Differential labor mobility, agglomeration and skill-biased migration policies

WORK IN PROGRESS

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Abstract

This paper develops an agglomeration model with two types of mobile labor. Workers are heterogeneous and differ both within and between skill groups with respect to their migration propensity. The model derives the pattern of spatial agglomeration and the interactions between both types of labor. It generalizes prior work and generates a wide range of agglomeration patterns within a single analytically solvable framework. The approach is used to analyze the impact of skill-biased migration policies in a setting where market size plays a role. The paper identifies an inverse relation between impediments to migration of one factor of production and the migration incentive of the other: Increasing (reducing) political barriers to migration for one factor of production, reduces (increases) the migration incentive of the other.

JEL classification: F12; F15; F22; R12

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1 Introduction

Industrialized countries are moving towards immigration policies that favor inflows of highly skilled labor. This trend becomes manifest in a variety of policy measures. In the Netherlands and Ireland fast-track visa for specialists facilitate immigration. Canada, Australia, New Zealand and the UK have adopted (or are about to adopt) a point-based immigration scheme where potential migrants earn points on the basis of their qualifications and language skills, their work experience and other personal factors (e.g., age, education of spouse, existing family ties in the destination country). The score achieved in the skill assessment helps to identify and to facilitate entry for highly skilled workers. Other countries, as in the case of Canada, further support the inflow of skilled labor by promoting access to the labor market for their spouses. The current migration policies of the United States are based on immigration quotas with respect to different skill levels. They promote the inflow of skilled labor by non-immigrant visa (H1B visa which permit a limited duration of stay) or the United States Permanent Resident Card (green card, which does not restrict the duration of stay). But opinions are voiced to adopt a point-based immigration scheme, as well (compare Bartlett (2007)).

The aim of this paper is to analyze the effects of skill-biased migration policies in a setting where market size plays a role. It argues that skilled-biased immigration policies can provoke counterproductive and politically unwanted side effects. To reveal these adverse effects, the paper develops a new trade model with increasing returns to scale and two mobile factors of production, which differ with respect to their abilities and migration impediments.

So far, new trade models combined with factor mobility (better know as new economic geography NEG) have been exploited to explain the patterns of spatial agglomeration and their evolution with respect to the level of economic integration (hier Fujita et. al. einfügen). The majority of these models based on labor mobility assumes two factors of production - one input is self-employed skilled labor and can migrate between different regions, whereas the other factor of production is unskilled labor and due to its total immobility is bound to its regions of origin. Under this set-up, NEG models establish a link between the degree of spatial agglomeration and trade costs. They predict dispersion of economic activity at high levels of trade costs. Economic integration then leads to agglomeration and, depending on the specification of the particular model, to redispersion once trade costs are sufficienctly low. As these NEG models are based on (skilled) labor mobility, they contribute insights to migration theory, especially brain drain. Commander et. al. (2004) point out three significant contributions: firstly, the migration incentive for skilled labor (brain drain) varies with the level of economic integration. Secondly, uneven development may arise even from identical starting points and is a natural and inevitable phase of global development. And thirdly, the emigration of skilled labor is detrimental for those left behind even in the absence of labor market frictions. This holds true as people in the periphery have to import more goods than those in the agglomeration core. Therefore, they pay more transport costs and have lower real wages.

The insights derived from standard NEG models are restricted to such an extend that they are based on the explicit immobility of the unskilled workforce. Furthermore, these models are not suitable to analyze the impact of skill-biased migration policies, as there is only one mobile factor of production. Russek (2008a) questions the assumption of total immobility of unskilled labor and develops an analytically solvable model with two types of mobile labor. Skilled labor is used a fixed input (R&E, headquarter services), unskilled labor is needed as variable factor of production. His analysis shows that the basic forces and insights identified by NEG models can be transfered into more general set-ups with more than one mobile type of labor. But the paper stops short of deriving policy implications. Particularly, the model is not suitable to analyze the impact of skill-biased migration policies, as skilled labor is assumed to be perfectly mobile between regions.

The model presented in this paper builds on the framework developed by Russek (2008a) and extends it by migration impediments for skilled labor. The contributions of this approach are three-fold:

Firstly, the model presents a new trade theory model with two types of workers who are mobile but heterogeneous. Labor differs with respect to its ability. There are self-employed workers (who are referred to as skilled labor) and (unskilled) employees, who are employed by firms. Furthermore, workers have individuals sources of (dis-)utility - be it from heterogeneous preferences over locations, costs or benefits from being remote from one's own socio-cultural surrounding, political barriers to migration, and so forth. These (partially unobservable) sources of utility differ both within and between skill groups. According to Russek (2008b), heterogeneity is analytically equivalent to matching costs - dislike or discontent about a region reduces the utility derived from real wages and, therefore, impede migration movements.

Secondly, the model allows to analyze the impact of skill-biased migration policies under increasing returns to scale. The paper shows that measures which promote the inflow of skilled labor *ceteris paribus* increase the immigration incentive for unskilled labor. But if immigration laws impede or even restrict the inflow of unskilled immigrants, the pressure for illegal immigration becomes stronger. Furthermore, if immigration policies artificially increase migration impediments for unskilled labor, skilled workers haver fewer incentives to immigrate. This is counterproductive to policy measures aiming at increasing immigration flows of the skilled workforce. The fundamental intuition behind these insights is the home market effect: Larger markets attract a larger share of businesses and working places for skilled labor. Markets with a great number of businesses and firms attract both skilled and unskilled labor. Consequently, migration policies which impede labor to enter the country keep markets artificially small. This lowers the immigration incentive of skilled and unskilled labor and may be counterproductive with respect to initial policy intentions.

And thirdly, the analytical framework of approach proposed in this paper exhibits an outstanding flexibility. On the one hand the model generalizes the model by Pflüger (2004) and Russek (2008a). The former arises by assuming perfect immobility of the unskilled workforce and perfect skilled labor mobility, the latter is obtained by allowing for unskilled labor mobility but neglecting migration impediments for skilled labor. On the other hand, the model generates a wide range of agglomeration patterns within one single framework. So, the evolution of economic activity with respect to falling trade costs can be bubble-shaped as in Tabuchi and Thisse (2002) or Pflüger and Südekum (2008) (who extend a standard NEG model by endogenous housing prices). In both models the agglomeration process is smooth and reversible. Or the agglomeration pattern may resemble a spearhead as proposed by Ludema and Wooton (1999) which exhibits a threshold of trade costs at which agglomeration is catastrophic. When both unskilled and skilled labor face low impediments to migration, agglomeration arises at high levels of trade costs. Economic integration then leads to redispersion. This in keeping with Helpman (1998) and Murata (2003).

There exist NEG models which have analyzed the impact of taste heterogeneity in new economic geography models but which differ significantly from the approach presented here. Ludema and Wooton (1999) and Tabuchi and Thisse (2002) have developed models where skilled workers are heterogeneous and have different intrinsic appreciations of regions. Different from the model presented here, these models assume that unskilled labor is homogeneous and perfectly immobile between regions. Murata (2003) and Helpman (1998) are NEG models without any immobile factor of production but which assume only one factor of production. In Murata (2003) labor has heterogeneous preferences over locations, which impedes migration movements. Helpman (1998) introduces a fixed stock of housing, which leads to flexible housing prices and makes migration movements more or less attractive.

This paper is organized as follows: section 2 describes the basic assumptions of the model and derives the short-run equilibrium for any given distribution of skilled and unskilled labor. Section 3 is dedicated to the long-run equilibrium of the model and determines the agglomeration pattern of both skilled and unskilled labor. In section 4, the impact of skill-biased migration policies is analyzed. Section 5 concludes.

