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Regional implications of financial market development: Industry location and income inequality

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ABSTRACT

We develop a heterogeneous-firms model with trade in goods, labor mobility and credit constraints due to moral hazard. Mitigating financial frictions reduces the incentive of mobile workers to migrate to one region such that an unequal distribution of industrial activity becomes less likely. Hence, financial market development has opposite regional implications as trade liberalization. While the former leads to more dispersion of economic activity across space, the latter tends to drive clustering. This has immediate implications for income inequality both between regions and workers. According to our model, financial development reduces inequality in both dimensions.

1. Introduction

There has been a long and still unsettled debate whether the integration of markets leads to a more or less equal distribution of economic activity and thus income across regions. While the conventional view suggests that market integration should lead to convergence and thus more equal living conditions, there is also a prominent opposition claiming that market integration magnifies inequality (Myrdal, 1957; Lewis, 1977; Krugman, 1991). The latter argument fuels policy makers' fears that market integration benefits primarily rich regions with a large home market. Accordingly, many federations have regional policies in place that transfer resources from the core to peripheral regions. For instance, the European Union spends about 50 billion euros per year on regional cohesion representing about one third of the overall EU budget.[1] In Germany, it is even fixed in the constitution that governments have to ensure sufficiently equal living conditions across regions. There is surprisingly little work that links the role of financial markets to this debate. It is surprising because

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[1] Regional cohesion is the second largest item of the EU budget amounting to more than 350 billion euros during 2007–2013 and 336 billion euros during 2014–2020 (see EU Commission, 2011).

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the importance of the financial sector for the real economy is widely acknowledged and we have seen a very pronounced development of financial markets in recent decades.

We show that more developed financial markets work towards more equality of income both within and across regions. The underlying economic mechanism for these results builds on access to external finance. Deeper financial markets allow less productive firms to secure external finance and enter the market. This raises the total number of firms, but reduces the *share* of exporters as only high-productive companies serve customers abroad. Thus, better access to external finance modifies the composition of firms and thereby the intensity of competition within and between markets. We show that this channel reduces agglomeration economies working towards more income equality.

As trade liberalization *raises* the share of exporters, a reduction in transport costs stimulates regional inequality. The latter represents a well-known mechanism in economic geography models with homogeneous firms (Krugman, 1991; Ottaviano et al., 2002). Our findings have substantial relevance for (regional) policy makers. First, deeper financial markets allow for more integrated product markets (that promise welfare gains from trade) without jeopardizing the goal of equal regional living conditions. Second, financial development may serve as a substitute for costly regional transfer programs with the goal of establishing cohesion.

Our model features trade in goods, labor migration, credit constraints, endogenous entry and exit of heterogeneous firms, and occupational choice (for the latter see Lucas, 1978; Egger and Kreickemeier, 2012). The financial friction stems from a moral-hazard problem in the tradition of Holmstrom and Tirole (1997). While entrepreneurs can choose their effort level to maximize their payoff, lenders cannot directly observe their behavior. Hence, asymmetric information introduces credit constraints as lenders demand a higher return from a given investment to ensure a higher payoff for entrepreneurs and thus diligent behavior. This leads to credit rationing as less productive firms cannot commit to diligence despite positive net present values. To obtain these selection effects, we need to introduce some kind of firm heterogeneity. We deviate from Holmstrom and Tirole (1997) in ignoring different endowments of firm assets, but rather follow Melitz (2003) in introducing different levels of productivity. Firm selection is thus an important channel through which financial development affects the spatial distribution of industry and welfare. Baldwin and Okubo (2006) and Ottaviano (2011, 2012) have stressed the importance of firm heterogeneity for the magnitude of agglomeration economies in the absence of financial frictions. In our model, entrepreneurs of productive (large) firms have no incentive to shirk and always receive external finance while small firms turn out to be credit constrained.

Our findings are in line with the recent literature in trade and finance arguing that deeper financial markets increase the volume of exports.[2] However, what matters for location decisions and our main results is the *share* of exporters rather than the *volume*. Building on recent evidence that the smallest (i.e. less productive) firms benefit most from financial development (Beck et al., 2005, 2008), the link between better access to external finance and a lower *share* of exporters becomes well-founded.

By examining the role of financial development for the location of industries, our paper contributes to the literature on determinants of agglomeration (see Duranton and Puga, 2004; Ottaviano and Thisse, 2004; Puga, 2010, for reviews of the literature). It fits into the line of research stressing the importance of market externalities as a driver for migration and economic density.[3] The link between economic geography and policy was established in papers that analyzed among others the role of tax competition (Baldwin and Krugman, 2004), infrastructure (Martin, 1999), economic growth (Martin and Ottaviano, 2001) and labor market institutions (Egger and Seidel, 2008). A related paper to ours is Hakenes and Kranich (2014) studying moral hazard and capital mobility, but without selection effects. In their framework investors need to incentivize managers which is less costly in industrialized regions. Our paper highlights the interactions between financial market institutions, firm heterogeneity, and migration that have not been analyzed so far.

The role of financial market integration for inequality has also been addressed in the literature on finance, growth, and development. Acemoglu and Zillibotti (1997) argue that rich countries have more developed financial markets providing better diversification which contributes to a widening gap between rich and poor countries. Krugman (1981) and Lucas (1990) were early contributions to point out why difference in capital-labor ratios may magnify over time. Matsuyama (2004) develops an overlapping-generations model with credit market imperfection and investment. He shows that financial markets may cause inequality as symmetric equilibria become unstable and regions separate into rich and poor. Similarly, Boyd and Smith (1997) and Hakenes et al. (2014) integrate financial frictions in growth models and show that financial integration may cause capital to flow from poor to rich countries. This process contributes to more income inequality. In contrast to our paper, none of the above-mentioned studies considers migration which is certainly a relevant feature at the regional level. Furthermore, we highlight a novel effect of financial markets on income inequality that works via goods trade and yields predictions that are consistent with the negative correlation between financial market development and income inequality within countries identified in the empirical literature (Clarke et al., 2006; Liang, 2006; Beck et al., 2007).[4]

[2] See, for example, Manova (2008, 2013). Financial development raises the volume of exports, but reduces the share of exporters in our model.

[3] The empirical relevance of agglomeration economies has been well documented. For instance, Ellison et al. (2010) and Redding and Sturm (2008) provide convincing evidence for demand-linkages and the home-market effect which are at the center of the location mechanism in our model.

[4] In a working paper version of this paper, we provide empirical evidence for a negative relationship between financial market development and the concentration of economic activity across European regions. This finding is consistent with our model and suggests that financial markets play a decisive role for location decisions of firms (see Ehrlich and Seidel, 2013a).

Recent research in international trade has studied the impact of credit constraints for exports, comparative advantage and welfare (e.g. Ju and Wei, 2011; Egger and Keuschnigg, 2014), but ignored industry location and inequality. The latter is highlighted in a number of recent papers addressing the role of trade liberalization for wage inequality (Felbermayr et al., 2011; Egger and Kreickemeier, 2008, 2012; Helpman et al., 2010), but without considering frictions on the capital market and endogenous industry location. This paper combines trade, labor migration, credit constraints and inequality in a unified framework and studies the link between trade integration and financial market development.

The paper is organized as follows. In the next section, we introduce a model of trade, labor mobility, and credit constraints. In Section 3, we derive equilibrium conditions and solve the model. In Section 4, we analyze the effects of financial market development on the location of economic activity and the distribution of income across regions. Section 5 concludes with a summary of the main findings and implications for regional policy.

2. The model

2.1. Overview

Before we go into the formal analysis of the model, we provide a non-technical overview of the setup and introduce some of the basic notation. We build on Krugman's (1991) seminal core-periphery framework with two regions and two sectors. One sector produces a homogeneous good Y that can be traded without cost using immobile workers L as the only input. The second industry consists of firms with heterogeneous productivities fabricating varieties of a differentiated good Q under monopolistic competition. This sector uses only mobile workers H.[5]

We extend the setup in sector Q in several ways. Most importantly, we introduce credit rationing due to moral hazard that plays a central role for the location of industry. To this end, we need firm heterogeneity and occupational choice as two additional modifications to allow for income differences of entrepreneurs. Fig. 1 illustrates the sequencing of decisions. Given their location in one of the regions, mobile individuals choose between an entrepreneurial career and working as an employee. To start a firm, entrepreneurs need to invest their labor endowment to develop a project that determines the productivity φ of the firm. Projects are drawn from a commonly known distribution function. Each entrepreneur faces the same probability of drawing a specific productivity ex ante.[6] Once the productivity is known, entrepreneurs need to secure a loan from the financial sector to undertake the fixed investment $f^{\ell}w$. Investment differs according to organizational choice. For domestic firms ($\ell = d$), entrepreneurs need to secure $f^d w$ while exporting ($\ell = x$) requires a larger investment $f^x w$ (where w denotes the wage rate).

The credit friction stems from the fact that effort of the entrepreneur is unobservable and firms are only economically viable under diligent behavior. If entrepreneurs shirk, the firm fails with certainty and generates no revenues. Thus, the financial sector requires a sufficiently high entrepreneurial income as a guarantee that shirking is unattractive. The information asymmetry leads to credit rationing for the less productive firms. Those entrepreneurs with a too low productivity (too low expected income) cannot enter the market. It is impossible to write a contract contingent on firm performance as each firm faces a non-zero probability of a bad shock rendering production impossible. Without loss of generality, we assume shirking to lead to a survival rate of zero while diligent behavior of the entrepreneur raises this probability to $0 < \psi < 1$.

The role of the financial sector is to pool default risk across firms. We assume that employees are unable to observe firm productivity before production takes place, but the financial sector is able to do so. It therefore discriminates between 'good' and 'bad' firms and allocates resources efficiently. The law of large numbers ensures that workers at 'good' firms that are hit by the bad shock are reimbursed by the default premium which surviving firms have to pay on their loan.

