University of Innsbruck

Working Papers in Economics

Knowledge-Capital Meets New Economic Geography

Peter Egger, Stefan Gruber, Mario Larch
and Michael Pfaffermayr

2004/01

Institute of Economic Theory, Economic Policy
and Economic History

Institute of Public Finance

Knowledge-Capital Meets New Economic Geography

Peter Egger*, Stefan Gruber§,

Mario Larch§, Michael Pfaffermayr§

February 4, 2004

Abstract

We incorporate the now standard knowledge-capital model of multinational firms in a new economic geography setting. The theoretical predictions of the agglomeration patterns in our model suggest that unskilled labor mobility leads to less regional concentration of production than skilled labor mobility does. Empirically, less agglomeration of production among European nations than among US regions is observed. Our model shows that the different patterns in labor mobility can explain actual differences in the spreading of industries. According to our welfare analysis, trade liberalization is likely Pareto-improving for a larger region with mobile unskilled labor.

Key words: Knowledge-capital model; New economic geography; unskilled labor mobility; skilled labor mobility

JEL classification: F12; F23; R12; R13

*Helen Kellogg Institute for International Studies at the University of Notre Dame, 130 Hesburgh Center, Notre Dame, Indiana 46556-5677, USA.

§University of Innsbruck, Department of Economics, Universitätsstraße 15, A-6020 Innsbruck, Austria.

1 Introduction[1]

"European nations are less specialized than US regions" (Krugman, 1991a, p. 76). This stylized fact was recently confirmed by the study of Midelfart-Knarvik et al. (2000). Although European agglomeration also tends to increase, especially after the ratification of the Maastricht Treaty, facilitating the mobility of production factors between the EU member states (Haaland et al., 1999, Overman et al., 2001), there is still a gap in concentration between Europe and the US left, which may be explained by multinational activity.

Since the early stages of new trade theory, the consideration of multinationals may be seen as one of the major innovations in the last two decades' economic research (Helpman, 1984, Helpman and Krugman, 1985, Markusen, 1984). From its beginning, this literature distinguishes firms by the scope of activities carried out: (i) national single plant firms engaging in trade, (ii) horizontal (two-plant) multinationals serving both the home and the foreign market locally (Markusen and Venables, 1998, 2000), and (iii) vertical multinationals with production only in the low-wage country and headquarters in the high-wage economy (Helpman, 1984). Both the horizontal and vertical model characterize multinationals by intangible assets (knowledge-capital). Only in the knowledge-capital model of multinationals and trade, all these types of firms may co-exist (for an overview see Markusen, 2002), which seems well in line with the stylized facts (Carr et al. 2001, Markusen and Maskus, 2002, Egger and Pfaffermayr, 2004).

Only recently, the links between multiregional production and agglomeration came into the limelight of research. Gao (1999) concentrates on vertical multiregional enterprises (MREs), which exploit international/interregional factor cost differences. Only one primary factor is used in the differentiated goods sector, and manufacturing output is either consumed or used as an intermediate input in the production of manufactures or for plant set-up. He finds that agglomeration may break down with economic integration (i.e., a reduction in trade costs) or

[1]We are grateful to Nadia Almaraz de Neuzil, Peter Huber, Gianmarco Ottaviano and participants at research seminars at the Universities of Bologna, Ferrara and Innsbruck.

economic growth. There is no agglomeration at very low transport costs, because unskilled labor-cost differentials become more important than the agglomeration forces in shaping production structure. Concerning the introduction of vertical MREs, he concludes that they speed up the spreading of industries and thus the process of industrialization.

Raybaudi-Massilia (2000) concentrates on the role of firms' location choice rather than workers' mobility. She introduces two factors, a specific one, land, and a mobile one, labor. Firms may defect from their location choice by setting up an additional plant, closing one of the two plants, or moving a plant from one region to the other. In this model, only horizontal, two-plant MREs may arise. Accordingly, the evolution of MREs makes agglomeration of production in only a single country/region less likely.

Ekholm and Forslid (2001) look at vertical and horizontal MREs separately and (i) confirm Raybaudi-Massilia's (2000) finding that rising trade costs and the associated surge of horizontal MREs lead to less agglomeration, and (ii) find that with vertical MREs agglomeration of headquarters becomes more likely. They introduce *footloose* multi-region firms which are not headquartered in a specific country. This strong assumption leads to a unique symmetric equilibrium. A reallocation of unskilled labor forces firms in the receiving region to produce at a higher scale and, therefore, at lower prices. Furthermore, the smaller region engages proportionally more in headquarter services, as fixed costs are equally borne by both regions. Accordingly, real (unskilled) labor rewards are lower in the larger region.

Our approach differs from the available work in several ways. First, it incorporates the now standard model of multinationals and trade, namely the knowledge-capital model, in a new economic geography setting. Therefore, regional (exporting) enterprises (REs) and horizontal as well as vertical MREs may arise endogenously, which allows for a richer firm and core-periphery structure. Similar to Markusen and Venables (2000), MREs are not footloose but they rather are headquartered in one specific region where fixed costs are paid.

Second, we are interested in the dependence of agglomeration patterns on transport costs, allowing either skilled or unskilled labor to be mobile as a response to differentials in real factor rewards. Despite the conceptual differences to Raybaudi-Massilia (2000), horizontal MREs make agglomeration less likely also in our framework.

In line with recent empirical evidence, we argue that the US are characterized by skilled rather than unskilled labor mobility. Chiquiar and Hanson (2002) point out that Mexican emigrants to the US exhibit higher skill levels than the average Mexican worker. Furthermore, Kennan and Walker (2003) find that unfavorable local income conditions stimulate US interstate migration of skilled male workers. The result of Adams (2003) that about two thirds of the US immigrants have at least secondary education levels points in a similar direction.[2]

In contrast, there are mainly unskilled immigrants in Europe (see Sapir, 2000, Coppel et al., 2001).[3] For instance, Constant and Massey (2003) argue that German immigrants mainly take unskilled and semi-skilled jobs shunned by natives. This is supported by the large sample study of De New and Zimmermann (1994), pointing out that immigration in Germany negatively affects the average worker's wages, leaving experienced German workers unchanged. Geddes (2003, p. 156) mentions that "migrants and their descendants in the UK are more likely found in lower-income and lower-status occupations, ...". According to Rygiel (2001), similar conclusions can be drawn for France.