2 The model

2.1 The basic set-up

The basic structure of this model is based on the analytically solvable footloose entrepreneur model developed by Russek (2008a). The crucial difference to this paper is that skilled labor is assumed to be heterogeneous in locational preferences. There are two countries in the economy named home (H) and foreign (F). Both countries are identical with respect to tastes, production technologies and the (initial) endowment of factors of production. There are two types of households, skilled and unskilled. The world population of unskilled labor is given by L which is the sum of unskilled labor living in home (L_H) and foreign (L_F). The world-wide mass of skilled people is formalized by K and is composed of skilled people of both regions, K_H and K_F (the subindex indicates the region of residence). Each type inelastically supplies one unit of factor input and receives unskilled wages (W) or skilled wages (R) as income, respectively. This income is entirely spent for the consumption of goods from which people derive utility. There are two types of goods. The homogeneous good (A) is produced under perfect competition with a linear constant returns to scale technology using unskilled labor as the only input. The homogeneous good can be traded without trade costs and serves as the numéraire. Furthermore, there is a set of heterogeneous goods (X) which shall be called manufacturing goods. Each variety is produced under monopolistic competition and increasing returns to scale using both skilled and unskilled labor. Unskilled labor is the only variable factor of production. The marginal input requirement is constant and is given by c. Furthermore, each firm needs one unit of skilled labor as fixed input (*e.g.*, headquarter services or R&D). Varieties of heterogeneous goods incur trade costs when traded between the regions, within a region trade is costless.

Both skilled and unskilled labor is assumed to be mobile across regions, but incurs costs when migrating from one region to the other. These costs differ between individuals. Within one region both types of workers are perfectly mobile between sectors. $\lambda = K_H/K$ and $(1-\lambda) = K_F/K$ express the share of skilled workers living in home (foreign) in relation to the world population of skilled workers. The share of unskilled workers residing in home (foreign) with respect to the world population of skilled labor is denoted by $\rho = L_H/K$ and $(\overline{\rho} - \rho) = L_F/K$. The parameter $\overline{\rho} = L/K$ is the world population of unskilled workers relative to the world population of skilled labor.

2.2 Preferences and demand

Preferences for goods are homogeneous and are given by a logarithmic quasi-linear utility function. The homogeneous good enters the utility function in the form of the linear extension, whereas the aggregate of heterogeneous goods enters logarithmically and is modeled as a CES bundle:

$$\begin{aligned} U &= \alpha \ln C_X + C_A \qquad \text{where } C_X \equiv \left[\int_{i=0}^{N_H} x_i^{\frac{\sigma-1}{\sigma}} \mathrm{d}n + \int_{j=N_H}^{N_F} x_j^{\frac{\sigma-1}{\sigma}} \mathrm{d}n\right]^{\frac{\sigma}{1-\sigma}} \\ \alpha &> 0, \qquad \sigma > 1 \end{aligned} \tag{1}$$

C_X (C_A) is the quantity consumed of the heterogeneous aggregate (homogeneous good), σ measures the elasticity of substitution between any pair of heterogeneous goods and is assumed to be greater one. The positive parameter α measures the weight of heterogeneous goods in the utility function. x_i (x_j) represents the per capita consumption of a domestic (imported) heterogeneous good. N_H and N_F stand for the number of domestic and foreign firms producing each one variety of the manufacturing good. Households maximize their utility given the budget constraint defined as follows:

$$PC_X + C_A = Y \qquad \text{where } \; P \equiv \left[\int_{i=0}^{N_H} p_i^{1-\sigma} \mathrm{d}n + \int_{j=N_H}^{N_F} (\tau p_j)^{1-\sigma} \mathrm{d}n\right]^{\frac{1}{1-\sigma}}, \tau > 1 \tag{2}$$

P is the optimal CES price index where the price of the domestic (imported) variety is given by p_i (p_j). As the homogeneous good is the numéraire, its price is normalized to one. The parameter τ is greater one and captures the (iceberg) trade costs. The income per household is given by Y which is W for unskilled and R for skilled labor. Utility maximization with respect to quantities consumed yields the following demands and the indirect utility function V:

$$\begin{aligned} C_X &= \alpha / P, \qquad C_A = Y - \alpha \\ x_i &= \alpha \; p_i^{-\sigma} \; P^{(\sigma-1)}, \qquad x_j = \alpha \; (\tau p_j)^{-\sigma} \; P^{(\sigma-1)} \\ V &= Y - \alpha \ln P + \alpha(\ln \alpha - 1) \end{aligned} \tag{3}$$

To guarantee that both types of goods are consumed, α is assumed to be less than Y.

2.3 Production and short-run equilibrium

The homogeneous good is produced under constant returns to scale and perfect competition. The production technology of the numéraire is assumed to be linear using a unit input requirement of unskilled labor. Consequently, the wage of unskilled workers equals one.

Each variety of the heterogeneous good is produced under increasing returns to scale with a linear production technology using unskilled labor as variable input. To produce one unit of the good, c units of unskilled labor is needed. Furthermore, one unit of skilled labor is required as fixed input to produce at all. Firms serve both the domestic and the foreign market. Exporting goods incurs trade costs which are formalized by iceberg trade costs. Hence, if τx units are sent away, x units arrive at the foreign market. Firms aim to maximize their profit function Π which for firm i is given by

$$\Pi_i = (p_i^H - c)(L_H + K_H)\, x_i^H \;+\; (p_i^F - c)(L_F + K_F)\, \tau x_i^F - R_i \tag{4}$$

The first (second) term on the LHS is the demand of the domestic (foreign) market. Maximizing profits with respect to the prices p_i^H and p_i^F leads to the following equilibrium prices:

$$p_i^H = p_i^F = p = \frac{\sigma}{\sigma - 1} c \tag{5}$$

Equilibrium prices are characterized by a constant mark-up over marginal costs (mill pricing). Due to free market entry and exit of firms, profits are zero in equilibrium. Setting the equilibrium price equal to average production costs reveals the equilibrium relation between firm size and skilled wages:

$$R_i = \frac{X_i c}{\sigma - 1} \tag{6}$$

where X_i is the aggregate production of variety i. In equilibrium aggregate production has to be equal aggregate demand by all skilled and unskilled workers. As prices are given by Eq. (5), the market clearing condition is uniquely determined by:

$$X_i = \frac{\alpha(\sigma-1)(L_H+K_H)}{\sigma c[K_H+\phi K_F]} + \frac{\alpha(\sigma-1)(L_F+K_F)\phi}{\sigma c[\phi K_H+K_F]} \tag{7}$$

where the RHS of Eq. (7) is the aggregate demand from domestic and foreign consumers. ϕ measures the freeness of trade and is commonly given by $\phi = \tau^{1-\sigma}$. If trade costs tend to infinity, ϕ tends to zero. If trade is costless, ϕ is one. As X_i is identical for all firms i, the subindex of X and R can be omitted. Substituting Eq. (7) into Eq. (6) and dividing both the denominator and the enumerator by K yields the equilibrium wage for skilled workers in region H for any given domestic share of skilled and unskilled labor (for region F the analogous holds true):

$$\begin{aligned} R_H &= \frac{\alpha}{\sigma}\left[\frac{\lambda+\rho}{\lambda+(1-\lambda)\phi} + \frac{\phi[(1-\lambda)+\overline{\rho}-\rho]}{\phi\lambda+1-\lambda}\right] \\ R_F &= \frac{\alpha}{\sigma}\left[\frac{\phi(\lambda+\rho)}{\lambda+(1-\lambda)\phi} + \frac{1-\lambda+\overline{\rho}-\rho}{\phi\lambda+1-\lambda}\right] \end{aligned} \tag{8}$$

Once the goods market equilibrium is determined, the labor market equilibrium can be characterized. The demand for unskilled labor per manufacturing firm of region H which is related to the equilibrium aggregate production X per variety is given by $N_H cX$. Putting Eq. (6) into this expression yields the following expression for the labor demand of the domestic manufactoring sector:

$$L^D = N_H R_H(\sigma-1) \tag{9}$$

Unskilled workers who are not employed in the manufacturing sector find employment in the homogeneous good sector. The demand for unskilled labor given by Eq. (9) is assumed to be less than the regional supply of unskilled labor L_H so that in either region both types of goods are produced. As in Russek (2008a), due to unskilled labor mobility the regional supply of unskilled labor is not exogenously given, but rather arises endogenously. In section 3 it is shown that the regional supply of unskilled labor is a function of trade costs and the geographical distribution of skilled workers. Taking into account the mobility of unskilled labor, the assumption of regional non-specialization is fulfilled for any given level of trade costs and for any geographical distribution of skilled labor whenever $\alpha < \sigma/2(\sigma-1)$ and $\overline{\rho} > \alpha(\sigma-1)/(\sigma/2-\alpha(\sigma-1))$. Furthermore, unskilled labor must not too mobile[1].