Finally, entrepreneurs of surviving firms hire additional workers as variable inputs and remunerate them out of production, repay the loan plus the default premium, and keep the profit as personal income. The fraction $1-\psi$ of all entrepreneurs that were able to secure external finance does not start producing and receive no income due to the bad shock. This system delivers real wages (that have to be equal to expected profits in equilibrium due to occupational choice) in both regions determining whether individuals migrate. A reallocation of mobile individuals leads to entry and exit of firms until real wages are equated or all mobile individuals cluster in one region.

We show that a better quality of the financial system reduces agglomeration economies implying a more equal distribution of income. The intuition behind this result builds on the intensity of competition within and across regions. It is well understood from Krugman (1991) that the manufacturing industry is distributed equally across both regions when trade costs are high, that is when competition through exports from the other region is weak. In that case, full agglomeration cannot be a stable location equilibrium as it pays off for an entrepreneur to locate in the periphery in order to exploit market power there. A similar logic applies to our model, with the difference that the balance between intra- and inter-regional competition is also affected by access to external finance and its effect on the composition of

[5] Although this setup only allows for endogenous location of sector Q, we need the immobile sector to allow for equilibria where the monopolistic competition industry is not fully agglomerated in one region. Technically, this argument is closely related to the 'no-black-hole condition' (see e.g. Fujita et al., 1999).

[6] It is helpful that productivities are unknown before occupational choice as it avoids the sorting problem of heterogeneous firms (entrepreneurs) in the migration equilibrium (see Ehrlich and Seidel, 2013b; for a discussion).

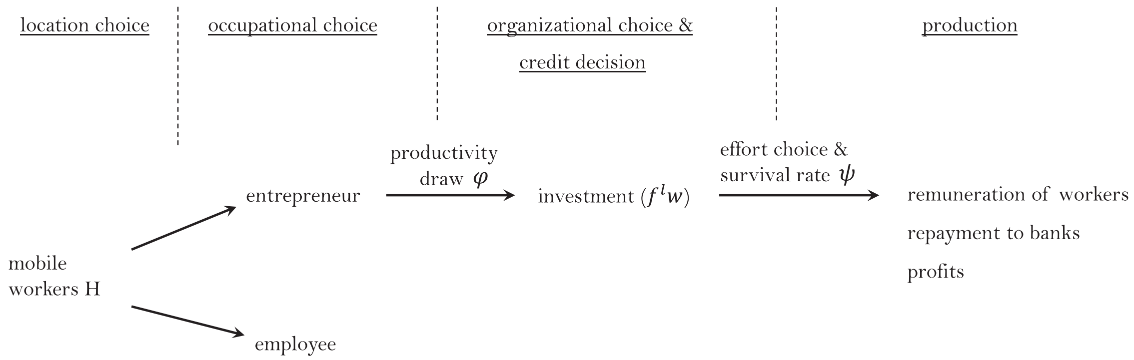

Fig. 1. Sequence of decisions.

exporting and non-exporting firms. Financial development leads to more firm entry and accordingly more intense local competition. At the same time deeper financial markets allow particularly less productive, non-exporting firms to get funded such that the total number of firms increases but the share of exporters decreases. A lower *share* of exporters implies less intense competition from abroad. Hence, better access to finance works against full agglomeration of industry – similarly to higher trade costs. We proceed by laying out the model in greater detail and solve it by backward induction.

2.2. Preferences and demand

Let us now go into more detail by turning to the formal analysis. Unless otherwise stated, we report expressions for region i stressing that similar equations exist for region j. Individuals derive utility from consuming two goods, a homogeneous good Y and a differentiated good Q, where the level of utility is determined by

$$U_i = Q_i^{\alpha} Y_i^{1-\alpha}. \tag{1}$$

The differentiated good is composed of a set V of varieties v that are aggregated according to $Q_i = \left(\int_{v \in V} q_i(v)^{(\sigma-1)/\sigma}\, dv\right)^{\sigma/(\sigma-1)}$. Note that V is determined endogenously in general equilibrium and σ represents the constant elasticity of substitution between any two varieties. Further, $q_i(v)$ describes the consumption level of variety v in region i – which may be a local or an imported type.

Maximizing (1) subject to the budget constraint delivers total demand for a variant of the differentiated good

$$q_i(v) = \frac{p_i(v)^{-\sigma}}{P_i^{1-\sigma}} \alpha E_i, \tag{2}$$

where $P_i = [\int_{v \in V} p_i(v)^{1-\sigma}\, dv]^{1/(1-\sigma)}$ denotes the price index, $p_i(v)$ represents the consumer price for variety v in region i and E_i is the expenditure for consumption (which is equal to income). With Cobb–Douglas preferences, each individual spends a constant income share on each class of goods such that $Q_i = \alpha E_i / P_i$ and $Y_i = (1-\alpha)E_i / P_{Yi}$. Plugging these demand functions into (1) yields indirect utility

$$W_i = \frac{\alpha^{\alpha}(1-\alpha)^{1-\alpha} E_i}{P_i^{\alpha} P_{Yi}^{1-\alpha}}. \tag{3}$$

2.3. Endowments and technology

Regions are endowed with two types of workers. Let us denote by L the global stock of immobile workers which are distributed symmetrically across both regions such that $L_i = L_j = L/2$. The global stock of mobile workers is denoted by $H = H_i + H_j$ and λ represents their share residing in region i. The homogeneous good is sold in a perfectly competitive market and requires immobile labor as the only input. We assume that one unit of immobile labor is required to produce one unit of output. Choosing Y as the numéraire and imposing zero trade costs across borders implies that the price for Y is equal to unity in both regions and so are wages of immobile workers.

Sector Q is characterized by monopolistic competition using mobile workers as the only factor of production. Fixed production costs generate increasing returns to scale such that each company exclusively manufactures one variety of the differentiated good for the market. Mobile workers have the choice between founding a firm (and becoming an entrepreneur) and working as an employee. Productivity is unknown and has to be obtained by investing the entrepreneur's own labor endowment. Technically, φ is drawn from a commonly known Pareto distribution function $G(\varphi) = 1 - \varphi^{-k}$, where

k captures the shape parameter. We have further normalized the scale parameter to one to simplify notation.[7] A high value of φ implies a low number of workers h_i to produce one unit of output, $q_i(\varphi)=\varphi h_i$.

Setting up a firm requires f^d employees as a fixed investment. This allows firms to service the domestic market. To sell goods in the other region through exporting, additional fixed costs are required. As we use superscript d for domestic and superscript x for exporting firms, net export fixed costs are given by $f^x - f^d$. Exporting is also associated with variable trade costs of the iceberg type implying that $\tau > 1$ units of the good have to be shipped for one unit to arrive at the final destination.

Profit-maximizing prices for domestic sales and exports are given by

$$p_{ii}(\varphi)=\frac{\sigma w_i}{(\sigma-1)\varphi}, \quad p_{ij}(\varphi)=\frac{\sigma\tau w_i}{(\sigma-1)\varphi},$$

where the first subscript refers to the place of production and the second subscript to the place of sale. We obtain revenues from domestic sales and exports as

$$r_{ii}(\varphi)=\frac{p_{ii}(\varphi)^{1-\sigma}}{P_i^{1-\sigma}}\alpha E_i, \quad r_{ij}(\varphi)=\frac{p_{ij}(\varphi)^{1-\sigma}}{P_j^{1-\sigma}}\alpha E_j.$$

Operating profits are a fixed fraction $1/\sigma$ of revenues due to constant markup pricing. To derive profits, we need to discuss the financial friction to which we turn next.

2.4. Credit decision

Entrepreneurs cannot finance their initial fixed investment $f^\ell w_i$ from sales and thus rely on the financial sector. However, there is a friction on this market as effort is not observable and firms are only economically viable if the entrepreneur behaves (Holmstrom and Tirole, 1997). Each firm faces a non-zero probability of being hit by a bad shock after the fixed investment has been undertaken. Under diligence, the survival rate is $0<\psi<1$ while firms fail with certainty under shirking. Therefore, it cannot be inferred from failure that the entrepreneur has shirked and a contract contingent on effort is infeasible. Hence, banks need to ensure that entrepreneurs receive a sufficiently high income such that shirking is unattractive. Otherwise, they end up with losses. This requirement is formally given by the incentive compatibility constraint

$$\psi\left[\frac{r_i^\ell(\varphi_i)}{\sigma}-R_i^\ell\right]\ge b w_i, \tag{IC}$$

where $r_i^\ell(\varphi_i)/\sigma$ denotes total operating profits, R_i^ℓ is the repayment to the financial sector and bw_i is the private benefit from shirking.[8] In the following, we refer to b as the agency cost parameter where lower values reflect better quality of financial system. According to (IC) entrepreneurs exert effort as long as their expected income exceeds the private benefit.

Employees are informed about potential shirking of entrepreneurs, but they cannot verify whether the incentive compatibility constraint is satisfied for a particular entrepreneur. This is the role of the financial sector which is able to identify those with a sufficiently high productivity to render shirking unattractive *before* production takes place. Thus, banks allocate resources efficiently by ensuring that only 'good' firms are granted a loan to hire workers. This guarantees that all workers receive the market wage in equilibrium even though some of these firms are hit by the bad shock.