Associating skilled labor mobility with the US case and unskilled labor mobility with the European case, our model provides a possible explanation for the different agglomeration patterns observed in Europe and the US. Our analysis suggests that unskilled labor mobility leads to a relatively more dispersed structure than skilled labor mobility. This fits nicely with the empirical stylized facts

[2]A press release by InfoAmericas from June 2001, available under http://tendencias.infoamericas.com/article_archive/2001/0601/0601_regional_trends.pdf, indicates that emigrants from many Latin American economies were high-skilled.

[3]However, it should be noted that migration rates in Europe are generally lower than in the US (see Bentivogli and Pagano, 1999). This seems mainly due to the more rigid labor markets and the different institutional framework in Europe (see Adsera and Boix, 2000, Sapir, 2000, Puga, 2002).

of both the different agglomeration patterns and the skill-specific characteristics of the mobility of workers in Europe and the US. Hence, we might conclude that these different types of factor mobility together with the activity of multinational firms are one of the driving forces behind the different agglomeration patterns observed.

Finally, we investigate the welfare consequences of trade liberalization. This is important, since, in the long run, trade costs are not necessarily fixed, but they are affected by regional politics (e.g., infrastructure investments). Hence, countries may choose to liberalize trade, depending on its impact on factor migration. For the larger region, the welfare analysis suggests that trade liberalization is likely to raise both, skilled and unskilled labor wages. For low values of trade costs, both regions gain individually from further liberalizing trade, irrespective of which factor is mobile.

The paper is organized as follows. The next section introduces the model, Section 3 looks at the core-periphery patterns. The welfare effects of trade liberalization are analyzed in Section 4. In Section 5, we assess the robustness of our results with respect to changes of several decisive parameters. The last section concludes.

2 The Model

2.1 Households

We model consumer preferences as a nest of homogeneous agricultural goods (Z-goods) and manufactures (X-goods), assuming Dixit-Stiglitz preferences (Dixit and Stiglitz, 1977) for the inner nest of X-varieties:

$$U_i = \left[(n_i + h_i + h_j + v_j)\, x_{ii}^{\frac{\sigma-1}{\sigma}} + (n_j + v_i) \left(\frac{x_{ji}}{1+\tau} \right)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}\mu} (Z_{ii} + Z_{ji})^{1-\mu}, \quad (1)$$

where U_i is region i's utility, $i = 1, 2$, μ denotes the Cobb-Douglas expenditure share for manufacturing products, and $\sigma > 1$ is the elasticity of substitution between varieties. n_i is the number of REs of region i, which sell on the local market and export to region j, h_i denotes the number of horizontal MREs headquartered in i, but running production plants in both regions, and v_i is the number of vertical MREs with headquarters in i and production plants only in j. In contrast to horizontal MREs, vertical ones engage in goods trade. Quantities are indexed twice, with the first subscript indicating the region the good originates from, and the second one referring to the region where the good is consumed.

We assume that Z-goods are costlessly tradable across regions, whereas X-goods trade incurs iceberg transport costs (τ), which are symmetric for either direction of shipment. In terms of quantity, one unit of consumption of an X-variety in region j requires a firm in i to send $(1 + \tau)$ units. For convenience, x_{ij} and x_{ji} are defined as firm-specific *production* (of both REs and vertical MREs) for the respective foreign market. Product market clearing and the complementary goods prices are thus given by

$$x_{ii} \geq p_i^{-\sigma} P_i^{\sigma-1} \mu Y_i \quad \perp \quad p_i \geq 0, \tag{2}$$

$$x_{ij} = p_i^{-\sigma} (1+\tau)^{1-\sigma} P_j^{\sigma-1} \mu Y_j, \tag{3}$$

$$Z_{ii} + Z_{ji} \geq \frac{1-\mu}{q_i} Y_i \quad \perp \quad q_i \geq 0, \tag{4}$$

where $\perp$ indicates that at least one of the adjacent conditions has to hold with equality. p denotes the price of X-varieties, and q that of Z-goods. Noteworthy, prices are only indexed once, since all (indigenous and foreign) homogeneous goods consumed at one location must face the same price. Therefore, q_i is the price of agricultural goods *consumed* in i. Further, p_i is the price of manufactured goods *produced* in i. Accordingly, the consumer price of X-goods originating from i and exported to j amounts to $p_i(1 + \tau)$. All varieties *produced* and *consumed* at the same location are sold at the same price because of equal marginal costs. The price index P_i for differentiated goods *consumed* in region i is

$$P_i = \left[(n_i + h_i + h_j + v_j) \, p_i^{1-\sigma} + (n_j + v_i) \left((1+\tau) p_j \right)^{1-\sigma} \right]^{\frac{1}{1-\sigma}}. \tag{5}$$

2.2 Factor Markets and Production

The agricultural sector is perfectly competitive, and we take q_1 as the numéraire. Since Z-production only uses unskilled labor (L), variable unit costs (i.e., marginal costs) c_{zi} satisfy

$$c_{zi} \geq w_{Li} \quad \perp \quad Z_{ii} \geq 0, \tag{6}$$

where w_{Li} is the unskilled labor reward in i. This implies

$$c_{zi} \geq q_j \quad \perp \quad Z_{ij} \geq 0. \tag{7}$$

There is monopolistic competition in the X-sector, and each firm produces under a CES technology, using both factors (where 'a' is the coefficient for skilled labor and '$1 - a$' for unskilled labor), with an elasticity of substitution of $1/(1-\rho)$ $(-\infty < \rho < 1)$. Cost minimization subject to this technology yields the region-specific unit input coefficients for the two factors of X-production (skipping the arguments): a_{Sxi}, a_{Lxi}. Additionally, REs and MREs require skilled labor to set up plants (a_{Sn}, a_{Sh}, a_{Sv}), and they employ unskilled labor to produce firm-specific assets and blue-prints (a_{Ln}, a_{Lh}, a_{Lv}).