Substituting equilibrium prices from Eq. (5) into the CES- price index yields:

$$P_H = p^*[\lambda + (1-\lambda)\phi]^{\frac{1}{1-\sigma}} \qquad P_F = p^*[\lambda\phi + (1-\lambda)]^{\frac{1}{1-\sigma}} \tag{10}$$

3 Long-run equilibrium

In the long run, skilled and unskilled labor are mobile across regions, but incur mobility costs. Following Tabuchi and Thisse (2002), these costs may arise from preferences over locations, from being remote from one's socio-cultural surrounding and other factors of influence. Consequently, they should be understood as permanent matching costs. The strength of these impediments to migration depends largely on (partially unobserved) personal characteristics, so that these costs differ between individuals. Heterogeneity is modeled by stochastic utility functions which are given by $\overline{V}_{rsk} = V_{rs} + \epsilon_{rsk}$. The term $\overline{V}_{rsk}$ is the perceived utility of person k with ability s (skilled or unskilled) in region r, the expression V_{rs} is given by Eq. (3) and stands for the indirect utility in region $r \in [H, F]$ for skill-level s. ϵ_{rsk} is a stochastic component which accounts for unobserved sources of (dis-)utility of person k and ability s in region r. Within skill groups, ϵ_{rsk} is assumed to be identically and independently Gumbel (*i.e.*, double exponentially) distributed[2] for all k with a mode of 0 and a variance of $\pi^2\eta^2/6$. The parameter η is a positive scale parameter. π is the circular constant.

A worker of ability s migrates to the region where his perceived indirect utility $\overline{V}_{rsk}$ is greatest. As ϵ_{rsk} are identically and independently distributed within skill groups, the

[1] Due to the analytical expression of the labor supply curve the points of intersection between the labor supply and demand curve cannot be determined analytically. But as both the labor demand and the labor supply are increasing in λ, it is possible to focus on $\lambda = \{0, 0.5, 1\}$. At these points the labor supply is always greater than the labor demand, if the above parameter restriction hold. Assuming that matching costs of unskilled labor are not too small ensures that labor supply of unskilled workers is greater than labor demand for any $\lambda \in [0, 1]$.

[2] The type of distribution is irrelevant. But assuming a Gumbel distribution leads to a closed form solution of the matching cost function.

share of workers of type s in region H with respect to the corresponding worldwide stock of these workers is determined by the probability that $\overline{V}_{sH}$ exceeds $\overline{V}_{sF}$. The share of s-workers in F is determined analogically. As the difference in two Gumbel distributed variables follows a logistic distribution (compare Anderson *et. al.* (1992)), the condition for a spatial equilibrium of each type of labor is given by

$$G \equiv \Delta V_s - \eta \ln \left[\frac{\psi}{1-\psi} \right] = 0 \tag{11}$$

where ψ denote either the share of skilled labor λ $(1-\lambda)$ or the share of unskilled labor $\rho/\overline{\rho}$ $(1-\rho/\overline{\rho})$ in H (F) with respect to the according world population by skill-level. ΔV_s is the difference in indirect utilities relevant for workers of skill-type s. Using Eq. (3), ΔV_s is given by

$$\Delta V_s \equiv V_{sH} - V_{sF} = -\alpha(\ln P_H - \ln P_F) + (Y_{sH} - Y_{sF}) \tag{12}$$

The second term on the RHS of Eq. (11) is the mobility costs curve $C(\psi)$, which is upward sloping in ψ and tends toward (negative) infinity, when ψ approaches (zero) one. The parameter η is a positive scale parameter and a direct measure of mobility costs. The greater η, the greater they are. In what follows it is assumed that matching costs differ between skilled and unskilled labor. Furthermore, it is plausible to assume that skilled labor faces lower levels of mobility costs than unskilled labor. On the one hand skilled labor should have greater ease to adapt to new socio-cultural environments. On the other hand, (score-based) immigration policies favor skilled labor rather than unskilled labor immigration. Consequently, in what follows η takes on the value ν (μ) for skilled (unskilled) labor with $\nu < \mu$. When $\nu = 0$ and $\mu > 0$, the model by Russek (2008a) arises where skilled workers are perfectly mobile and the unskilled workforce faces migration costs. If $\nu = 0$ and $\mu \to \infty$, skilled (unskilled) labor is perfectly mobile (immobile) so that the model laid out in Pflüger (2004) is obtained.

Using Eq. (10) and (8) in (12) and taking into account that in both regions unskilled wages equal one, the conditions for spatial equilibria are given by

$$\begin{aligned} S(\lambda) \equiv & \ \tfrac{\alpha}{1-\sigma}\ln\tfrac{\lambda\phi+1-\lambda}{\lambda+\phi(1-\lambda)} + \tfrac{\alpha(1-\phi)}{\sigma}\left(\tfrac{\rho+\lambda}{\lambda+(1-\lambda)\phi} - \tfrac{\overline{\rho}-\rho+1-\lambda}{\phi\lambda+1-\lambda}\right) - \nu\ln\left[\tfrac{\lambda}{1-\lambda}\right] = 0 \\ G(\rho/\overline{\rho}) \equiv & \ \tfrac{\alpha}{1-\sigma}\ln\tfrac{\lambda\phi+1-\lambda}{\lambda+\phi(1-\lambda)} - \mu\ln\left[\tfrac{\rho/\overline{\rho}}{1-\rho/\overline{\rho}}\right] = 0 \end{aligned} \quad (13)$$

$S(\lambda)$ and $G(\rho/\overline{\rho})$ are the migration incentive of skilled and unskilled labor net of matching costs, respectively. As in Russek (2008a), there are two equations in λ and $\rho/\overline{\rho}$ which **simultaneously** and **unambiguously** determine the spatial equilibria. In comparison to the model with perfectly mobile skilled labor, the third term of the RHS of $S(\lambda)$ in Eq. (13) is novel and reflects the existence of migration impediments for skilled workers. To analyze the stability of the equilibria defined by Eq. (13), the paper follows Russek (2008a) but restricts the analysis to the case that skilled worker are first-movers. Skilled labor takes the initiative to deviate from a spatial equilibrium, whereas unskilled labor is assumed to follow. The approach is motived by the fact that skilled workers faces less migration costs and, therefore, have greater ease to choose their region of residence[3]. Analytically, the equilibrium share of unskilled labor for any given distribution of skilled labor is given by solving $G(\rho/\overline{\rho})$ in Eq. (13) with respect to ρ:

$$\rho(\Delta V_U) = \frac{\overline{\rho}}{1+\exp(-\Delta V_U/\mu)} \quad (14)$$

where $\Delta V_U = \Delta V_U(\lambda,\phi)$ is the migration incentive of unskilled labor as defined by the first expression of $G(\rho/\overline{\rho})$ in Eq. (13). Consequently, we have $\rho = \rho(\lambda,\phi)$. From Eq. (14) it becomes obvious that greater levels of migration costs reduce the willingness to migrate. Using Eq. (14) in $S(\lambda)$ defined by Eq.(13) yields the equilibrium condition of skilled labor taking into account the reaction of unskilled workers $S(\lambda) = S(\lambda,\ \rho(\lambda,\phi),\ \phi)$.

[3] Alternatively, unskilled labor could take the initiative to devite from a spatial equilibrium, whereas skilled labor follows according its equation of motion. In citer2008a both approaches lead to the same result.