Due to the moral-hazard problem, the entrepreneur can pledge only a fraction of her income to the lenders without violating the incentive compatibility constraint, namely $r_i^\ell(\varphi)/\sigma - bw_i/\psi$. To avoid bank losses, the expected pledgeable income must not fall short of the principal. We refer to this condition as the participation constraint (PC) which can be expressed as

$$\psi\left[\frac{r_i^\ell(\varphi)}{\sigma}-\frac{b w_i}{\psi}\right]\ge f^\ell w_i. \tag{PC}$$

We observe from (PC) that entrepreneurs have to generate expected operating profits that cover at least $bw_i+f^\ell w_i$ as a necessary condition for banks to allow a credit. As operating profits increase in productivity, only more productive companies receive external finance. Note that (PC) holds with equality for the marginal entrepreneur with productivity φ_{ii}^* who receives financing. In contrast to a world without moral hazard, some entrepreneurs (with $\varphi<\varphi_{ii}^*$) are unable to secure external funding to pay for fixed costs because they cannot commit to behave diligently. Even if they offered a higher premium to the lender, the bank would not grant the loan as the remaining income of the entrepreneur would be too low to be incentive compatible. Hence, entrepreneurs who do not meet (PC) due to a too low productivity level cannot start

[7] This normalization is without loss of generality as the location pattern is not affected by the scale parameter. It can be shown that the critical levels of agency and trade costs that render symmetry unstable and agglomeration the equilibrium outcome are independent of the scale parameter.

[8] We denote the private benefit in terms of wages as the loan is paid out in units of local wages, too. Intuitively, a part of the loan is withdrawn for private usage when entrepreneurs shirk. This enhances tractability of the model and allows us to isolate the selection effect. All our results remain valid if we denote private benefits in terms of the numéraire good which adds an asymmetric cost effect of credit constraints. The latter would correspond to the 'fixed investment section' in Holmstrom and Tirole (1997).

producing and thus end up with no income. As entrepreneurs are able to raise funds from a perfectly competitive banking sector, those that satisfy (PC) offer the lowest possible claim to the lender that meets (IC), that is $R_i^\ell = f^\ell w_i/\psi$.[9] This result shows that the entrepreneur receives the entire surplus if the project is funded.

The model features two determinants of credit constraints: firm productivity φ and agency costs bw_i. First, firms are more likely to receive external finance if they are more productive. As profits strictly increase in φ, more productive firms leave the entrepreneur with a higher income inducing her to behave. Second, agency costs govern the entrepreneur's ability to borrow. We observe from (PC) that this term captures the non-pledgeability of income. The higher its value, the more difficult it is to secure external finance for a given level of expected operating profits.[10]

2.5. Organizational choice

Based on these insights, we can proceed to discuss the entrepreneur's decision about firm organization. Profits from domestic sales and exporting are respectively given by

$$\pi_{ii}(\varphi) = r_{ii}(\varphi)/\sigma - f^d w_i/\psi, \quad \pi_{ij}(\varphi) = r_{ij}(\varphi)/\sigma - (f^x - f^d) w_i/\psi.$$

Since each surviving firm has to earn at least bw_i/ψ plus the respective fixed costs $f^\ell w_i/\psi$, the decision to become an exporter is affected by the moral-hazard problem only to the extent that the additional fixed costs $(f^x - f^d)w_i/\psi$ have to be financed externally. As long as operating profits from exporting does not fall short of the extra credit costs, it pays for an entrepreneur to export. We derive the export productivity cutoff φ_{ij}^* by using the condition $\pi_i^x(\varphi_{ij}^*) = \pi_i^d(\varphi_{ij}^*)$ which is equivalent to

$$\frac{r_{ij}\left(\varphi_{ij}^*\right)}{\sigma} = (f^x - f^d)w_i/\psi. \tag{4}$$

An entrepreneur with productivity draw φ_{ij}^* is indifferent between paying the higher fixed costs f^x to become an exporter and paying the lower fixed costs f^d to serve only the domestic market. Every entrepreneur with productivity draw beyond φ_{ij}^* decides to set up an exporting firm. Note that the participation constraint (PC) is always met for an entrepreneur who drew a productivity $\varphi > \varphi_{ij}^*$ and accordingly decides to establish an exporting firm. Under exporting, operating profits are $r_i^x(\varphi)/\sigma = r_{ii}(\varphi)/\sigma + r_{ij}(\varphi)/\sigma$ while fixed costs become $w_i[f^d + (f^x - f^d)]/\psi$ such that the participation constraint reads $\psi[r_{ii}(\varphi)/\sigma + r_{ij}(\varphi)/\sigma - bw_i/\psi] \geq w_i f^x$. Hence, the pledgeable income of an exporter exceeds the pledgeable income of a domestic entrepreneur by $\psi[r_{ij}(\varphi)/\sigma]$ while exporting increases the principal by $w_i(f^x - f^d)$. From (4) it is evident that all entrepreneurs who decide to export are characterized by an increase in pledgeable income that dominates the increase in external financial needs and are therefore not affected by credit rationing.

We are now ready to derive the marginal-credit-access condition (MCA) which relates average profits from domestic sales and exporting, $\overline{\pi}_i$ to the cutoff productivity, φ_{ii}^*. In contrast to Melitz (2003), (MCA) substitutes for the zero-cutoff profit condition because the marginal firm in our model is determined by getting access to external finance rather than by zero profits. Combining (PC) and (4) the marginal-credit-access condition is given by[11]

$$\overline{\pi}_i = \frac{bkw_i}{\psi(k-\sigma+1)} + \frac{(\sigma-1)w_i}{\psi(k-\sigma+1)}\left[f^d + \chi_i(f^x - f^d)\right], \tag{MCA}$$

where χ_i denotes the share of exporting firms. It is evident that average profits increase in b for given wages and exporter share. This is because a more severe credit constraint prevents less profitable firms from securing external finance and thus entering the market.

2.6. Occupational choice

The final aspect we discuss in this section concerns the choice of mobile workers to pursue an entrepreneurial career. They do so as long as expected profits exceed entry costs, that is their opportunity cost from working as an employee, w_i. Indifference between working as an entrepreneur and an employee is given by the free-entry condition

$$\psi\left(\varphi_{ii}^*\right)^{-k}\overline{\pi}_i = w_i, \tag{FE}$$

where the left-hand side describes average profits, conditional on drawing a sufficiently high productivity, $1 - G(\varphi_{ii}^*) = (\varphi_{ii}^*)^{-k}$, to obtain a loan, and the survival rate ψ.

[9] Her income is then given by $r_i^\ell(\varphi)/\sigma - f^\ell w_i/\psi \geq bw_i/\psi$ which is a reformulation of (IC).

[10] Note that in Holmstrom and Tirole (1997), agency costs include a second component, the likelihood ratio, that is equal to unity in our model because we have set the survival rate under shirking to zero. This simplifies notation without loss of generality (see Ehrlich and Seidel, 2013a, for a version of the model with non-zero survival rate under shirking).

[11] See Appendix A for a detailed derivation.

3. Equilibrium

We now derive the equilibrium and examine how it depends on agency cost b and trade costs τ. In order to isolate the relationship between productivities and wages we combine the participation constraint for the marginal firm with (4), and $r_{ij}(\varphi^*_{ij}) = r_{jj}[(\varphi^*_{ij}w_j)/(\tau w_i)]$. This delivers the export cutoff as a function of wages and the domestic cutoff in the destination market,

$$\varphi^*_{ij} = \tau\left(\frac{f^x - f^d}{f^d + b}\right)^{1/(\sigma-1)}\left(\frac{w_i}{w_j}\right)^{\sigma/(\sigma-1)}\varphi^*_{jj}. \tag{5}$$

To ensure that exporting firms also serve local consumers, we restrict the parameter space to $(f^x - f^d)/(f^d + b) > 1$.[12] This guarantees that the conditional export probability is limited to range between zero and unity. Taking region i's export cutoff based on (5), we can formulate the conditional export probability as

$$\chi_i = \left(\frac{\varphi^*_{ii}}{\varphi^*_{ij}}\right)^k = \tau^{-k}\left(\frac{f^d + b}{f^x - f^d}\right)^{k/(\sigma-1)}\left(\frac{w_j}{w_i}\right)^{\sigma k/(\sigma-1)}\left(\frac{\varphi^*_{ii}}{\varphi^*_{jj}}\right)^k. \tag{6}$$

We will refer back to this ratio later as agency costs exert their impact on location equilibria and thus regional inequality through χ_i. For symmetry, it is obvious that the export propensity is decreasing in net export fixed costs $f^x - f^d$ and variable trade costs τ while it is increasing in domestic setup costs f^d as well as in the agency cost parameter b.

In a next step, we combine (FE) and (MCA) jointly with the export probability from equation (6) to express the domestic cutoff as a function of relative wages. For region i we have

$$\varphi^*_{ii} = \left[\frac{bk + f^d(\sigma-1)}{k-\sigma+1}\frac{1-\eta^2}{1-\eta\left(\frac{w_j}{w_i}\right)^{\sigma k/(\sigma-1)}}\right]^{1/k}, \tag{7}$$

where we have defined $\eta \equiv \tau^{-k}((b+f^d)/(f^x-f^d))^{(k-\sigma+1)/(\sigma-1)}((b+f^d)(\sigma-1))/(bk+f^d(\sigma-1))$.[13] Fig. 2 illustrates (MCA) and (FE) for symmetry showing that higher agency costs raise the productivity cutoff. This is intuitive as a more severe credit constraint precludes the less productive firms from producing and only more productive firms receive external finance. Put differently, it requires higher operating profits (higher productivity φ) to meet (PC). Once regions become asymmetric, the cutoffs remain strictly positive in both regions and the region with the higher wage rate features the lower cutoff productivity. This is because higher wages reduce expected profits and result in less entry of entrepreneurs and thus less intense competition.