Factor market clearing requires

$$\begin{aligned} S_i &\geq a_{Sxi}\left(\left(n_i + h_i + h_j + v_j\right) x_{ii} + \left(n_i + v_j\right) x_{ij}\right) + a_{Sn} n_i + a_{Sh} h_i + a_{Sv} v_i \\ &\perp \; w_{Si} \geq 0. \qquad (8) \\ L_i &\geq a_{Lxi}\left(\left(n_i + h_i + h_j + v_j\right) x_{ii} + \left(n_i + v_j\right) x_{ij}\right) + Z_{ii} + Z_{ij} \\ &\quad + a_{Ln} n_i + a_{Lh} h_i + a_{Lv} v_i \quad \perp \quad w_{Li} \geq 0, \qquad (9) \end{aligned}$$

where S_i and L_i are region i's endowments with skilled and unskilled labor, respectively. The factor rewards are denoted by w_{Si} and w_{Li}. Variable unit costs of producing x_{ii} or x_{ij} are given by $c_{xi} = a_{Sxi} w_{Si} + a_{Lxi} w_{Li}$. There is a fixed markup over variable costs, which is determined by the elasticity of substitution between varieties:

$$p_i \leq c_{xi} \frac{\sigma}{\sigma - 1} \quad \perp \quad x_{ii} \geq 0, \tag{10}$$

Free entry implies that firms earn zero profits, since operating profits are used to cover fixed costs. Therefore, the number of firms is determined by Chamberlin's "tangency solution". Since REs in i have to bear fixed costs of $a_{Sni} w_{Si} + a_{Lni} w_{Li}$, we have

$$a_{Sn} w_{Si} + a_{Ln} w_{Li} \geq \frac{p_i\left(x_{ii} + x_{ij}\right)}{\sigma} \quad \perp \quad n_i \geq 0. \tag{11}$$

and similarly for vertical and horizontal MREs:

$$a_{Sv}w_{Si} + a_{Lv}w_{Li} \geq \frac{p_j\left(x_{jj} + x_{ji}\right)}{\sigma} \quad \perp \quad v_i \geq 0. \tag{12}$$

$$a_{Sh}w_{Si} + a_{Lh}w_{Li} \geq \frac{p_i x_{ii} + p_j x_{jj}}{\sigma} \quad \perp \quad h_i \geq 0. \tag{13}$$

In line with the literature, we assume $a_{Sn}w_{Si} + a_{Ln}w_{Li} < a_{Sv}w_{Si} + a_{Lv}w_{Li} < a_{Sh}w_{Si} + a_{Lh}w_{Li}$, and, specifically, $a_{Sn} = a_{Ln} = 1$, $a_{Lv} = a_{Lh} = 1 + \delta$, $a_{Sv} = 1 + \gamma$, and $a_{Sh} = 2 + \gamma$, without loss of generality (see Markusen, 2002). Thereby, δ is the additional unskilled labor requirement to organize a multi-regional network, and $1 + \gamma$ are the fixed costs region i's MREs have to incur to set up a plant in j. As mentioned above, horizontal MREs also run domestic production plants, which is reflected by $a_{Sh} > a_{Sv}$.

2.3 Income and Real Wages

We assume that all factors are owned by households, so that consumer income in region i is given by

$$Y_i = w_{Si}S_i + w_{Li}L_i. \tag{14}$$

The equivalence of total factor income (Y_i, Y_j) and demand in each economy implicitly balances international payments.

Real factor rewards (ω) are normalized by region-specific costs of living ($P_i^{\mu} q_i^{1-\mu}$), and are thus given by:

$$\omega_{Li} = w_{Li} P_i^{-\mu} q_i^{\mu-1}. \tag{15}$$

$$\omega_{Si} = w_{Si} P_i^{-\mu} q_i^{\mu-1}. \tag{16}$$

3 Core-Periphery-Patterns

In contrast to most new economic geography models, production of the manufacturing good uses two input factors (S and L). In the standard models it is straightforward to assume that the factor used in the manufacturing sector is mobile across regions. In our setting, we deal more extensively with factor mobility assumptions. In line with the literature, both factors are immobile in the short run. In the long run, we investigate situations where either L (intensively used in production) or S (intensively used in research and plant set-up) is mobile.[4]

3.1 Unskilled Labor Mobility

Figure 1 depicts the agglomeration pattern if unskilled labor is mobile, where $\lambda_L(\lambda_S)$ denotes region i's share of world endowment of unskilled (skilled) labor. A long run equilibrium is defined similar to Krugman (1991b) by real wage equalization across regions ($\omega_{Li} = \omega_{Lj}$ if unskilled labor is mobile and $\omega_{Si} = \omega_{Sj}$ if skilled labor is mobile).

We find five interior equilibria, three stable and two unstable ones. The stability of a long run equilibrium can be verified by exogenously shifting one unit of unskilled labor to the other region, and deriving the new short run equilibrium. Then, firms are allowed to enter and exit to avoid losses and exploit profits. If this reallocation of production factors results in a decline of real wages in the receiving region, the initial equilibrium can be considered as stable. Otherwise, the initial equilibrium is unstable, because even more workers have an incentive to relocate.

– Figure 1 –

We obtain one long run symmetric equilibrium where manufacturing is spread evenly across the two regions. Such an equilibrium is found in most of the new economic geography models (see Krugman, 1991b, Fujita et al., 1999). In contrast to these models, in our framework only REs arise endogenously in the symmetric equilibrium.

Furthermore, there exist four partially agglomerated equilibria, two stable and two unstable ones.[5] In the partially agglomerated stable equilibrium at $\lambda_L \approx 0.25$,

[4] We have chosen the following parameter values for our simulations: $\delta = 0.01$, $\gamma = 0.1$, $\sigma = 4$, $\mu = 0.8$, $\rho = -0.5$, $a = 0.2$, $\tau = 0.2$ if constant, $L = L_1 + L_2 = 100$, $S = S_1 + S_2 = 60$. As mentioned by Baldwin et al. (2003), if both factors were mobile, a region would become "extinct", since everyone would always have an incentive to avoid trade costs by agglomerating in one region.