3.1 Model forces, break and dispersion point

The symmetric allocation of skilled and, consequently, unskilled labor is always an equilibrium ($S(\lambda = 0.5) = 0$). The stability of this equilibrium is revealed by the sign of the first derivative of $S(\lambda)$ with respect to λ evaluated at symmetry, which is given by:

$$\left.\frac{\mathrm{d}S(\lambda)}{\mathrm{d}\lambda}\right|_{\lambda=1/2} = \left[\frac{\partial(-\alpha\Delta\ln P)}{\partial\lambda} + \frac{\partial\Delta R}{\partial\lambda} + \frac{\partial\Delta R}{\partial\rho}\frac{\mathrm{d}\rho}{\mathrm{d}\lambda} - \frac{\partial C(\lambda)}{\partial\lambda}\right]_{\lambda=1/2} \tag{15}$$

where $\Delta\ln P \equiv \ln P_H - \ln P_F$ and $\Delta R \equiv R_H - R_F$. The analytical expressions of the linkages can be found in appendix A. The first two terms of the RHS of Eq. (15) are known from Pflüger (2004), Pflüger and Südekum (2008) and Russek (2008a). The first expression is the supply linkage. When λ rises the price index in H falls, because more varieties are produced domestically and do not have to be imported. In F the opposite holds true, which leads to a greater migration incentive for skilled labor toward H. The second term of Eq. (15) can be decomposed into two different forces (compare Pflüger and Südekum (2008)). Firstly, holding the individual demand per good constant, an increase in λ leads to a bigger domestic market and higher profits. This increases the attractiveness of region H (demand linkage by skilled labor). Secondly, holding the market size constant, the lower price index in H relatively increases the price of a variety in region H. Consequently, people demand less units per variety, which lowers the profit of domestic firms making the region less attractive (competition effect). The third term of the LHS of Eq. (15) is the demand linkage by unskilled labor which originates in unskilled labor mobility. An increase in λ raises the migration incentive of unskilled workers as the price index drops in H and rises in F. The gap in regional price levels then increases the share of unskilled labor residing in H and increases the domestic market. This in turn raises domestic profits and the wages of the skilled workforce. Summarizing, there are three forces which foster agglomeration, whereas the competition serves as dispersion force. The fourth term of Eq. (15) reflects the fact that skilled workers face matching costs. Migration is profitable if the increase in real wages outweighs the costs associated with it.

Eq. (13) and (15) show that the migration incentive (terms one to three) can be additively separated from migration costs (term four). Setting $\nu = 0$ ignores these costs for the moment. This corresponds to the analysis in Russek (2008a). The migration incentive of skilled labor is a function of the degree of unskilled labor mobility (μ) and its relative population size ($\overline{\rho}$). The mobility parameter μ influences the relative strength of the demand linkage by unskilled labor and the competition effect. If $\mu > \alpha/(\sigma - 1)$, the (dispersive) competition effect is stronger than the (agglomerative) demand linkage by unskilled workers at any level of trade costs. The relative population size $\overline{\rho}$ determines by how much the competition effect exceeds the demand linkage. If $\overline{\rho}$ is great ($\overline{\rho} > \overline{\rho}_t$, see appendix B), the net dispersion force is strong leading to a migration incentive at symmetry as shown by Fig. 1a. The figure plots the level of trade freeness against the marginal migration incentive at $\lambda = 0.5$. The migration incentive is negative for high levels of trade costs, but becomes positive once trade costs have fallen below a critical threshold. The smaller the relative population size of unskilled workers, the less important are the competition effect and the demand linkage by unskilled workers. Consequently, the (agglomerative) supply and demand linkage by skilled labor gain strength. The latter forces are the stronger, the higher are trade costs (see appendix A). Fig. 1b shows the migration incentive for $\overline{\rho}_t/2\sigma < \overline{\rho} < \overline{\rho}_t$. The migration incentive of skilled labor is positive for any level of trade costs and exhibits a maximum in $\phi \in [0, 1]$. For $\overline{\rho} < \overline{\rho}_t/2\sigma$ the migration incentive is positive for all levels of trade costs but downward-sloping in $\phi \in [0, 1]$ as depicted in Fig 1c. Next, assume that $\mu < \alpha/(\sigma-1)$. The demand linkages by skilled and unskilled labor then overcompensate the competition effect. Agglomeration forces prevail so that the migration incentive for skilled labor is positive but steadily decreasing in $\phi \in [0, 1]$. See also Fig. 1c.

[Figures 1a to 1c about here]

Now the impact of matching costs for skilled labor is considered. At symmetry the marginal costs are given by 4ν, which is constant (see appendix A). The dashed horizontal lines in Figs. 1a to 1c reflect different values of these costs. The intersections between migration incentive and the marginal migration cost curves are the break point (*i.e.*, the level of trade costs at which a symmetric allocation becomes unstable) and the redispersion point (*i.e.*, the level of trade costs at agglomeration becomes unstable). If marginal migration costs are greater than the migration incentive, the population is dispersed. Otherwise, we observe (partial) agglomeration. Analytically, the two critical thresholds are determined by setting Eq. (15) evaluated at symmetry equal to zero and solving it for ϕ:

$$\phi_b = \frac{\mu(\sigma-1)[\alpha(1+\overline{\rho})-\nu\sigma]-\alpha^2\overline{\rho}-\sqrt{Z}}{\mu\left[\nu(\sigma-1)\sigma-\alpha(2+\overline{\rho}-(3+\overline{\rho})\sigma)\right]-\alpha^2\overline{\rho}} \tag{16}$$

$$\phi_r = \frac{\mu(\sigma-1)[\alpha(1+\overline{\rho})-\nu\sigma]-\alpha^2\overline{\rho}+\sqrt{Z}}{\mu\left[\nu(\sigma-1)\sigma-\alpha(2+\overline{\rho}-(3+\overline{\rho})\sigma)\right]-\alpha^2\overline{\rho}} \tag{17}$$

$$\text{with} \quad Z = \alpha\mu\left[\alpha\left(\mu(2\sigma-1)^2+4\nu\overline{\rho}(\sigma-1)\sigma\right)-4\mu\nu(1+\overline{\rho})(\sigma-1)^2\sigma\right]$$

where ϕ_b (ϕ_r) is the break (redispersion) point. Whether and which of these two thresholds is real and lies in the inteval $\phi \in [0,1]$, depends on the degree of matching costs of both types of labor, μ and ν, as well as the relative population size $\overline{\rho}$. Table 1 summarizes the results.

Table 1: Overview of parameter restrictions

μ	case	$\overline{\rho}$	ν_{min}	ν_{max}
$\mu > \alpha/(\sigma-1)$	(a)	$\overline{\rho} > \overline{\rho}_t$	0	$\overline{\nu}$
	(b)	$\overline{\rho}_t/2\sigma < \overline{\rho} < \overline{\rho}_t$	$\underline{\nu}$	$\overline{\nu}$
	(c)	$\overline{\rho} < \overline{\rho}_t/2\sigma$	0	$\underline{\nu}$
$\mu < \alpha/(\sigma-1)$	(d)	$\overline{\rho} > 0$	0	$\underline{\nu}$

Parameter values are displayed in appendix B. Whenever ν is greater than the upper bound ν_{max}, the migration incentive is always less than the marginal migration costs for all levels of trade costs so that dispersion is the only stable equilibrium[4]. Therefore, neither the break nor the redispersion point exist. If in cases (**a**) and (**b**) it holds true that $\nu_{min} < \nu < \nu_{max}$, both the break and redispersion point lie in the interval $\phi \in [0,1]$. Consequently, we observe dispersion - agglomeration - redispersion in the process of economic integration. If in case (**b**) the level of skilled migration costs is smaller than

[4]The value $4\nu_{max}$ always corresponds with the greatest value of migration incentive in the interval $\phi \in [0,1]$.

the lower threshold ν_{min}, only ϕ_r is in $\phi \in [0, 1]$. Consequently, even at high levels of trade costs, the economy is (partially) agglomerated in either region. Economic integration then leads to further agglomeration before redispersion is observed . In cases (**c**) and (**d**) the greatest migration incentive is observed at high levels of trade costs. As long as migration costs of skilled labor are lower than ν_{max} reported in Table 1, only ϕ_r is in $\phi \in [0, 1]$ so that we also observe agglomeration for high levels of trade costs. Falling trade cost lead to redispersion.

The comparative statics of the break and redispersion point are straightforward: $\partial\phi_b/\partial\alpha < 0$ and $\partial\phi_r/\partial\alpha > 0$ which is due to stronger agglomerative forces as heterogeneous goods get more weight in the utility function, $\partial\phi_b/\partial\mu > 0$ and $\partial\phi_r/\partial\mu < 0$ meaning weaker agglomerative forces as the unskilled demand linkage becomes less important. With respect to changes in the elasticity of substitution, we find that $\partial\phi_b/\partial\sigma > 0$ and $\partial\phi_r/\partial\sigma < 0$ since agglomeration forces become weaker as firms have less market power and lower mark-ups over marginal costs. And finally, we have $\partial\phi_b/\partial\overline{\rho} > 0$ and $\partial\phi_r/\partial\overline{\rho} < 0$, if migration costs of unskilled labor μ are greater than $\alpha/(\sigma-1)$. The competition effect then outweighs the demand linkage of unskilled labor, so that a greater number of unskilled labor strengthens the dispersive competition effect. Otherwise, we find that $\partial\phi_b/\partial\overline{\rho} < 0$ and $\partial\phi_r/\partial\overline{\rho} > 0$.