In equilibrium, both the labor market and the goods market have to be clear. Noting that M_i denotes that number of active firms in i of which a share χ_i exports, we can formulate the market-clearing condition for mobile workers (*LMC*) in region i as

$$\lambda H = M_i\left[\frac{q_{ii}(\tilde{\varphi}_{ii})}{\tilde{\varphi}_{ii}} + \frac{f^d}{\psi}\right] + \chi_i M_i\left[\frac{q_{ij}(\tilde{\varphi}_{ij})}{\tilde{\varphi}_{ij}} + \frac{f^x - f^d}{\psi}\right] + (\varphi^*_{ii})^k\frac{M_i}{\psi}, \tag{LMC}$$

where $q_{ii}(\tilde{\varphi}_{ii})$ and $q_{ij}(\tilde{\varphi}_{ij})$ represent average domestic sales and average exports, respectively.[14] Labor demand on the right-hand side of (LMC) has three components. (i) The first component captures variable and fixed labor inputs of all firms in region i that produce for the domestic market plus the fixed inputs of firms that were hit by the bad shock. (ii) The second component refers to the number of exporters $\chi_i M_i$ and the additional labor inputs needed to serve the export market following the same logic. (iii) Finally, some mobile workers have chosen to become entrepreneurs which is captured by the last term. A fraction of these entrants is not productive enough to secure external finance while another fraction has been granted a loan, but was hit by the bad shock before production started. Both groups end up with no income.[15] Note that

[12] Note that for symmetric regions $w_i = w_j$ and $\varphi^*_{ii} = \varphi^*_{jj}$ such that $\varphi^*_{ji} > \varphi^*_{ii}$ implies $\varphi^*_{ji} > \varphi^*_{jj}$ and $\varphi^*_{ij} > \varphi^*_{jj}$ implies $\varphi^*_{ij} > \varphi^*_{ii}$. For asymmetric regions, ensuring that only domestically active firms start exporting imposes a limit on relative wages. These conditions and the existence of asymmetric interior equilibria are discussed in the online appendix.

[13] Note that $0 < \eta < 1$ due to $(f^x - f^d)/(f^d + b) > 1$ and $k > \sigma - 1$. The latter is the standard assumption to ensure that the integral over productivities converges.

[14] The Pareto distribution ensures that the ratio of the average productivity levels with respect to the relevant cutoff is constant, that is $\tilde{\varphi}_{ii}/\varphi^*_{ii} = \tilde{\varphi}_{ij}/\varphi^*_{ij} = [k/(k-\sigma+1)]^{1/(\sigma-1)}$.

[15] The number of entrants corresponds to the number of workers who want to become an entrepreneur. Only $(\varphi^*_{ii})^{-k}\psi$ of those will not be hit by the bad shock and eventually become an active entrepreneur. In order to endogenously determine productivities and firm numbers, we need to impose some (opportunity) costs of drawing a productivity (as in Melitz, 2003). Yet, we may allow non-successful entrepreneurs drawing $\varphi < \varphi^*$ to return to the labor market and supply a fraction of their labor endowment. While this complicates the analysis, all results remain valid.

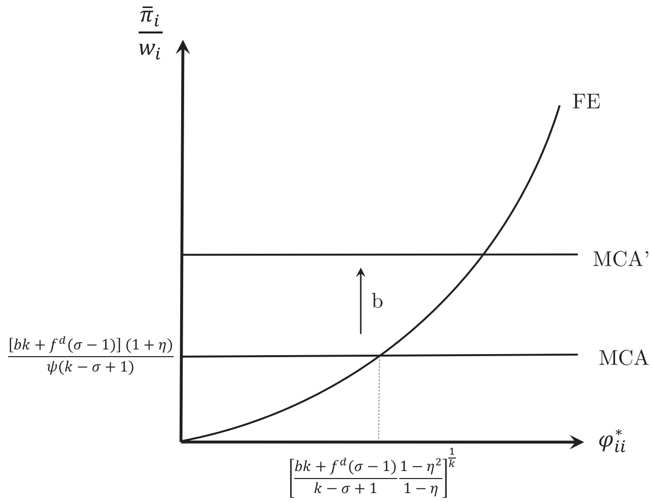

Fig. 2. Domestic productivity cutoff.

according to (2) quantities are functions of the price index which is given by

$$P_i=\left[M_i\left(\frac{\sigma w_i}{(\sigma-1)\tilde{\varphi}_{ii}}\right)^{1-\sigma}+\chi_j M_j\left(\frac{\tau\sigma w_j}{(\sigma-1)\tilde{\varphi}_{ji}}\right)^{1-\sigma}\right]^{1/(1-\sigma)}. \tag{8}$$

The goods-market-clearing condition (*GMC*) equates net exports of manufactured varieties with net imports of the homogeneous good. The latter is the difference between local expenditure for the homogeneous good and local production of that good. For region *i*, this can be expressed as $(1-\alpha)[L/2+\lambda H w_i]-L/2$ such that the goods-market-clearing condition reads[16]

$$(1-\alpha)\lambda H w_i-\alpha L/2=\chi_i M_i r_{ij}(\tilde{\varphi}_{ij})-\chi_j M_j r_{ji}(\tilde{\varphi}_{ji}). \tag{GMC}$$

The left-hand side represents the difference between aggregate revenues from exports in *i* and *j*. If production in the manufacturing industry is larger in *i* than in *j*, region *i* is a net exporter of manufactured goods and a net importer of the homogeneous good.

A solution of the model is a vector $\{w_i, w_j, M_i, M_j, \varphi^*_{ii}, \varphi^*_{jj}, \chi_i, \chi_j\}$ satisfying equations (*LMC*), (*GMC*), (6), and (7) for each region where revenues, quantities and price indices have been substituted. Like in Krugman (1991), endogenous variables enter in a non-linear fashion such that closed-form solutions are not generally feasible. This is further complicated by heterogeneous productivity and credit constraints that render the number of firms endogenous. Thus, we have to rely on numerical methods to solve the model in the general case. However, we are able to derive analytical results for symmetry and full agglomeration which turn out as the only stable migration equilibria. The following two subsections present model solutions for two cases. First, we solve the model for an exogenous share of mobile workers λ in region *i* in Section 3.1. Second, we endogenize λ in Section 3.2 by imposing equality of indirect utility in both regions as an additional equilibrium condition.

3.1. Exogenous location

To simplify notation, we follow a standard procedure in the literature (Fujita et al., 1999; Baldwin et al., 2003) by normalizing $L=1-\alpha$ and $H=\alpha$.[17] A useful illustration in this context is Fig. 3 which shows differences in mobile workers' indirect utility for each possible labor allocation λ.[18] The functions represent equilibria for three levels of trade costs. We observe that indirect utilities differ across regions except for $\lambda=0.5$ and that the slope of the functions differ with trade costs. Note that Fig. 3 represents a solution without credit constraints ($b=0$). This allows us to document that the economic mechanisms in our model produce the same location pattern as in Krugman (1991) – although he abstracts from heterogeneous firms and export fixed costs.

[16] Note that for goods-market-clearing the value of excess demand for *Q* products in *i* has to equal the value of excess production of *Q* in *j*, $ED^Q_i=EP^Q_j$. At the same time, the value of excess demand for *Y* in *j* has to equal the value of excess production of *Y* in *i*, $ED^Y_j=EP^Y_i$. Balanced trade requires with two regions and two sectors that $EP^Q_j=EP^Y_i$ such that we obtain $ED^Q_i=EP^Y_i$ and $ED^Y_j=EP^Q_j$. In our framework the latter immediately yields (GMC).

[17] Note that the model can also be solved without normalizing *L* and *H* and our results are not affected by this normalization. See Ehrlich and Seidel (2013a) for a version of the model without this normalization.

[18] For Figs. 3–6 we choose the following parameter values: $f^x=40$ $f^d=5$, $k=4$, $\alpha=0.4$, and $\sigma=3$. All the results are insensitive to the choice of these parameters. In choosing the parameter values we account for the so-called 'no-black-hole' condition $(\sigma-1)/\sigma>\alpha$.

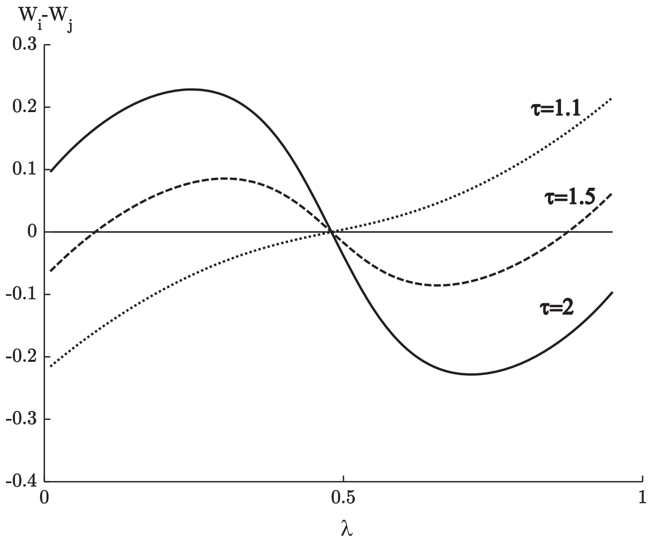

Fig. 3. Trade costs and location.

We can go beyond numerical solutions in two distinct cases: symmetry ($\lambda = 0.5$) and full agglomeration ($\lambda = 0$ or $\lambda = 1$). These closed-form solutions allow insights about how credit frictions work. Moreover, these equilibria turn out as the only stable location equilibria when λ is endogenized in Section 3.2.

We now solve the model for the symmetric case in closed form and relegate derivations of the full-agglomeration case to Appendix B. Using (GMC) and (LMC) for $\lambda = 1/2$, we obtain the equilibrium wages and number of firms as

$$w_i = w_j = 1 \quad \text{and} \quad M_i = M_j = \frac{\alpha\psi(k-\sigma+1)(\sigma-1)}{2k\sigma[f^d(\sigma-1)(1+\eta)+b(k\eta+\sigma-1)]}.$$

Domestic cutoffs and export shares emerge directly from (6) and (7). While wages do not respond to changes in agency costs, the number of firms decreases in b because lower agency costs allow less productive firms to secure external finance. This leads to more entry and a larger number of operating firms. As low-productive non-exporting firms enter, the export propensity declines in agency costs. We document in Appendix B that the comparative static insights for the symmetric case extend to full-agglomeration equilibria. Proposition 1 summarizes the analytical findings.