[5] Remember that the core-periphery model and most of its extensions have at most three

there are REs as well as headquarters of both horizontal and vertical MREs in region i. This outcome seems to be somewhat surprising, as one would expect agglomeration to take place in the larger region. However, the firm structure per se is not informative with respect to production volumes. In our setting, the smaller region is relatively skilled labor abundant (since $\lambda_L < \lambda_S$ by assumption) and therefore has a comparative advantage in running MREs, since setting up foreign plants requires additional skilled labor input.[6] Region i could be considered as a developed one, specializing in the provision of headquarter services and skilled labor-intensive goods.[7] In contrast, the larger region j is unskilled labor-abundant, specialized in the *production* of goods rather than research and brand proliferation.

Concerning the firm regimes, we find that horizontal MREs exist, if unskilled labor endowments are very different between the regions. This implies a strong relative skilled labor abundance of one region, where firms have then an incentive to run two plants in order to avoid transport costs. Noteworthy, this is in contrast to the model of Markusen and Venables (2000), where factors are internationally immobile. If the skilled labor abundance decreases, vertical MREs come into existence because of factor price differences (even at *real* factor price equalization, *nominal* factor prices can differ quite significantly). If a region becomes unskilled labor abundant, skilled labor is essential in producing manufactured goods and therefore not used to set up plants. This effect can even get strong enough to cause the unskilled labor abundant region to own neither REs nor MREs at all.

So far, we have analyzed the core-periphery pattern and the firm structure at a specific value of transport costs. Now, we investigate at which levels of transport costs the core-periphery pattern is a possible outcome (the *sustain point* as in Fujita et al., 1999), and at which it is a necessary one (the *break point*).

Let transport costs (τ) vary between 0.01 and 0.99. Figure 2 shows the re-

interior equilibria, where only the symmetric one is stable (see Baldwin et al., 2003, Fujita et al., 1999). An exception are Ekholm and Forslid (2001), who obtain two interior stable equilibria in their model with vertical MREs.

[6]Note that we assume that firms use only skilled labor from the home region to set up plants.

[7]Since there are variable input coefficients, production of X-goods in region i is much more skilled labor-intensive than in region j.

sulting core-periphery bifurcation[8], which we call the "butterfly bifurcation". If transport costs are very high, only horizontal MREs exist due to the proximity-concentration trade-off. In this case, marginal changes in transport costs are no longer relevant and the price indices in both regions are therefore the same. Together with the possibility of free trade of agricultural goods and shifting of factor intensities in production, this leads to an *equilibrium area* where real wages are equalized, if only horizontal MREs exist. Hence, shifts of unskilled labor supply in a specific range do not alter the firm structure and, therefore, a long run equilibrium exists, even at $\lambda_L \neq 0.5$. This is in contrast to Ekholm and Forslid (2001) who find a unique stable symmetric equilibrium if only horizontal MREs exist, due to their assumption of footloose MREs forced to cover their fixed costs in equal proportions in both regions.

– Figure 2 –

At low transport costs, only the symmetric equilibrium is stable in the long run, because it does not pay off to run horizontal MREs. Vertical MREs do not exist, since trade barriers are so low that factor price differences cannot increase enough to make unbundling profitable. Thus, we are left with REs only. Note that standard new economic geography predicts full agglomeration if trade costs are low. The different outcome in our model is due to the threefold use of unskilled labor: in homogeneous goods production, in differentiated goods production, and in plant/firm set-up.

Looking at Figure 2 in a different way, we find two break points. Moving from the left towards the right, a symmetric equilibrium remains stable until $\tau \approx 0.25$. Then, this equilibrium breaks and only a partially agglomerated equilibrium is stable in the long run. Starting from high transport costs (i.e., moving from the right to the left), we obtain another break point at $\tau \approx 0.37$. There, the long run stable equilibrium area collapses and a core-periphery pattern necessarily

[8] In all bifurcation diagrams long run stable equilibria are depicted by solid lines, areas of long run stable equilibria are cross-hatched and bordered by dashed lines, and unstable equilibria are indicated by dotted lines.

emerges. On the contrary, in a model with REs only, the symmetric equilibrium would never become unstable, i.e., no break point exists.[9]

If we are initially in a partially agglomerated equilibrium (for historical reasons or by incidence), we find an astonishingly wide *sustain range* at $0.12 \lessapprox \tau \lessapprox 0.8$, resulting from our rich model structure, which allows to exploit real wage differentials without shifting unskilled labor. This is in line with the empirical observation that unskilled labor differentials diminish, despite unskilled labor being still quite immobile (see for instance Barba Navaretti et al., 2002, Puga, 2002). Our outcome suggests that unskilled labor mobility is not necessary to obtain real unskilled labor rewards equalization, and that an unequal division of unskilled labor between regions can be a long run stable equilibrium in a wide range of transport costs.

Now assume that region i owns only 25% of world skilled labor endowment, keeping unskilled labor mobile.[10] Compared to the butterfly bifurcation, the resulting "trousers bifurcation" (Figure 3) shows a quite different pattern. At low transport costs ($\tau \lessapprox 0.51$), the only long run stable equilibrium is a rather pronounced core-periphery pattern ($0.1 \lessapprox \lambda_L \lessapprox 0.18$). In those cases, mainly REs from region j and vertical MREs headquartered in i exist. The latter, because of the relative skilled labor abundance of region i and the former because of the relatively large home market and the comparatively low transport costs. At higher transport costs ($\tau \gtrapprox 0.51$), it becomes attractive to set up foreign plants. Nevertheless, a long run equilibrium could not be achieved, if unskilled labor were equally divided. This would lead to horizontal MREs headquartered in j only. Factor price equalization of the immobile factor would not occur due to the large difference in skilled labor endowments ($w_{Si} > w_{Sj}$).

