No	No	No
Region FE	No	No	No	Yes	No	No	Yes
Industry FE (3d)	No	No	No	No	Yes	No	No
Industry FE (4d)	No	No	No	No	No	Yes	Yes
Observations	129116	129116	129116	129116	129116	129116	129116
Pseudo R^2	0.63	0.63	0.65	0.65	0.79	0.88	0.88

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for ten sub-sectors within manufacturing and eight census regions. Regressions are weighted by initial employment in each sector-commuting zone cell. The sample includes 392 manufacturing industries in 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 7 – First stage regressions of the trade shock coefficient corresponding to table 1

	$\Delta Imp_j^{US,Ch} \times ln(pop_c)$	$\Delta Imp_j^{US,Ch} \times ln(pop_c)$	$\Delta Imp_j^{US,Ch} \times ln(pop_c)$	$\Delta Imp_j^{US,Ch} \times ln(pop_c)$	$\Delta Imp_j^{US,Ch} \times ln(pop_c)$
$\Delta Imp_j^{Ot,Ch}$	-0.03	-0.10	-0.09	0.14	0.17
	(0.106)	(0.123)	(0.123)	(0.230)	(0.317)
$\Delta Imp_j^{Ot,Ch}$ $\times log(pop_c)$	1.26***	1.26***	1.26***	1.23***	1.22***
	(0.125)	(0.126)	(0.126)	(0.128)	(0.125)
$ln(pop_c)$	0.08**	0.09*	0.11**	0.10**	0.09**
	(0.038)	(0.048)	(0.050)	(0.048)	(0.046)
Time FE	Yes	Yes	Yes	Yes	Yes
Sub-sector FE	No	Yes	Yes	No	No
Region FE	No	No	Yes	No	No
Industry FE (3d)	No	No	No	Yes	No
Industry FE (4d)	No	No	No	No	Yes
Observations	129116	129116	129116	129116	129116
Pseudo R^2	0.69	0.70	0.70	0.77	0.83

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for ten sub-sectors within manufacturing and eight census regions. Regressions are weighted by initial employment in each sector-commuting zone cell. The sample includes 392 manufacturing industries in 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8 – Wage and employment regressions on the commuting zone level using 2SLS with log population

	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c
$\Delta Imp_c^{US,Ch}$	-0.7***	-0.7***	-4.7***	-1.6	-4.7**	-1.8	-3.6**	-1.5
	(0.11)	(0.24)	(1.75)	(1.87)	(1.87)	(1.90)	(1.63)	(1.78)
$\Delta Imp_c^{US,Ch} \times ln(pop_c)$			0.3**	0.1	0.3**	0.1	0.2*	0.1
			(0.13)	(0.16)	(0.14)	(0.16)	(0.12)	(0.15)
$ln(pop_c)$	-0.2**	-0.3*	-0.8***	-0.4	-0.8***	-0.2	-0.9**	-0.7
	(0.10)	(0.15)	(0.26)	(0.42)	(0.24)	(0.41)	(0.38)	(0.74)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	Yes	Yes	Yes	Yes
Additional controls	No	No	No	No	No	No	Yes	Yes
Observations	1444	1444	1444	1444	1444	1444	1444	1444
Pseudo R^2	0.06	0.49	0.10	0.49	0.13	0.52	0.32	0.57
AP F-statistic ΔExp	95.15	95.15	3.56	3.56	2.89	2.89	2.80	2.80
AP F-statistic IA	.	.	4.21	4.21	3.01	3.01	3.55	3.55

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for eight census regions. Regressions are weighted by initial employment in each commuting zone. The sample includes 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 9 – Wage and employment regressions on the commuting zone level using 2SLS with absolute population

	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c	ΔL_c	Δw_c
$\Delta Imp_c^{US,Ch}$	-0.66***	-0.68***	-0.87***	-0.79***	-0.89***	-0.83***	-0.85***	-0.79***
	(0.097)	(0.256)	(0.123)	(0.217)	(0.134)	(0.186)	(0.208)	(0.258)
$\Delta Imp_c^{US,Ch} \times pop_c$			0.03***	0.01*	0.03***	0.01*	0.03***	0.02**
			(0.006)	(0.008)	(0.004)	(0.008)	(0.004)	(0.009)
pop_c	0.00	-0.02***	-0.06***	-0.05**	-0.07***	-0.05*	-0.08***	-0.07*
	(0.003)	(0.004)	(0.023)	(0.023)	(0.017)	(0.028)	(0.012)	(0.037)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	No	No	No	No	Yes	Yes	Yes	Yes
Additional controls	No	No	No	No	No	No	Yes	Yes
Observations	1444	1444	1444	1444	1444	1444	1444	1444
Pseudo R^2	0.06	0.51	0.24	0.52	0.29	0.54	0.46	0.59
AP F-stat: ΔImp	97.79	97.79	78.45	78.45	68.32	68.32	38.04	38.04
AP F-stat: IA	.	.	86.97	86.97	80.60	80.60	75.02	75.02

Note: Robust standard errors clustered at the three digit SIC level are reported in parenthesis. The regressions include fixed effects for eight census regions. Regressions are weighted by initial employment in each commuting zone. The sample includes 722 commuting zones for the periods 1991 - 1999 and 1999 - 2007 that are stacked in the estimation. The population variable is defined in units of 100,000 inhabitants and demeaned such that $\Delta Imp_j^{US,Ch}$ is the effect of an import competition shock for the mean-sized commuting zone. Stars indicate significance levels the following levels *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.