Proposition 1. *For symmetry ($\lambda = 0.5$) and full agglomeration ($\lambda = 0$ or $\lambda = 1$), a reduction of agency cost parameter b reduces the domestic cutoff productivity φ_{ii}^* and the share of exporters χ_i. This implies a larger number of operating firms M_i while leaving the wage w_i unaffected.*

Proof. See Appendix B. □

3.2. Endogenous location

Since we are mostly interested in the role of financial frictions for location equilibria, we now turn to the derivation of the share of mobile workers residing in region i, referred to as λ. Mobile workers migrate as long as the target region offers higher indirect utility. For interior equilibria, we have

$$\frac{w_i}{P_i^\alpha} = \frac{w_j}{P_j^\alpha}. \tag{9}$$

Alternatively, all workers and thus firms may agglomerate in one region. It is noteworthy that it is not firms that move, but individuals. Changing the allocation of labor results in endogenous adjustments of firms and wages to meet the equilibrium conditions. Fig. 3 helps identifying location equilibria by applying (9). Generally, there are five potential location equilibra: symmetry, interior asymmetric steady states, and full agglomeration. In the following, we show that interior asymmetric solutions turn out non-stable such that either $\lambda = 0.5$ or $\lambda = 1 \vee \lambda = 0$ comprise the relevant migration equilibria. At high levels of trade costs, the symmetric equilibrium with $\lambda = 0.5$ is the only stable outcome while corner solutions ($\lambda = 1$ or $\lambda = 0$) evolve with low trade barriers. The functions in Fig. 3 represent equilibria for exogenous allocations of mobile workers, λ. Allowing workers to migrate renders interior equilibria only stable if the slope at $W_i - W_j = 0$ is negative. Otherwise, a deviation from the symmetric equilibrium raises indirect utility in the target region inducing more outmigration until all mobile workers reside in one region. It is apparent that full agglomeration of the manufacturing industry occurs at low levels of trade costs ($\tau = 1.1$). For an intermediate level of trade costs ($\tau = 1.5$), there are five steady states. However, only the full agglomeration equilibria ($\lambda = 0$ and $\lambda = 1$) and the symmetric dispersion equilibrium ($\lambda = 0.5$) are stable. Increasing trade frictions to $\tau=2$ renders dispersion forces dominant such that only $\lambda=0.5$ is a stable equilibrium. According to the above analysis there are two critical levels of trade costs for which we can derive implicit solutions (see Appendix C). First, the *break point* τ_B describes the lower bound of the set of trade frictions associated with symmetric equilibria. Second, the *sustain point* τ_S defines the upper bound of trade costs associated with full agglomeration. In the following we study how these critical values vary with agency costs b.

Three forces determine the location equilibrium. (i) Firms earn higher profits in the larger market and thus pay higher wages. This effect is referred to as the *home-market effect* and works in favor of allocating the manufacturing industry entirely in one region (due to higher nominal wages). (ii) The second effect is called *market-crowding effect* and works as a dispersion force. The idea is that – for given market size – entrepreneurs prefer fewer competitors as this increases their market share and hence profits. To meet the labor-market clearing condition, nominal wages need to fall when competition increases. (iii) Finally, the *price-index effect* states that mobile workers prefer to live in the region with the lower price index. This is usually the larger region as fewer varieties need to be imported and thus, consumer prices are lower. This effect works in favor of agglomeration.[19]

4. Financial market development

4.1. Location equilibria

Let us now turn to the role of credit constraints for the equilibrium distribution of mobile workers. For this exercise, we keep trade costs constant (e.g. in Fig. 4 at $\tau=1.7$) and vary the agency cost parameter instead. In Fig. 4 the solid, dashed, and dotted functions depict values for W_i-W_j for each level of λ and three scenarios ($b=0$, $b=10$, and $b=20$).[20] A tightening of credit constraints (an increase in b) leads to an anti-clockwise rotation of W_i-W_j around $\lambda=0.5$. Fig. 4 helps us identify migration equilibria. In the absence of credit constraints, that is $b=0$, we observe that only the symmetric interior equilibrium is stable. Full agglomeration is unstable. For an intermediate level of credit constraints, $b=10$, five potential equilibria exist: two asymmetric interior, a symmetric interior and two agglomeration equilibria. In contrast to the symmetric interior and the agglomeration equilibria, the asymmetric interior equilibria are not stable. Raising the financial constraints' intensity further to $b=20$ results in a destabilization of the symmetric equilibrium and implies that asymmetric interior equilibria no longer exist. Hence, for sufficiently tight credit constraints the entire manufacturing industry is located in one region. In the simulation, we chose parameter values for σ, k, and f^x-f^d that are in line with recent literature (see e.g. Egger et al., 2013), but the instability of asymmetric interior equilibria is insensitive to the choice of these parameters.[21] Accordingly, we focus in the following on symmetric and full agglomeration equilibria. Fig. 4 contains two messages. First and similar to Krugman (1991), there are only three stable migration equilibria. Second, tighter credit constraints can turn a stable symmetric equilibrium into a stable full-agglomeration equilibrium.

To shed more light on the interaction between credit constraints and trade frictions, we build on the implicit functions of the *break point* (C.2) and the *sustain point* (C.7) derived in Appendix C. Unfortunately, nonlinearities render analytical comparative static results infeasible, but we are able to plot $\tau_B(b)$ and $\tau_S(b)$ for a large parameter space. Since agency costs are limited by the difference between domestic and exporting fixed costs ($b<f^x-2f^d$), we can plot both critical trade cost levels for the full range of potential agency costs in our benchmark. The dashed line represents the sustain point $\tau_S(b)$. For given agency cost parameter b, all trade cost levels above this threshold are associated with symmetric equilibria. Analogously, the solid line depicts the break point $\tau_B(b)$ that separates multiple equilibria (between $\tau_B(b)$ and $\tau_S(b)$) from stable full-agglomeration equilibria (below $\tau_B(b)$). It is evident from Fig. 5 that both thresholds increase in agency costs. This means that deeper financial markets weaken agglomeration economies and establish symmetric equilibria for a wider range of trade costs.[22]

Result 1. *Financial market development, that is a reduction in b, weakens the incentives for mobile workers and industries to cluster in one location while trade liberalization implies the opposite.*

What is the intuition behind these effects? Why does financial development have the opposite impact on the location of industry as trade liberalization? A key result in the economic geography literature (see e.g. Krugman, 1991; Forslid and Ottaviano, 2003) is that high trade costs cannot be associated with full agglomeration of manufacturing firms. If markets face little competition from firms in the other market, it pays off to leave the agglomeration and produce in the periphery to exploit market power. For lower levels of trade costs, the advantages of producing in the larger market dominate. These insights must remain

[19] Note that the mechanism highlighted in our benchmark model works also in alternative NEG models with weaker agglomeration forces. We incorporated the assumptions of a 'Footloose Entrepreneur Model' in the spirit of Forslid and Ottaviano (2003), fixed regional expenditure shares as in Martin and Rogers (1995), and quasi-linear preferences as in Pflüger (2004) in our setting which confirmed all results.

[20] Note that we chose very pronounced changes in b for illustration purposes while the equilibrium distribution of economic activity will also be affected by minor changes as is shown in Fig. 5.

[21] Graphs analogous to Fig. 4 (and the corresponding Matlab files) for alternative parameter constellations are provided from the authors upon request.

[22] We document in Appendix C that these results are robust to changes in other model parameters. We illustrate in Figs. 7 and 8 how $\partial\tau_B/\partial b$ and $\partial\tau_S/\partial b$ change with respect to (i) different levels of net export fixed costs f^x-f^d, (ii) the shape parameter k of the productivity distribution, (iii) the expenditure share for manufacturing products, α, and (iv) the elasticity of substitution σ.

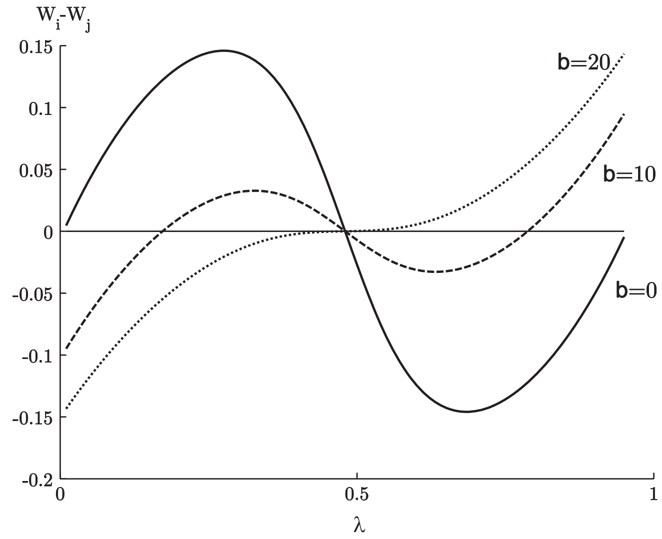

Fig. 4. Credit constraints and location.