– Figure 3 –

Again, at very high transport costs we find a stable equilibrium area, which is

[9]The bifurcation diagrams with REs only are provided in the supplementary material to this paper following page 25.

[10]If λ_S is constant at 0.75, the resulting bifurcation diagram for region i is a mirror image of Figure 3 around $\lambda_L = 0.5$, since the share of factor endowments add up to unity.

dominated by horizontal MREs with a break point at $\tau \approx 0.51$. Note that there is no sustain point. Therefore, when starting in a situation with a very unequal distribution of unskilled labor, the initial core-periphery pattern remains stable over the whole range of transport costs.

3.2 Skilled Labor Mobility

If skilled labor is mobile and unskilled labor equally allocated ($\lambda_L = 0.5$), there are three interior equilibria. In contrast to the case of mobile unskilled labor, the symmetric equilibrium is unstable. Again, two partially agglomerated equilibria turn out to be stable. In both of them, only REs exist. Horizontal and vertical MREs only come into existence if skilled labor is very unevenly distributed between the regions in equilibrium.

The "lampshade bifurcation" (Figure 4) shows a wide equilibrium area at high transport costs. Again, this is due to the fact that only horizontal MREs exist. At low values of transport costs, only an unequal allocation of skilled labor satisfies our long run equilibrium conditions. The reason is that the centrifugal forces are too strong for a symmetric equilibrium to be stable.

– Figure 4 –

In Figure 4, there is one break point at $\tau \approx 0.34$ and one sustain point at $\tau \approx 0.45$. In other words, we find a very large range ($0.99 \geq \tau \gtrapprox 0.34$) where long run equilibria can arise at different values of λ_S ($0.26 \lessapprox \lambda_S \lessapprox 0.74$), when starting from very high transport costs. In contrast, at $\tau \lessapprox 0.34$ partial agglomeration is the only stable equilibrium, and remains sustainable until $\tau \approx 0.45$, when starting from zero transport costs. The lampshade bifurcation shows that with skilled labor mobility a long run symmetric equilibrium can only be reached, if transport costs are sufficiently high (i.e., higher than the break point). At lower transport costs, the centrifugal forces are strong enough to motivate agglomeration. Since most products incur transport costs lower than 33% (see Baier and Bergstrand, 2001), our model can cope with the observed agglomeration tendency of skilled labor.

As mentioned before, the symmetric equilibrium is unstable if skilled labor is mobile. Skilled labor migration out of the symmetric equilibrium leads to a comparative advantage in running MREs for the receiving region. This is a profitable activity which raises the price of skilled labor and induces further skilled labor flows. With mobile unskilled labor instead, a shift of one unit away from the symmetric case induces only few additional REs because of the scarcity of skilled labor (recall that $\gamma > \delta$). The latter raises real wages of skilled labor and the price of the manufactured goods in the enlarging region. The latter increase in the costs of living leads to a reduction of real unskilled labor rewards.

Comparing this bifurcation diagram to that one of a model with REs only, we find that MREs lead to a more dispersed structure. This does not contradict Gao's (1999) result that vertical MREs speed up the spread of industries, since in our framework with skilled labor mobility, horizontal MREs become much more important than vertical ones.[11]

Turning to the case where unskilled labor endowment in region i is constant at $\lambda_L = 0.25$ (see Figure 5), we find full agglomeration of skilled labor in region j at low values of transport costs ($\tau \lessapprox 0.49$). Region i is therefore specialized in producing agricultural goods, whereas it imports all the manufactured goods consumed. Beyond this level of transport costs, there are incentives for region j to run horizontal MREs. This leads to a less pronounced core-periphery pattern, since setting up foreign plants requires some additional skilled labor input compared to domestic plants.

– Figure 5 –

Comparing the agglomeration patterns in the cases of skilled and unskilled labor mobility, we see that overall the concentration tends to be higher when skilled labor is mobile, for both, equal and unequal endowments of the immobile factor.

[11]Skilled labor mobility stimulates real factor price equalization, since the factor price differential for unskilled labor is restricted by costless homogeneous goods trade. Recall that homogeneous goods only require unskilled labor in production.

This is especially true for lower values of trade costs ($\tau < 0.2$) which are found to be the empirically relevant ones (see Hummels, 1999, Baier and Bergstrand, 2001). Therefore, and in accordance with the empirical facts, we suggest to refer to the case of lower concentration when unskilled labor is mobile as the "European Case", and to the case of higher concentration when skilled labor is mobile as the "American Case".

4 Effects of Trade Liberalization on Real Factor Rewards

In order to determine whether a region is willing to adopt a trade liberalizing policy, we look at the real factor rewards in each of the previously introduced bifurcation diagrams. We only account for the long run stable equilibria and denote in the case of partially agglomerated equilibria region 1 as the mobile factor scarce one ($\lambda < 0.5$) and region 2 as the mobile factor abundant one ($\lambda > 0.5$). Following Wong (2001), we speak of a Pareto-improving change in trade costs for a region, if at least one factor price in that region increases and none decreases after liberalization.

– Figure 6 –

Figure 6 depicts the ranges of trade costs where Pareto-improvements are possible, according to the previously introduced criterion. For each bar in the figure, we show for which long run stable equilibria lowering trade costs is a beneficial policy.[12] To obtain those bars, we investigate the changes of real factor rewards associated with a decline in trade costs (trade liberalization). Actually, we look at the graphs of real factor rewards against trade costs.[13] If both real factor reward lines were rising (or at least none of them falling) when moving from the right to the left (trade liberalization), we consider the range of the rising part of the curves as a Pareto-improvement region, which is reflected by a bar in Figure

[12]The darker bar represents region 1, the lighter one region 2.

[13]These graphs can be found in the supplementary material to this paper following page 25.

6.[14]

For example for $\tau = 0.2$ we obtain three long run stable equilibria in the butterfly bifurcation (Figure 2). In Figure 6 (column I) we mention that lowering trade costs in the symmetric equilibrium is Pareto-improving.[15] If the regions are in a partially agglomerated equilibrium, trade liberalization is not Pareto-improving.[16] The results in the following paragraphs are derived and depicted in the same way as explained in the example before.