3.2 The patterns of regional development

3.2.1 Skilled labor agglomeration

The interregional distribution of skilled labor depends on the relative stock of unskilled labor $\overline{\rho}$ as well as the degrees of unskilled and skilled labor mobility, μ and ν. Analytically, the type of agglomeration pattern is determined by the sign of the third derivative of the migration incentive $S(\lambda)$ with respect to λ evaluated at the critical levels of trade costs ϕ_b and ϕ_r. Appendix B shows these measures. The focus here is to highlight the interaction between the migration incentive of skilled labor and its matching costs graphically. This graphical-intuitive approach was first used by Ludema and Wooton (1999) and has proven to be a usefool tool in analyzing more complex NEG models (see Russek (2008b)). Recall that in Eq. (13) the matching costs (MC in short) of skilled labor can be separated additively from the migration incentive (MI in short). Consequently, the two curves can be depicted separately in a single diagram. As in Ludema and Wooton (1999) a spatial equilibrium is obtained at points of intersection between MI and MC. The stability of such an equilibrium is revealed by the slopes of the respective curves. Whenever the slope of MC is greater (smaller) than the slope of MI at a point of intersection, the spatial equilibrium is (un-)stable.

Fig. 2a and 3a show the migration incentive curve as well as the cost curve for different values of trade costs and structural parameters. MC is independent of trade costs and is upward sloping in the whole interval $\lambda \in [0, 1]$. When λ tends to 1 (0) MC tends to (negative) infinity. If the set of parameters is as in Table 1 case (**a**), the migration incentive curve is identical to what has been worked out by Russek (2008a). Consequently, the shape of MI depends on μ and $\overline{\rho}$. If $\mu > \mu_{crit}$ (see appendix B), the MI-curve is as shown in Fig. 2a and resembles the curve worked out by Pflüger (2004). At high levels of trade costs MI is downward-sloping, but economic integration increases the migration incentive. Once the break point is reached, falling trade costs lead to a smooth and reversible transition from dispersion to partial agglomeration. Further reductions of trade costs reduce the migration incentive and lead to redispersion of skilled labor. Once trade costs have fallen below the redispersion point, dispersion is the only stable equilibrium. Therefore, the pattern of regional development is bubble-shaped as in Tabuchi and Thisse (2002) and shown in Fig. 2b. Observe that complete agglomeration never is an equilibrium, because MC tends to (negative) infinity when λ tends to 1 (0).

[Figures 2a and 2b about here]

If unskilled labor faces small matching costs so that $\mu < \mu_{crit}$ and the relative population size of unskilled labor exceeds a certain threshold $\overline{\rho}_{crit}$ (see appendix B), MI is as shown in Fig. 3a and resembles the migration incentive of the seminal core-periphery-model by Krugman (1991). According to Russek (2008a) the transformation of the shape is due to the increase of domestic income induced by unskilled labor immigration. The evolution of MI with respect to falling trade costs is similar to above: At high (low) levels of trade costs, economic integration makes MI rotate counterclockwise (clockwise). The interplay of MI and MC leads to a set of regional distribution patterns as described in Ludema and Wooton (1999) and Basevi (1999). The probably most prominent shape of economic distribution is the spearhead as shown in Fig. 3b. But while Ludema and Wooton (1999) have to rely on simulations and intuitive guesses to determine to resulting shape of economic distribution, this paper provides analytical measures which unambiguously reveal the type of bifurcation (see appendix B). Case (**b**) yields qualitatively similar results, if $\underline{\nu} < \nu < \overline{\nu}$.

[Figures 3a and 3b about here]

Fig. 4 shows the resulting bifurcation pattern of case (**b**), if ν is smaller than ν_{min}. Partial agglomeration prevails even at very high levels of trade costs. Falling trade costs first foster the concentration of economic activity, before redispersion is observed. A similar pattern arises in cases (**c**) and (**d**). But here the highest degree of economic concentration is observed at (prohibitively) high levels of trade costs. Economic integration then reduces the incentive to agglomerate and leads to dispersion. Fig. 5 shows the corresponding distribution of economic activity.

[Figures 4 and 5 about here]

3.2.2 The distribution of unskilled labor

Once the equilibrium share of skilled labor is determined, one can derive the equilibrium distribution of unskilled labor at any level of trade costs by using $\rho^*/\overline{\rho} = \rho^*/\overline{\rho}(\lambda^*(\phi), \phi)$ described by Eq. (14). Observe that $\rho/\overline{\rho}$ follows a logistic probability function with the migration incentive for unskilled labor ΔV_U being the argument. As the migration incentive of unskilled labor is monotonically increasing in the degree of skilled labor agglomeration, there is a positive one-to-one relationship between skilled and unskilled labor distribution agglomeration. Furthermore, it follows that both types of labor agglomerate in the same region.

Figs. 6a and 6b show the evolution of unskilled labor concentration (black lines) and the skilled labor agglomeration (grey lines) with respect to falling trade costs. As long as skilled labor is dispersed, unskilled labor is equally split between regions, as well. Once trade costs have fallen below the breakpoint ϕ_b, skilled and, therefore, unskilled labor agglomeration becomes stable. If skilled labor agglomeration is smooth and reversible (catastrophic) as described in Fig. 2b (2c), unskilled labor agglomeration is smooth (catastrophic), as well. As in Russek (2008a), falling trade costs have two opposing effects on the migration incentive of unskilled workers:

$$\frac{\mathrm{d}\Delta V_U}{\mathrm{d}\phi} = \frac{\partial \Delta V_U}{\partial \lambda^*}\frac{\mathrm{d}\lambda^*}{\mathrm{d}\phi} + \frac{\partial \Delta V_U}{\partial \phi} \tag{18}$$

The first term of the RHS of Eq. (18) reflects the fact that economic integration changes the pattern of skilled labor agglomeration as shown by Figs. 2b to 5. The second expression shows that falling trade costs reduce the difference in domestic price levels so that the migration incentive of unskilled labor decreases. As long as λ^* is increasing in ϕ, these two forces oppose each other. Due to symmetry in price levels at dispersion, the overall effect of economic integration on the migration incentive of unskilled labor at the break point is positive. Consequently, around ϕ_b the share of unskilled labor $\rho/\overline{\rho}$ is increasing in ϕ. Once skilled labor agglomeration has peaked in either region, both forces act into the same direction leading to redispersion of the unskilled workforce. When trade costs falle below the redispersion point, dispersion of both skilled and unskilled labor is the only stable equilibrium.

4 Policy implications

Governments seek to influence the skill pattern of immigrants: governmental policies usually prefer skilled labor immigration, whereas most country try to reduce the inflow of unskilled labor. The aim of this section is to analyze the impact of each of these policy measures in the presented framework and to work out their counterproductive interactions.

Consider an economic in a stable spatial equilibrium as described above and assume (without loss of generality) that there is partial agglomeration in either region ($\lambda^* > 0.5$). Pro-skilled immigration policies reduce political barriers to immigration. Analytically, this can be represented by lower values of ν. *Ceteris paribus*, the immigration incentive net of mobility costs $S(\lambda)$ increases, leading to a higher equilibrium share of skilled labor ($\mathrm{d}\lambda^*/\mathrm{d}\nu < 0$). But pro-skilled immigration policies induce a second effect further enhancing skilled labor immigration: As the equilibrium share λ^* increases, the immigration incentive for unskilled labor increases, as well. Analytically, we find $\mathrm{d}G(\lambda^*)/\mathrm{d}\nu = (\partial G/\partial\lambda^*)(\mathrm{d}\lambda^*/\mathrm{d}\nu) < 0$. Consequently, the equilibrium share of unskilled labor $\rho^*/\overline{\rho}$ rises. This increase in domestic market size rises profits of domestic firms and implies a positive feedback for skilled immigration. The overall effect of pro-skilled migration policies on the immigration incentive of skilled workers can be summarized as follows

$$\frac{\mathrm{d}S[\lambda^*, \rho/\overline{\rho}(\lambda^*)]}{\mathrm{d}\nu} = \frac{\partial S(\lambda^*)}{\partial\nu} + \frac{\partial S(\rho/\overline{\rho})}{\partial\rho/\overline{\rho}}\frac{\partial\rho/\overline{\rho}}{\partial\lambda^*}\frac{\mathrm{d}\lambda^*}{\mathrm{d}\nu} \tag{19}$$

where the first term captures the direct impact on skilled migration costs and the second term embraces the indirect effect through unskilled labor immigration. Both forces work into the same direction.