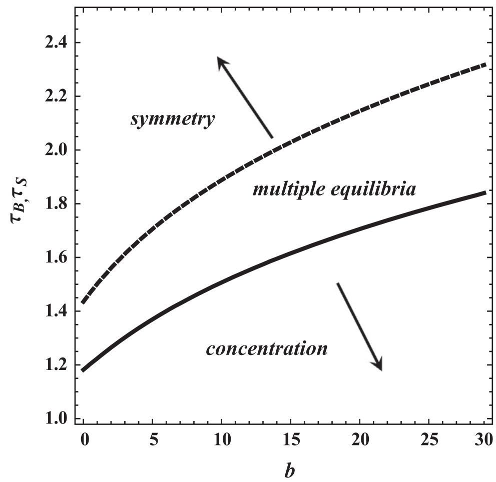

Fig. 5. Migration equilibria. *Note*: the solid and dashed curves display the break-point and sustain-point levels of variable trade costs as functions of agency costs b, respectively. The break point τ_B marks lower bounds of critical $\tau - b$ combinations to ensure symmetry whereas the sustain point τ_S is an upper bound for stable full-agglomeration equilibria. Note that we set $k=4$, $\sigma=3$, $f^d=5$, and $f^x=40$ and provide graphs for alternative parameter constellations in Appendix C.

valid even if we endogenize the export propensity. Lower trade barriers not only reduce the consumer price of imported varieties, but also increase the number and share of available products in each market.

In our model, the export propensity is determined by trade costs and financial development. We know from (6) that lower agency costs reduce the share of exporting firms (despite more firm entry). Entrepreneurs that have a too low productivity to secure external finance may receive the loan when agency costs decline. However, these firms are not productive enough to cover additional fixed costs for supplying customers in the other region. As a consequence, the share of exporters falls when agency costs decline. Further, a lower export propensity implies less inter-regional competition such that net agglomeration forces decline. Note that our mechanism primarily builds on the extensive margin with respect to small firms.[23]

To further improve intuition, let us consider the boundary cases of symmetry and full agglomeration. With a low share of exporters, concentration of the manufacturing industry in one region cannot be a stable situation because the first

[23] This implies that the economic channel we highlight is consistent with the evidence in Amiti and Weinstein (2011). They argue that the Japanese financial crisis has caused the export volume of large listed firms to decline more than their domestic sales. Our focus lies on the implications of financial development for the universe of firms.

entrepreneur who moves to the periphery will have strong monopoly power in this market implying high profits. Hence, dispersion forces dominate in this case. In contrast, if agency costs are high and only large firms survive this means that almost all firms export. In such a situation firms do not gain from moving to the periphery because this does not allow them to avoid competition. Hence, they prefer to cluster and capitalize on the agglomeration benefits due to a larger home market. In this case, the dispersion force is negligible and agglomeration forces dominate. As financial development (a decrease in agency costs) reduces the *share* of exporters, a symmetric distribution of workers and manufacturing firms turns out to be a stable equilibrium for a wider range of trade costs (see Fig. 5). Note also that a very low degree of firm heterogeneity (large k) implies that the share of exporters converges to zero in the absence of credit constraints which rules out agglomeration for any level of τ.

4.2. Income inequality

Let us now turn to the implications for income inequality. In Fig. 6, we plot the ratio of real income in the two regions, W_i/W_j, as a function of trade costs for alternative levels of credit constraints. The yellow (light) area represents symmetric equilibria where inter-regional incomes are identical while "dark red" captures equilibria with the most unequal relative incomes. Note that we have normalized the total number of immobile workers to $L = L_i + L_j = 1-\alpha$ and the total number of mobile workers to $H_i + H_j = \alpha$. This ensures that the nominal wage of Q-sector workers equals the agricultural wage in the symmetric and full concentration equilibria. Hence, regional inequality is not simply driven by a concentration of the scarce factor which receives a higher reward on the labor market, but by lower prices (higher *real* wages) due to access to a wider range of products.

Let us start from a symmetric equilibrium (yellow/light area). If trade costs fall below the *break point*, the symmetric equilibrium collapses causing a sharp increase in inequality as individuals in i are able to consume more manufactured products at lower costs than in j. Fig. 6 nicely illustrates that the break point decreases in financial development (lower b). Interestingly, the more integrated the regions become, the more the important is a frictionless capital market for avoiding a divergence in per-capita GDP. This is because for low levels of trade costs already a moderate level of credit constraints yields divergence while for high trade costs even very poor financial market institutions will not break symmetry.

Beyond this insight, Fig. 6 further reveals how income inequality changes with trade costs and financial development once clustering of the manufacturing industry has occurred. Generally, smaller distances to the break point imply more inequality. However, a further reduction in trade costs *reduces* inequality while inequality *increases* with deeper financial markets (lower b) on the full-agglomeration surface. In the full-agglomeration scenario, financial development raises inequality as the number of firms (and thus product varieties) strictly increases and benefits primarily residents in the core. This effect relies on love-of-variety preferences and is certainly of second-order importance compared to the pronounced jump in inequality once we move from a symmetric to an asymmetric equilibrium. Importantly, inequality is strictly lower if economic activity is evenly distributed across both regions. We can also make statements about income inequality between mobile and immobile workers across both regions. It is obvious that a higher inequality between regional GDP must be associated with higher inequality between groups as clustering of industry is driven by the agglomeration of mobile workers in the core region.

Result 2. *Through its effect on industry location, better quality of financial system (lower b) reduces income inequality both between regions and between mobile and immobile workers. Trade liberalization exerts the opposite effect. In the full-agglomeration case, deeper financial markets raise inequality while trade liberalization reduces it, but inequality remains higher than in the symmetric equilibrium.*

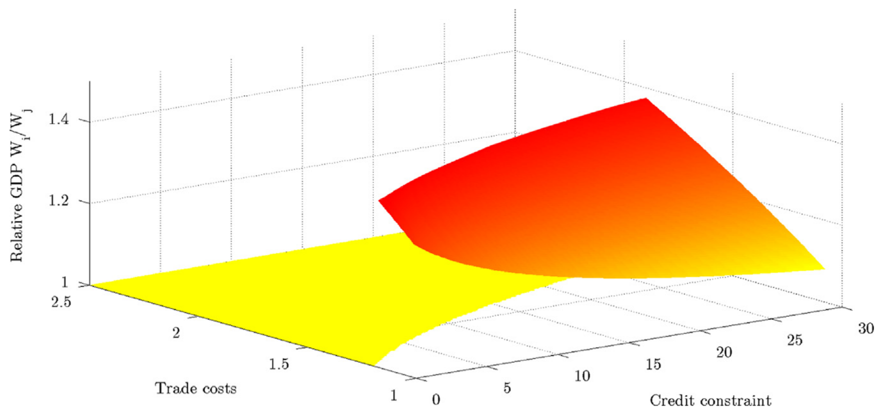

Fig. 6. Per-capita income inequality. *Note*: the yellow (light) area marks symmetric equilibria with equal distribution of per-capita GDP across regions. On the asymmetric surface red (dark) areas mark more unequal distributions of per-capita GDP. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this article.)

5. Concluding remarks

In this paper, we have developed a model that combines goods trade, labor migration and credit constraints due to moral hazard to study the role of financial market development for the distribution of economic activity and income both across and within regions. We show that better access to external funds reduces the incentives for mobile workers to cluster in one region such that economic activity and thus income is more equally distributed. This result stands in contrast to previous research in the finance and growth literature where globalization of financial markets was shown to cause more inequality.

In our framework, the effects of financial market development work through integrated product markets. Mitigating credit constraints reduces the export propensity as low-productive firms that were previously excluded from credit markets are now able to enter the market. Entrepreneurs of larger exporting firms are not subject to credit constraints as their profits are high enough to commit to diligent behavior. The reduction of the export share lowers inter-regional competition compared to local competition and thus renders full agglomeration of industrial activity less attractive.

Our results have important implications for public policies. As politicians are often concerned about regional cohesion, it is crucial to understand the implications of financial market development for the location pattern of industries. In this regard, our paper conveys good news in the sense that lower financial frictions work as a countervailing force to trade integration in reducing the incentive for clustering. Further, deeper financial markets allow for more integrated product markets (that promise welfare gains from trade) without jeopardizing the goal of equal regional living conditions.

Acknowledgments

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Appendix A. Deriving the marginal-credit-access condition (MCA)

Average expected profits accrue from domestic operating profits $r_{ii}(\tilde{\varphi}_{ii})/\sigma$ minus fixed costs for domestic sales and from foreign operating profits $r_{ij}(\tilde{\varphi}_{ij})/\sigma$ minus export fixed costs. The latter have to be weighted by the probability of becoming an exporter conditional on being active in the domestic market. Hence, the average expected profits in region i read

$$\overline{\pi}_i = \frac{r_{ii}(\tilde{\varphi}_{ii})}{\sigma} - \frac{f^d w_i}{\psi} + \left(\frac{\varphi^*_{ii}}{\varphi^*_{ij}}\right)^k \left[\frac{r_{ij}(\tilde{\varphi}_{ij})}{\sigma} - \frac{(f^x - f^d)w_i}{\psi}\right]. \tag{A.1}$$

From the participation constraint (PC), we derive operating profits of the marginal firm that secures external finance:

$$r_{ii}(\varphi^*_{ii}) = \frac{\sigma w_i}{\psi}\left(f^d + b\right). \tag{A.2}$$

In the next step, we substitute $r_{ii}(\tilde{\varphi}_{ii}) = (\tilde{\varphi}_{ii}/\varphi^*_{ii})^{\sigma-1} r_{ii}(\varphi^*_{ii})$ and $r_{ij}(\tilde{\varphi}_{ij}) = (\tilde{\varphi}_{ij}/\varphi^*_{ij})^{\sigma-1} r_{ij}(\varphi^*_{ij})$ in (A.1). Then, we replace $r_{ii}(\varphi^*_{ii})$ and $r_{ij}(\varphi^*_{ij})$ using (4) and (A.2) to obtain

$$\overline{\pi}_i = \left[\left(\frac{\tilde{\varphi}_{ii}}{\varphi^*_{ii}}\right)^{\sigma-1}\left(f^d + b\right) - f^d\right]\frac{w_i}{\psi} + \left(\frac{\varphi^*_{ii}}{\varphi^*_{ij}}\right)^k \left[\left(\frac{\tilde{\varphi}_{ij}}{\varphi^*_{ij}}\right)^{\sigma-1} - 1\right]\left(f^x - f^d\right)\frac{w_i}{\psi}.$$

Further substituting the Pareto distribution's characteristics $\tilde{\varphi}_{ii}/\varphi^*_{ii} = \tilde{\varphi}_{ij}/\varphi^*_{ij} = \left[k/(k-\sigma+1)\right]^{1/(\sigma-1)}$ and $\chi_i = (\varphi^*_{ii}/\varphi^*_{ij})^k$ delivers average expected profits as stated in equation (MCA).