4.1 Unskilled Labor Mobility

If unskilled labor is mobile and skilled labor evenly distributed, the larger region (region 2) is in favor of adopting trade liberalization over a broad range of trade costs in a long run stable, partially agglomerated equilibrium. For initially low values of trade costs, any further trade liberalization is Pareto-improving in the symmetric equilibrium (see column I in Figure 6). In the case of an uneven distribution of skilled labor, lowering trade costs is Pareto-improving for the skilled labor scarce region (see column II in Figure 6).

Generally, the wages of unskilled labor are higher, and those of skilled labor are lower if a partially agglomerated equilibrium occurs, compared to a situation with only horizontal MREs (i.e., τ is high), inducing a more even distribution of unskilled labor. Even though trade costs are higher in these situations, horizontal MREs lead to a convergence of real unskilled and skilled labor rewards.

4.2 Skilled Labor Mobility

The result that further trade liberalization is Pareto-improving if trade costs are already low persists in the case of mobile skilled labor (see column III in Figure 6). In the range between break point and sustain point ($0.34 \lessapprox \tau \lessapprox 0.45$ in Figure 4) region i would prefer to end up with an unskilled labor endowment distribution

[14]Note, that we omit all those cases, where Pareto-improvements are impossible.

[15]As it can be seen there is a bar for region 1 and region 2, which indicates that trade liberalization is beneficial for both regions.

[16]Note, that there is only a bar for region 2. At this level of τ, trade liberalization is beneficial only for region 2.

lying in the equilibrium range rather than to switch into a core-periphery pattern. If unskilled labor endowments are different, the smaller region (region 1) favors trade liberalization in a wide range of trade costs where full agglomeration is a long run stable equilibrium (see column IV in Figure 6, which corresponds to Figure 5).

Summing up, trade liberalization is likely to be Pareto-improving for the larger region if unskilled labor is mobile. Concerning Europe, this may explain why especially large countries are in favor of the enlargement of the EU (e.g., Germany, France) and some smaller countries are more cautious (e.g., Lithuania). For low values of trade costs, both regions gain from further liberalizing trade irrespective of whether skilled labor or unskilled labor is mobile. As mentioned above, transport costs below 20% seem to be empirically realistic, and therefore the welfare predictions fit nicely to the observed ongoing reduction of trade barriers in both Europe and the US.

5 Robustness of the Findings

To investigate the robustness of our results, we discuss variations of the parameters μ, ρ and σ. For every new parameter value, we analyze the effects with respect to our two reference cases for unskilled as well as skilled labor mobility, where the respective immobile factor is equally allocated between the two regions. These reference cases correspond to Figures 2 and 4.

So far, consumers are assumed to spend 80% ($\mu = 0.8$) of their income on manufactured goods (this is well supported by empirical evidence). We lower this value to (i) $\mu = 0.5$ and (ii) $\mu = 0.3$, which is the value frequently used in new economic geography models, for instance in Krugman (1991b) or Ekholm and Forslid (2001). We find that for lower values of μ, MREs become more important, because skilled labor is abundant and therefore the additional fixed costs for setting up a plant abroad are low (remember that skilled labor is only used in differentiated goods production). Full agglomeration is a rather unlikely outcome in our framework. Nevertheless, if μ and τ are both low enough, full agglomeration occurs in the case of skilled labor mobility.

We continue by analyzing the effects of reducing the substitutability between skilled and unskilled labor, ρ, to -5 (corresponding to a TRS of 1/6) and -20 (TRS=1/21), respectively. As skilled labor is not only needed in manufacturing goods production but also essential for covering plant-set up costs, a lower substitutability between the two types of labor in the production of manufactures causes the skilled labor reward to rise. Thus, setting up MREs becomes less attractive and therefore the equilibrium area with only horizontal MREs gets smaller and only exists for high transport costs. Moreover, we find that the long run stable, partially agglomerated equilibria are present over the whole range of transport costs, and that the agglomeration itself is more pronounced. Making factors in production of manufactured goods more substitutive (changing ρ from -0.5 to 0.5 (implying a TRS of 2) and 5/6 (TRS=6), respectively), leads the partially agglomerated equilibria to be more pronounced, and the equilibrium area with only horizontal MREs appears for a larger range of transport costs.

A lower elasticity of substitution between varieties of the manufactured good (additionally to $\sigma = 4$, we run experiments for $\sigma = 2$ and $\sigma = 6$) implies that the equilibrium area with only horizontal MREs becomes smaller or even vanishes. On the other hand, the ranges of the long run stable symmetric equilibrium as well as the partially agglomerated equilibria rise as σ becomes lower.

By and large, the main agglomeration patterns in the butterfly and lampshade bifurcation prove to be robust with respect to changes in μ, ρ and σ. We mainly observe leftward or rightward shifts of the diagrams, which can be explained by the changing underlying firm structure (proximity-concentration trade-off).

6 Conclusions

Empirical evidence suggests that European nations are less concentrated than US regions. To the best of our knowledge, new economic geography models do not deal explicitly with these differences in the agglomeration patterns so far.

We incorporate the now standard knowledge-capital model of multinationals in a new economic geography setting to account for the growing importance of foreign direct investment in the last decades. Accordingly, regional exporting firms and both horizontal and vertical multi-regional firms may endogenously arise. There are two sectors, a homogeneous one producing with unskilled labor only, and a differentiated one, which unlike most other new economic geography models, uses both skilled and unskilled labor in production. In contrast to previous research, we find that the existence of multinationals leads to more pronounced core periphery patterns.

Recent empirical studies point to an important difference between Europe and the US, namely that in Europe unskilled labor is more mobile than skilled labor and that the reverse is true for the US. Accordingly, we analyze the agglomeration patterns for both unskilled and skilled labor mobility, arguing that the former represents the European case and the latter one the US case.