In analogy to the above, anti-unskilled immigration policies lead to tougher migration impediments and are equivalent to higher levels of μ. *Ceteris paribus*, the propensity of unskilled workers to migrate decreases. Analytically, it holds true that $\mathrm{d}G(\rho^*/\overline{\rho})/\mathrm{d}\mu < 0$ which leads to a lower equilibrium share of the unskilled workforce $\rho^*/\overline{\rho}$. But as before, the reduction of the unskilled population has an impact on the equilibrium level of skilled workers - as the domestic market size decreases, profits of domestic firms become smaller, making the domestic market less profitable. Analytically, we find that

$$\frac{\mathrm{d}S(\lambda^*)}{\mathrm{d}\mu} = \frac{\partial\Delta R^*}{\partial\rho^*/\overline{\rho}}\frac{\mathrm{d}\rho^*/\overline{\rho}}{\mu} < 0 \tag{20}$$

Therefore, the equilibrium share of skilled labor decreases ($\mathrm{d}\lambda^*/\mathrm{d}\mu < 0$). In analogy to the above, a lower equilibrium share of skilled workers has a negative feedback on the equilibrium distribution of unskilled workers. Summarizing, the overall effect of anti-unskilled migration policies on the immigration incentive of the unskilled workforce is given by

$$\frac{\mathrm{d}G}{\mathrm{d}\mu} = \frac{\partial G}{\partial \mu} + \frac{\partial G}{\partial \rho^*/\overline{\rho}} \frac{\partial \rho^*/\overline{\rho}}{\partial \lambda^*} \frac{\mathrm{d}\lambda^*}{\mathrm{d}\mu} \tag{21}$$

The first term on the RHS of Eq. (21) reflects the direct effect by migration impediments. The second term embraces the indirect effect via changes in the equilibrium size of skilled labor. Both forces reduce the migration incentive of unskilled workers.

The impact of skill-biased immigration policies are straightforward. Lower immigration impediments for skilled labor increases the immigration incentive for both skilled and unskilled workers. But increased obstacles for unskilled labor impede unskilled labor immigration and, therefore, reduce the immigration incentives of skilled labor. This is counterproductive to what the government sought to achieve. Furthermore, depending on the actual policy design of immigration impediments for unskilled workers, the volume of illegal immigration of unskilled could increase. The inflow of qualified workers shifts production towards the immigration area, making it more attractive for unskilled workers, as well. But if immigration policies deny them to enter the country, these individuals might seek (illegal) ways to avoid political controls and to profit from higher real wages.

5 Conclusion

This paper has developed a new trade theory model with two mobile factors of production - skilled, self-employed labor and unskilled employees. Individuals are heterogeneous both between skill types and within skill groups. Heterogeneity reflects the factor that workers have different preferences over locations, heterogeneous costs from being remote from one's own socio-cultural surrounding, different obstacles to migration, etc. Consequently, there workers face migration impediments which vary between individuals.

The advantage of this approach is three-fold: firstly, it offers a trade model under increasing returns to scale and two mobile factors of production. Secondly, it allows to analyze the impact of skill-biased migration policies in settings where market sizes play a significant role. And thirdly, the model generalizes prior work and exhibits an outstanding analytical flexibility.

The model has identified five central market and non-market forces, which give rise to regional agglomeration pattern. Firstly, an inflow of skilled labor shifts production toward the immigration area and increases the gap in regional price levels (supply linkage). Secondly, the inflow of skilled labor increases the domestic market size and domestic aggregate income making domestic firms more profitable (demand linkage by skilled labor). But the creation of new firms also increases competition for costumers, which lowers profits of domestic firms and decreases the immigration incentive of skilled labor (competition effect). Fourthly, the shift in production and the rising gap in regional price level induce the inflow of unskilled workers. The migration flows raise the domestic aggregate income, increasing profits of domestic firms (demand linkage by unskilled labor). The first three forces are in keeping with standard NEG models with one mobile factor of production, the latter force is analogous to Russek (2008a). Furthermore, both skilled and unskilled labor face mobility costs which act as (non-market) dispersion force.

The geographical distribution of skilled and unskilled workers depends on two sets of parameters. On the one hand, trade costs. When trade costs are greater than a critical threshold (break point) or less than a lower critical value (redispersion point), only the symmetric distribution of both factor of production is stable. If trade costs are in between these thresholds, regional symmetry becomes instable giving rise to partial agglomeration of skilled and unskilled labor in the same region.
On the other hand, the level of matching costs for both types of labor influences the critical levels of trade costs and the pattern of regional development. Here, two different effects have to be distinguished. For any type of labor and any given skill specific migration incentive, lower matching costs increase the net value of migration. Consequently, the regional concentration of the particular type labor increases at any level of trade costs. Furthermore, the interval of trade costs in which agglomeration of both types of labor is stable increases at the upper as well as the lower end, i.e., the break point occurs at higher and the redispersion point occurs at lower levels of trade costs.

Furthermore, the paper there is an inverse relationship between mobility costs of one type of labor and the migration incentive of the other factor of production, which is an important feature of the model: The less are matching costs of unskilled employees (i.e., the greater is their mobility), the stronger is the immigration incentive for skilled labor. The intuition originates in the home market effect - lower impediments to unskilled labor migration induce inflows of unskilled immigrants, increasing the domestic market size and domestic aggregate income. Larger markets, in turn, make domestic firms more profitable and lead to higher skilled wages. Consequently, for any given level of trade costs and migration impediments for skilled labor, the regional concentration of skilled labor increases. In analogy to the above, this includes a wider ranger of trade cost in which partial agglomeration is stable.

The same argument holds true with respect to migration impediments for skilled workers: the smaller are their costs of migration, the greater is the migration incentive for the unskilled. Taking the migration incentive for skilled workers as given, a reduction in matching costs increases the net utility of skilled migration, enhancing skilled labor flows. The shift in production towards the immigration country increases real wages of unskilled workers for any level of unskilled migration impediments. The resulting inflow of unskilled migrants leads to the positive feedback on skilled wages and skilled migration flows. Consequently, we observe the same effects on the degree of spatial agglomeration and the range of trade costs as described above.

The interdependency and mutual reinforcement of skilled and unskilled labor migration is what causes the unintended and adverse effects of skill-biased migration policies.

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A Model forces and breakpoint

The first derivative evaluated at $\lambda = 0.5$ can be decomposed into the following forces:

- Supply linkage:

$$\left.\frac{\partial(-\alpha \ln \Delta P)}{\partial \lambda}\right|_{\lambda=1/2} = \frac{4\alpha(1-\phi)}{(\sigma-1)(1+\phi)} > 0 \tag{22}$$

- Demand linkage of skilled labor:

$$\left.\frac{\partial \Delta R}{\partial \lambda}\right|_{\lambda=1/2, x^* fixed} = \frac{4\alpha(1-\phi)}{\sigma(1+\phi)} > 0 \tag{23}$$

- Competition effect:

$$\left.\frac{\partial \Delta R}{\partial \lambda}\right|_{\lambda=1/2, marketsizefixed} = -\frac{4\alpha(\overline{\rho}+1)(1-\phi)^2}{\sigma(1+\phi)^2} < 0 \tag{24}$$

- Demand linkage of unskilled labor:

$$\left.\frac{\partial \Delta R}{\partial \rho}\frac{\partial \rho}{\mathrm{d}\lambda}\right|_{\lambda=1/2} = \frac{4\alpha^2\overline{\rho}(1-\phi)^2}{\mu(\sigma-1)\sigma(1+\phi)^2} > 0 \tag{25}$$

- Marginal migration costs of skilled labor:

$$\frac{\partial C}{\partial \lambda}\Big|_{\lambda=1/2} = 4\nu \tag{26}$$

The sum of competition effect and demand linkage of unskilled labor : Eq. (24)+(25):

$$\mathrm{DL}_U + \mathrm{CE}\Big|_{\lambda=1/2} = \frac{4\alpha\left[\overline{\rho}\left[\alpha - \mu(\sigma-1)\right] - \mu(\sigma-1)\right]}{\mu(\sigma-1)\sigma(1+\phi)^2} \tag{27}$$

For $\mu > \alpha/(\sigma-1)$ this expression is less than zero for any given value of $\overline{\rho}$. Furthermore, the first derivate with respect to $\overline{\rho}$ is then negative. A greater number of unskilled labor increases the relative strength of the competition effect.