Appendix B. Symmetric and full agglomeration equilibria

B.1. Symmetric equilibrium: comparative statics

Noting that

$$\frac{\partial \eta}{\partial b} = \frac{bk\eta(k-\sigma+1)}{(\sigma-1)(b+f^d)\left[bk+f^d(\sigma-1)\right]} > 0,$$

we immediately obtain $\partial M_i/\partial b < 0$. Moreover,

$$\frac{\partial \varphi_{ii}^*}{\partial b} = \left[\frac{bk+f^d(\sigma-1)}{k-\sigma+1}(1+\eta)\right]^{\frac{1}{k}}\left[\frac{1}{k(1+\eta)}\frac{\partial \eta}{\partial b}+\frac{1}{bk+f^d(\sigma-1)}\right] > 0. \text{ QED.}$$

B.2. Agglomeration equilibrium

We are now considering the case of full agglomeration in region i, so $\lambda=1$ and hence, $H_j=M_j=0$. The price indices simplify to

$$P_i = M_i^{1/(1-\sigma)}\frac{\sigma w_i}{(\sigma-1)\tilde{\varphi}_{ii}}$$
$$P_j = \tau P_i(\chi_i)^{(k-\sigma+1)/(k(1-\sigma))}. \tag{B.1}$$

With the above normalization, the goods-market-clearing conditions imply that the mobile workers' wage is unity in the agglomeration equilibrium:

$$M_i(\varphi_{ii}^*/\varphi_{ij}^*)^k\frac{\alpha E_j}{P_j^{1-\sigma}}p_{ij}(\tilde{\varphi}_{ij})^{1-\sigma} = (1-\alpha)w_iH_i-\alpha L$$
$$w_i = 1 \tag{B.2}$$

Using (PC) and (4), the marginal firms that enter the domestic and exporting markets are characterized by the following conditions:

$$r_{ii}(\varphi_{ii}^*) = \frac{\sigma f^d}{\psi}+\sigma b$$
$$r_{ij}(\varphi_{ij}^*) = \frac{\sigma(f^x-f^d)}{\psi}. \tag{B.3}$$

Employing the above conditions jointly with the price indices we obtain the conditional export probability

$$\chi_i = \frac{1-\alpha}{1+\alpha}\frac{f^d+b}{f^x-f^d}. \tag{B.4}$$

Combining (FE) and (MCA) and inserting (B.3) and (B.4), we obtain the cutoff productivites for the two firm types:

$$(\varphi_{ii}^*)^k = \frac{\sigma-1}{k-\sigma+1}\left[\frac{bk}{\sigma-1}+f^d+\frac{1-\alpha}{1+\alpha}(f^d+b)\right]$$
$$\varphi_{ij}^* = (\chi_i)^{1/k}\varphi_{ii}^*. \tag{B.5}$$

Given the normalization of L and H, $w_i=1$, and using (2), the labor market clearing condition from (LMC) can be stated as

$$H_i = M_i\left[\frac{\alpha(1+\alpha)}{2P_i^{1-\sigma}}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}(\tilde{\varphi}_{ii})^{\sigma-1}+f^d/\psi\right]+M_i\chi_i\left[\tau^{1-\sigma}\frac{\alpha(1-\alpha)}{2P_j^{1-\sigma}}\left(\frac{\sigma}{\sigma-1}\right)^{-\sigma}\left(\tilde{\varphi}_{ij}\right)^{\sigma-1}+f^x/\psi\right]+M_i(\varphi_{ii}^*)^k/\psi. \tag{B.6}$$

Finally, inserting (B.1) in the labor market constraint delivers the equilibrium number of firms

$$M_i = \frac{\alpha\psi}{\sigma\left[f^d+\chi_i f^x+(\varphi_{ii}^*)^k\right]}. \tag{B.7}$$

Hence, the agglomeration equilibrium is characterized by (B.2), (B.4), (B.5), and (B.7). From the expressions it is immediately evident that $\varphi_{ii}^*/\partial b > 0$ and $\chi_i/\partial b > 0$. Accordingly, $M_i/\partial b < 0$ has to hold. QED.

Appendix C. Break point and sustain point

C.1. Break point

At $\lambda=0.5$ it holds true that $dW_i = -dW_j$. Therefore, the symmetric equilibrium is stable as long as an additional worker in i decreases real wages in i – which corresponds to an increase of real wages in j and a negative real wage differential W_i-W_j (graphically this means a negative slope of W_i-W_j at $\lambda=0.5$ in Fig. 4). Hence, the break point τ_B is characterized by the level of trade costs that satisfies

$$\left.\frac{dW_i}{d\lambda}\right|_{\lambda=0.5} = 0 \Leftrightarrow dw_i = \alpha w_i\frac{dP_i}{P_i} \quad \text{for } \lambda = 0.5 \tag{C.1}$$

Solving for the break point involves tedious algebra. First, we totally differentiate the labor market clearing condition (LMC), the goods-market-clearing condition (GMC), and the price index (8). Second, we use this equation system to solve for the derivatives of the price index, $dP_i/d\lambda$, the wage rate, $dw_i/d\lambda$, and the number of firms, $dM_i/d\lambda$ (which is part of the price indices' total derivatives). Second, we use the equilibrium values of w_i, P_i, and M_i at $\lambda=0.5$ as derived in Appendix B and evaluate the above-mentioned derivatives at the symmetric equilibrium.

Finally, plugging in $dw_i/d\lambda$, $dM_i/d\lambda$, and $dP_i/d\lambda(dw_i/d\lambda, dM_i/d\lambda)$ into the definition of the break point from (C.1) yields

$$\frac{(\eta-1)(\sigma-1)^2}{(\eta+1)\alpha\sigma}+\frac{2\eta k\left[f^d(\sigma-1)+bk\right]}{f^d(\sigma-1)(1+\eta)+b(\eta k+\sigma-1)}=\frac{\eta\left[f^d(\sigma-1)+bk\right](2k-\sigma+1)+A(b+f^d)(\sigma-1)^2}{\eta f^d(\sigma-1)+b\eta k-A(b+f^d)(\sigma-1)}, \tag{C.2}$$

where $A=(1-\alpha)/(1+\alpha)$. The break point level of trade costs τ_B solves the above condition and it is plotted for different parameter constellations in Figs. 5 and 7.

C.2. Sustain point

Considering region i to accommodate all mobile workers and using the results for the agglomeration equilibrium as derived in Appendix B, the sustain point is characterized by the following condition:

$$(W_i-W_j)|_{\lambda=1}=0 \quad\Leftrightarrow\quad w_j=\left(\frac{P_j}{P_i}\right)^{\alpha}=(\chi_i)^{(\alpha(k-\sigma+1))/(k(1-\sigma))} \quad \text{for} \quad \lambda=1 \tag{C.3}$$

The agglomeration equilibrium becomes unstable once $(W_i-W_j)|_{\lambda=1}<0$. As shown above the conditional export probability in the agglomerated region χ_i is only a function of parameters so all we need to do is to solve for the wage w_j. In order to obtain the nominal compensation of the first mobile worker to emigrate to the periphery we make use of the fact that (MCA) and (FE) have to balance in region j as well:

$$\left(\varphi_{jj}^*\right)^k=(\varphi_{ii}^*)^k+\frac{(\sigma-1)(f^x-f^d)}{k-\sigma+1}(\chi_j-\chi_i), \tag{C.4}$$

where φ_{ii}^* is given in (B.5). Using (5) jointly with $\varphi_{ij}^*=(\chi_i)^{1/k}\varphi_{ii}^*$ we can substitute φ_{jj}^* in (C.4) to obtain

$$w_j=\tau^{(\sigma-1)/\sigma}\left(\frac{f^x-f^d}{f^d+b}\right)^{1/\sigma}(\chi_i)^{(\sigma-1)/\sigma k}\left[1+\frac{(\sigma-1)(f^x-f^d)(\chi_j-\chi_i)}{(k-\sigma+1)(\varphi_{ii}^*)^k}\right]^{(\sigma-1)/\sigma k}, \tag{C.5}$$

where χ_i, and φ_{ii}^* are function of exogenous parameters only as stated in Appendix B and using (5) for both regions we can express the conditional export propensity in j as a function of parameters, too:

$$\chi_j=\tau^{-2k}\left(\frac{f^d+b}{f^x-f^d}\right)^{2k/(\sigma-1)}\frac{1}{\chi_i}. \tag{C.6}$$

Accordingly, (C.5) and (C.3) determine an implicit solution of the sustain point

$$(\chi_i)^{(\alpha\sigma(k-\sigma+1))/(k(1-\sigma))}\tau^{\alpha}=\left(\frac{1-\alpha}{1+\alpha}\right)\tau^{\sigma-1}(\chi_i)^{(\sigma-1-k)/k}\left[1+\frac{(\sigma-1)(f^x-f^d)(\chi_j-\chi_i)}{(k-\sigma+1)(\varphi_{ii}^*)^k}\right]^{(\sigma-1)/k}, \tag{C.7}$$

where χ_i,χ_j and φ_{ii}^* are defined according to (B.4) and (B.5), respectively. The sustain point level of trade costs τ_S solves the above condition and is plotted in Figs. 5 and 8.