The theoretical predictions of the agglomeration patterns in our model suggest that unskilled labor mobility leads to lower concentration than skilled labor mobility. The different factor mobility between Europe and the US could therefore be an important factor in explaining the observed differences in the spreading of industries.

According to our welfare analysis, trade liberalization is likely Pareto-improving for the larger region if unskilled labor is mobile. This may explain why especially large EU countries like Germany or France are in favor of the Eastern Enlargement, whereas some smaller countries like Lithuania are more cautious about it. At low trade costs, both regions gain from even further liberalizing trade irrespective of which factor is mobile. By and large, these results prove robust with respect to changes in the parametrization of the model.

7 References

Adams, R.H. (2003), International Migration, Remittances and the Brain Drain: A Study of 24 Labor-Exporting Countries, *World Bank Policy Research Working Paper No. 3069.*

Adsera, A., Boix, C. (2000), Must we choose? European Unemployment, American Inequality, and the Impact of Education and Labor Market Institutions, *European Journal of Political Economy* 16, pp. 611-38.

Baier, S.L., Bergstrand, J.H. (2001), The Growth of World Trade: Tariffs, Transport Costs, and Income Similarity, *Journal of International Economics* 53(1), pp. 1-27.

Baldwin, R.E., Forslid, R., Martin, P., Ottaviano, G.I.P., Robert-Nicoud, F. (2003), *Economic Geography and Public Policy*, Princeton University Press, Princeton.

Barba Navaretti, G., Checchi, D., Turrini, A. (2003), Adjusting Labour Demand: Multinational vs. National Firms A Cross-European Analysis, *Journal of the European Economic Association* 1(2-3) pp. 708-19.

Bentivogli, C., Pagano, P. (1999), Regional Disparities and Labour Mobility: The Euro-11 versus the USA, *Labour* 13, pp. 737-60.

Boeri, T., Bruecker, H. (2003), Eastern Enlargement and EU-Labour-Markets: Perceptions, Challenges and Opportunities, *The World Economy*, forthcoming.

Carr, D.L., Markusen, J.R., Maskus, K.E. (2001), Estimating the Knowledge-Capital Model of the Multinational Enterprise, *American Economic Review* 91(3), pp. 693-708.

Chiquiar, D., Hanson, G.H. (2002), International Migration, Self-Selection, and the Distribution of Wages: Evidence from Mexico and the United States, *NBER Working Paper No. 9242.*

Coppel, J., Dumont, J-C., Visco, I. (2001), Trends in Immigration and Economic Consequences, *OECD Economics Department Working Papers No. 284*.

Constant, A., Massey, D.S. (2003), Labor Market Segmentation and the Earnings of German Guestworkers, *IZA (Institute for the Study of Labor) Discussion Paper No. 774*.

Dixit, A.K., Stiglitz, J.E. (1977), Monopolistic Competition and Optimum Product Diversity, *American Economic Review* 67(3), pp. 297-308.

De New, J.P., Zimmermann K.F. (1994), Blue Collar Labor Vulnerability: Wage Impact on Migrations, in: Steinmann G., Ulrich R., *The Economic Consequences of Immigration to Germany*, Physica Verlag, Heidelberg, pp. 81-99.

Egger, P., Pfaffermayr, M. (2004), Distance, Trade and FDI: A SUR Hausman-Taylor Approach, *Journal of Applied Econometrics*, forthcoming.

Ekholm, K., Forslid, R. (2001), Trade and Location with Horizontal and Vertical Multi-region-Firms, *Scandinavian Journal of Economics* 103(1), pp. 101-18.

Fujita, M., Krugman, P., Venables, A.J. (1999), The Spatial Economy - Cities, Regions, and International Trade, The MIT Press, Cambridge, Massachusetts.

Gao, T. (1999), Economic Geography and the Department of Vertical Multinational Production, *Journal of International Economics* 48, pp. 301-20.

Geddes, A. (2003), Migration and the Welfare State in Europe, *The Political Quarterly* 74(1), pp. 150-162.

Haaland, J.I., Kind, H.J., Midelfart-Knarvik, K.H., Torstensson, J. (1999), What Determines the Economic Geography of Europe?, *CEPR Discussion Paper Nr. 2072*.

Helpman, E. (1984), A Simple Theory of International Trade with Multinational Corporations, *Journal of Political Economy* 32(3), pp. 451-71.

Helpman, E., Krugman, P.R. (1985), *Market Structure and Foreign Trade - Increasing Returns, Imperfect Competition and the International Economy*, The MIT Press, Cambridge, Massachusetts.

Hummels, D. (1999), Toward a Geography of Trade Costs, mimeo.

Kennan, J., Walker, J.R. (2003), The Effect of Expected Income on Individual Migration Decisions, *NBER Working Paper No. 9585*, March 2003.

Krugman, P. (1991a), *Geography and Trade*, Leuven University Press and MIT Press, Leuven, Belgium and Cambridge, Massachusetts.

Krugman, P. (1991b), Increasing Returns and Economic Geography, *Journal of Political Economy* 99(31), pp. 483-99.

Krugman, P., Venables, A.J. (1995), Globalization and the Inequality of Nations, *Quarterly Journal of Economics* 110(4), pp. 857-80.

Markusen, J.R. (1984), Multinationals, Multi-Plant Economies, and the Gains from Trade, *Journal of International Economics* 16, pp. 205-26.

Markusen, J.R. (2002), *Multinational Firms and the Theory of International Trade*, The MIT Press, Cambridge, Massachusetts.

Markusen, J.R., Maskus, K.E. (2002), Discriminating Among Alternative Theories of the Multinational Enterprise, *Review of International Economics* 10(4), pp. 694-707.

Markusen, J.R., Venables, A.J. (1998), Multinational Firms and the New Trade Theory, *Journal of International Economics* 46, pp. 183–203.

Markusen, J.R., Venables, A.J. (2000), The Theory of Endowment, Intra-industry and Multi-national Trade, *Journal of International Economics* 52, pp. 209–34.

Midelfart-Knarvik, K.H., Overman, H.G., Redding, S.J., Venables, A.J. (2000), The Location of European Industry, Report prepared for the Directorate General for Economic and Financial Affairs, European Commission.