The sum of the demand linkage of both skilled and unskilled labor as well as the competition effect: Eq. (23)+(24)+(25):

$$\mathrm{DL}_S + \mathrm{DL}_U + \mathrm{CE}\Big|_{\lambda=1/2} = \frac{4\alpha(1-\phi)(\alpha\overline{\rho}(1-\phi) - \mu(\sigma-1)(\overline{\rho}(1-\phi) - 2\phi))}{\mu(\sigma-1)\sigma(1+\phi)^2} \tag{28}$$

If $\mu < \alpha/(\sigma-1)$, this expression is positive for any given amount of unskilled labor $\overline{\rho}$. Consequently, the agglomeration forces prevail. The first derivative with respect to $\overline{\rho}$ reveals that that the net agglomeration forces become stronger, the greater the unskilled workerforce.

B Critical parameter values

$$\overline{\rho}_t = \mu\sigma / \left(\mu(\sigma-1) - \alpha\right) \tag{29}$$

$$\overline{\nu} = \frac{\alpha\mu(2\sigma-1)^2}{4\left[\mu(\overline{\rho}+1)(\sigma-1) - \alpha\overline{\rho}\right](\sigma-1)\sigma} \tag{30}$$

$$\underline{\nu} = \frac{\alpha\left[\alpha\overline{\rho} + \mu(\overline{\rho} + \sigma - \overline{\rho}\sigma)\right]}{\mu(\sigma-1)\sigma} \tag{31}$$

$$\overline{\rho}_{crit} \equiv \frac{2\mu^3(\sigma-1)^3\sigma}{\alpha\mu^2(\sigma-1)^2(4\sigma-1) - 2\mu^3(\sigma-1)^3\sigma - \alpha^3(2\sigma-1)} \tag{32}$$

$$\mu_{crit} \equiv \frac{\alpha(2\sigma-1)}{4(\sigma-1)\sigma} + \frac{1}{4}\sqrt{\frac{\alpha^2(\sigma(20\sigma-12)+1)}{(\sigma-1)^2\sigma^2}} \tag{33}$$

The third derivative of $S(\lambda, \rho(\lambda, \phi), \phi)$ with respect to λ and evaluation at symmetry is given by

$$S_{\lambda}^{(3)}(\lambda = 0.5, \phi_c) = -\frac{32\left(\alpha^2\overline{\rho}\left[\alpha^2 - 4\mu^2(\sigma-1)^2\right](1-\phi_c)^4 - F(1-\phi_c)^3\right)}{\mu^3(\sigma-1)^3\sigma(1+\phi_c)^4} - 32\nu \tag{34}$$

where $\phi_c \in \{\phi_b, \phi_r\}$ and $F = \alpha\mu^3(\sigma-1)^2\left[\sigma - 3\overline{\rho}(\sigma-1)(1-\phi_c) + (7\sigma-6)\phi_c\right]$.

If $S_{\lambda}^{(3)}(\lambda = 0.5, \phi_c) < 0 (> 0)$, the transition between dispersion and agglomeration at ϕ_c is smooth (catastrophic).

Figure 1a

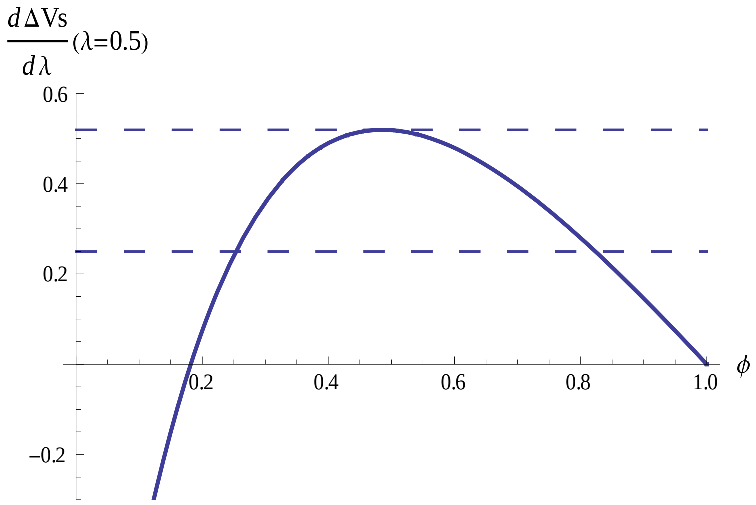

Figure 1b

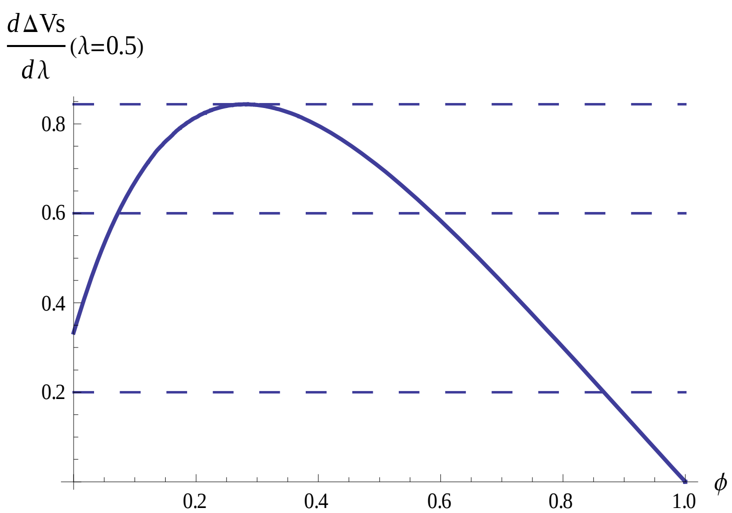

Figure 1c

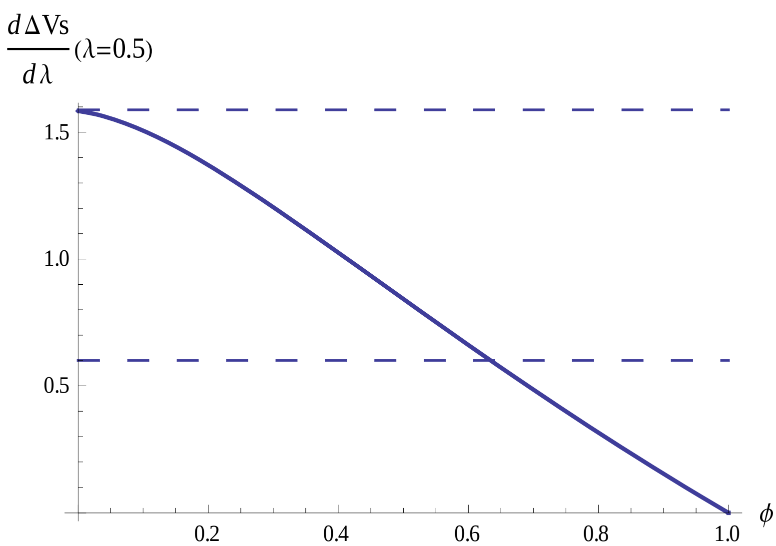

Figure 2a – The interplay of migration incentive and matching costs (numerical evaluation for $\alpha = 0.5, \sigma = 2, \overline{\rho} = 150, \mu = 0.9, \nu = 0.000003$)