Appendix D. Comparative statics

See Figs. 7 and 8 here.

Appendix E. Supplementary data

Supplementary data associated with this paper can be found in the online version at http://dx.doi.org/10.1016/j.euroecorev.2014.10.008.

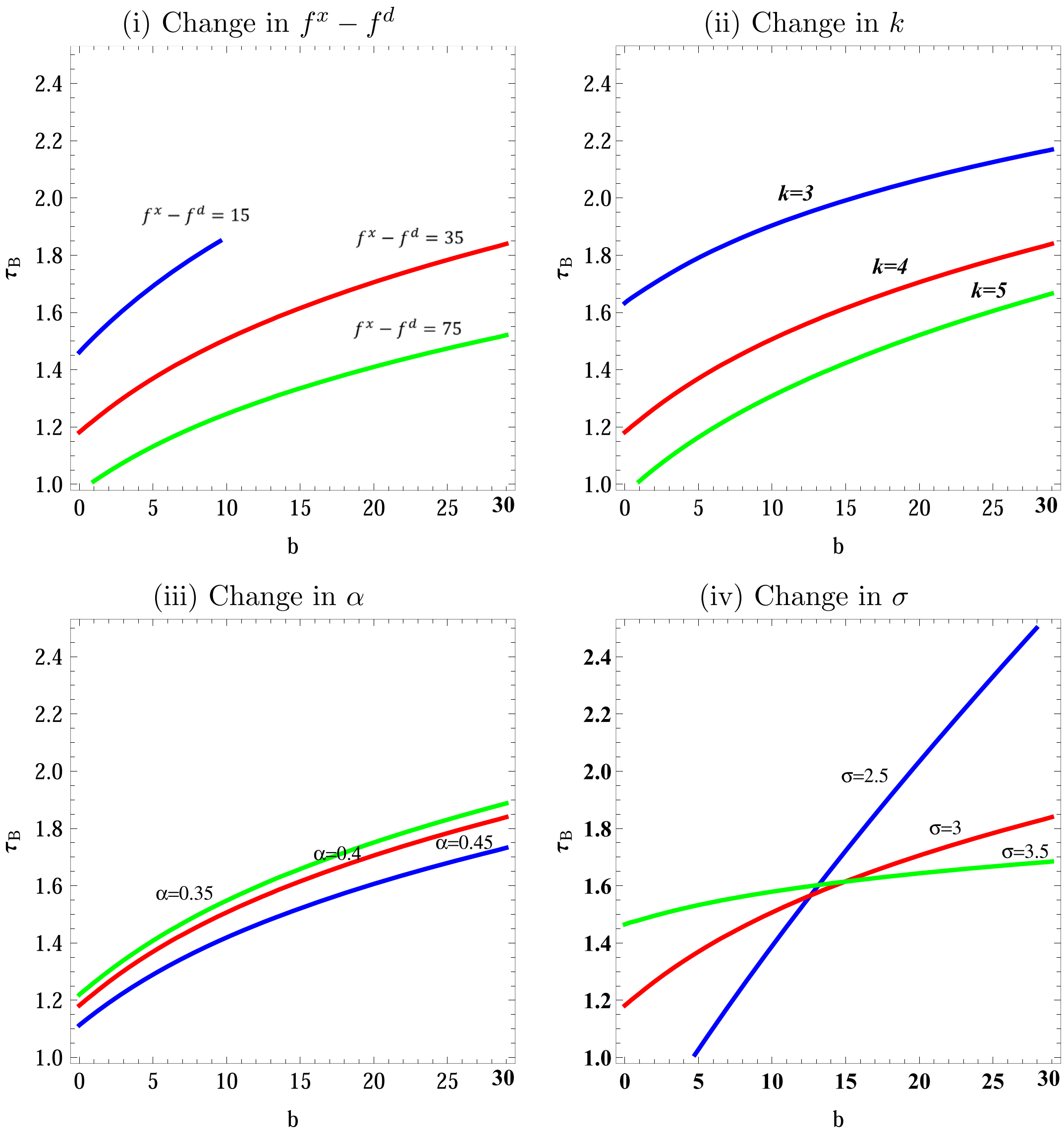

Fig. 7. Comparative statics of the break point. (i) Change in $f^x - f^d$, (ii) change in k, (iii) change in α, and (iv) change in σ. *Note*: the figures display the break point level of variable trade costs τ_B as a function of agency costs b for various levels of fixed trade costs $f^x - f^d$, firm heterogeneity k, expenditure shares of the manufacturing sector α, and elasticity of substitution σ. The curves display the critical $\tau - b$ combinations where symmetry just starts to become unstable. In the area northwest of the curves symmetry is stable while it is unstable southeast of the curves. The functions follow immediately from (C.2) in Appendix C. In each of the plots, the red line corresponds to a benchmark with $k=4$, $\sigma=3$, $f^x=40$, $f^d=5$. Note that the parameter space for b is limited to $b < f^x - 2f^d$ as we require $\varphi^*_{ji} > \varphi^*_{ii}$.

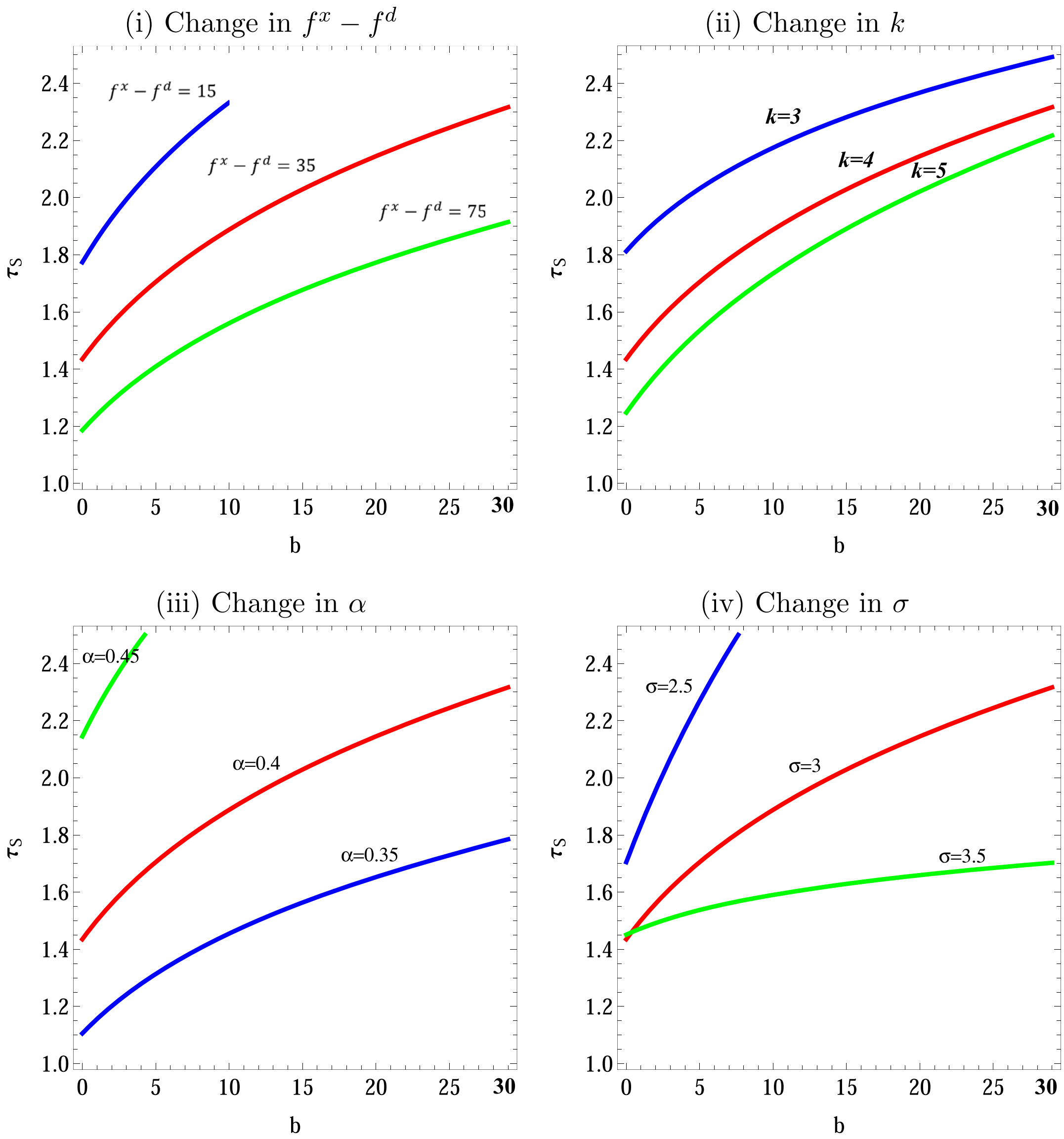

Fig. 8. Comparative statics of the sustain point. *Note*: the figures display the sustain point level of variable trade costs τ_S as a function of agency costs b for various levels of fixed trade costs $f^x - f^d$, firm heterogeneity k, expenditure shares of the manufacturing sector α, and elasticity of substitution σ. The curves display the critical $\tau - b$ combinations where agglomeration just starts to become stable/sustainable. In the area northwest of the curves agglomeration is unstable while it is sustainable southeast of the curves. The functions follow immediately from (C.7) in Appendix C. In each of the plots, the red line corresponds to a benchmark with $k=4$, $\sigma=3$, $f^x=40$, $f^d=5$. Note that the parameter space for b is limited to $b < f^x - 2f^d$ as we require $\varphi^*_{ji} > \varphi^*_{ii}$.

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