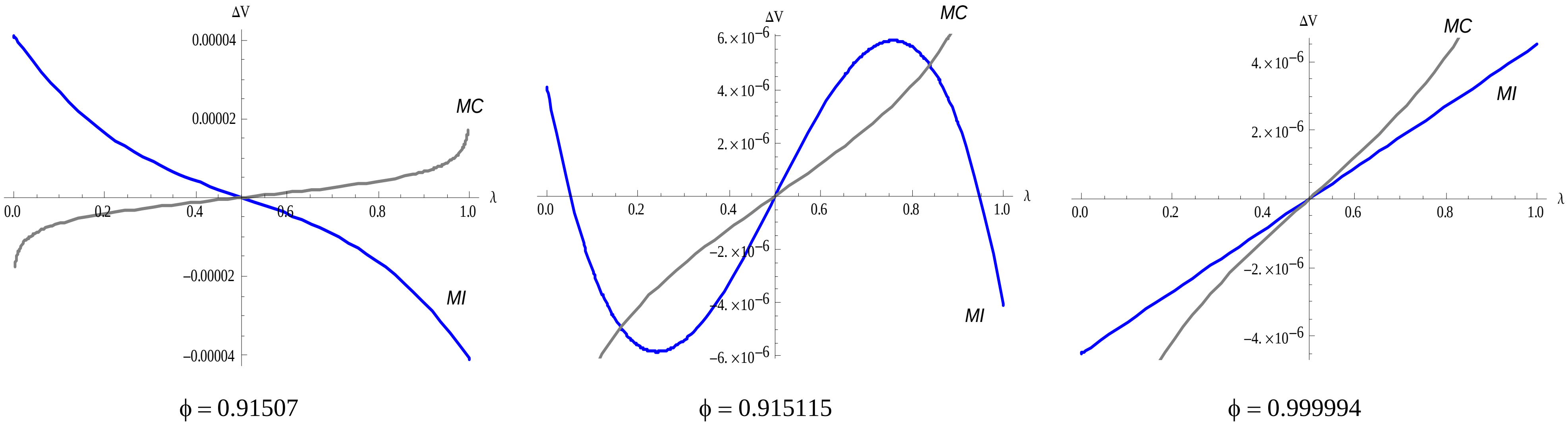

Figure 2b – Bubble bifurcation (numerical evaluation for $\alpha = 0.5, \sigma = 2, \overline{\rho} = 150, \mu = 0.9, \nu = 0.000003$)

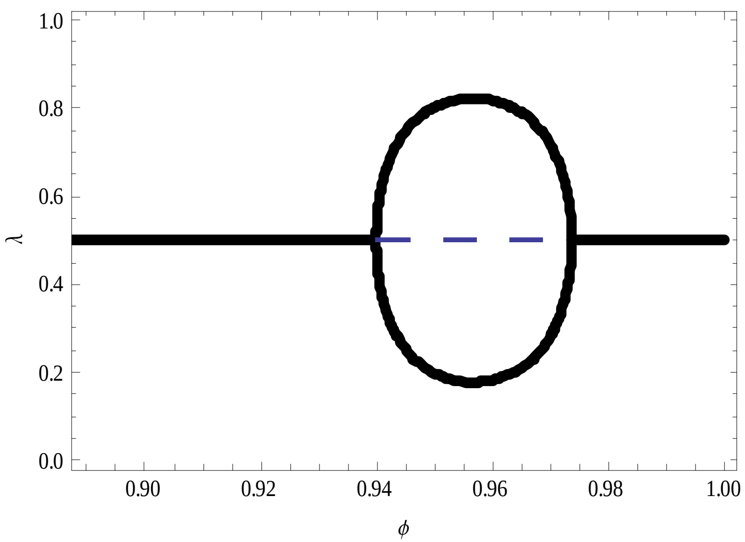

Figure 3a - The interplay of migration incentive and matching costs (numerical evaluation for $\alpha = 0.2, \sigma = 2, \overline{\rho} = 100, \mu = 0.25, \nu = 0.003$)

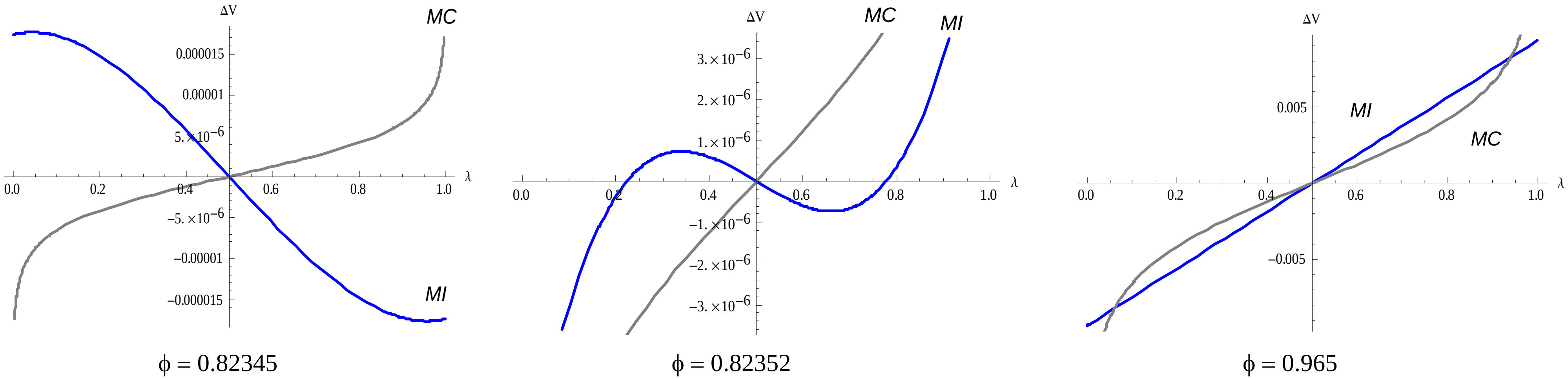

Figure 3b - Spearhead bifurcation (numerical evaluation for $\alpha = 0.2, \sigma = 2, \overline{\rho} = 100, \mu = 0.25, \nu = 0.003$)

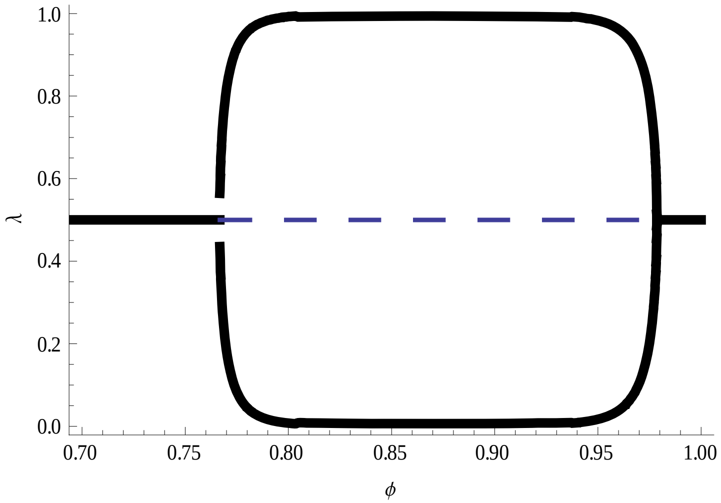

Figure 4 – numerical evaluation for $\alpha = 0.5, \sigma = 2, \overline{\rho} = 8, \mu = 0.6, \nu = 0.14$

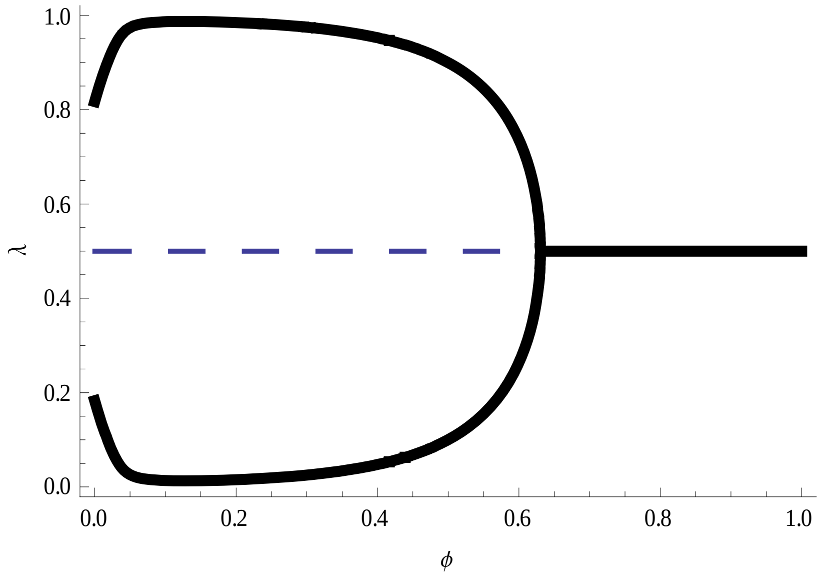

Figure 5 - numerical evaluation for $\alpha = 0.5, \sigma = 2, \overline{\rho} = 3, \mu = 0.6, \nu = 0.1245$