Overman, H.G., Redding, S., Venables, A.J. (2001), The Economic Geography of Trade, Production, and Income: A Survery of Empirics, *Centre of Economic Performance*, London School of Economics.

Puga, D. (2002), European Regional Policies in Light of Recent Location Theory, *Journal of Economic Geography* 2(4), pp. 372-406.

Raybaudi-Massilia, M. (2000), Economic Geography and Multinational Enterprise, *Review of International Economics* 8(1), pp. 1-19.

Rygiel, P. (2001), *Destins immigrés: Cher, 1920-1980*, Trajectoires d'Immigrés d'Europe, Annales littéraires de l'Université de Franche Comté, Besançon.

Sapir, A. (2000), Who is Afraid of Globalization? The Challenge of Domestic Adjustment in Europe and America, *CEPR Discussion Paper No. 2595.*

Wong, Kar-yiu (2001), Direct Investment Liberalization, Commodity Trade, and Income Distribution: What Can the WTO Do?, *Pacific Economic Review* 7(2), pp. 377-400.

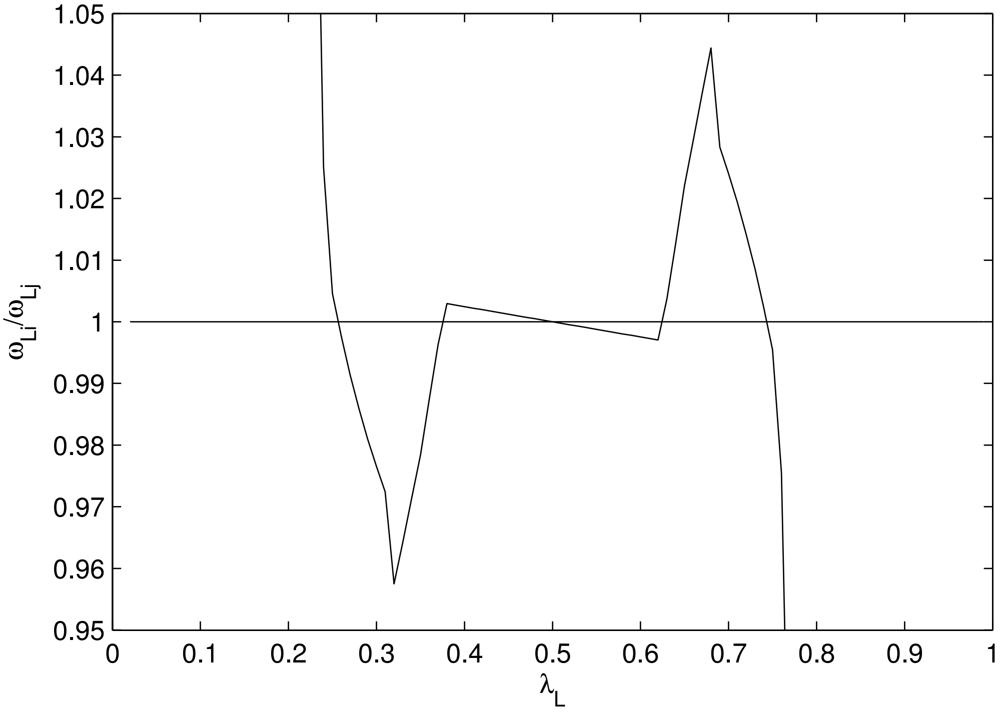

Figure 1: Core-periphery pattern with mobile unskilled labor and $\lambda_S = 0.5$.

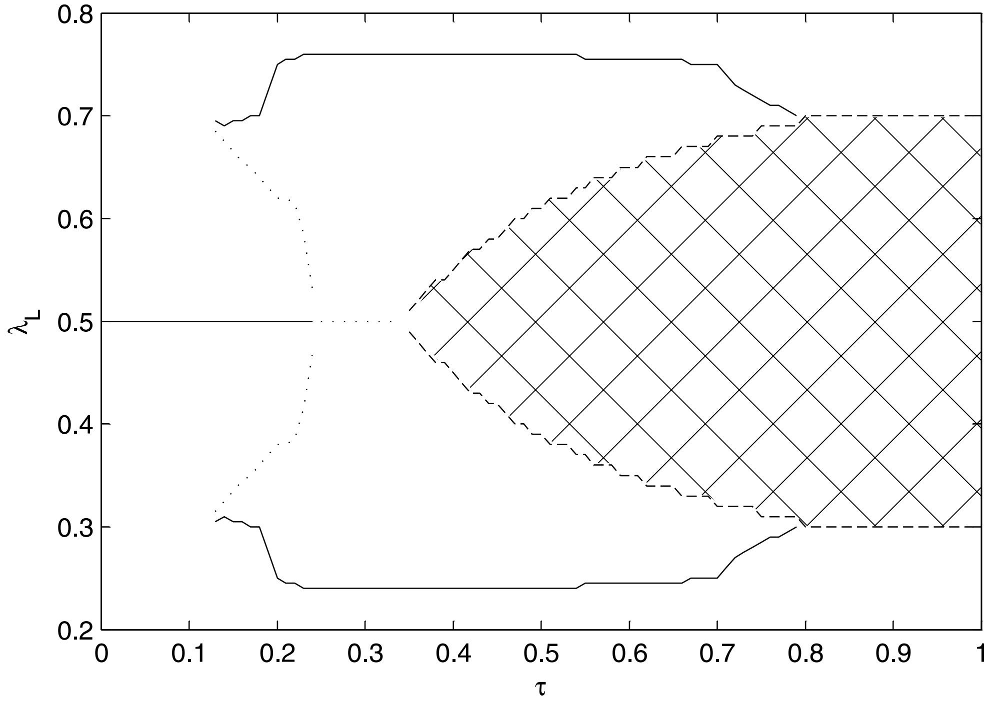

Figure 2: Butterfly bifurcation with mobile unskilled labor and $\lambda_S = 0.5$.

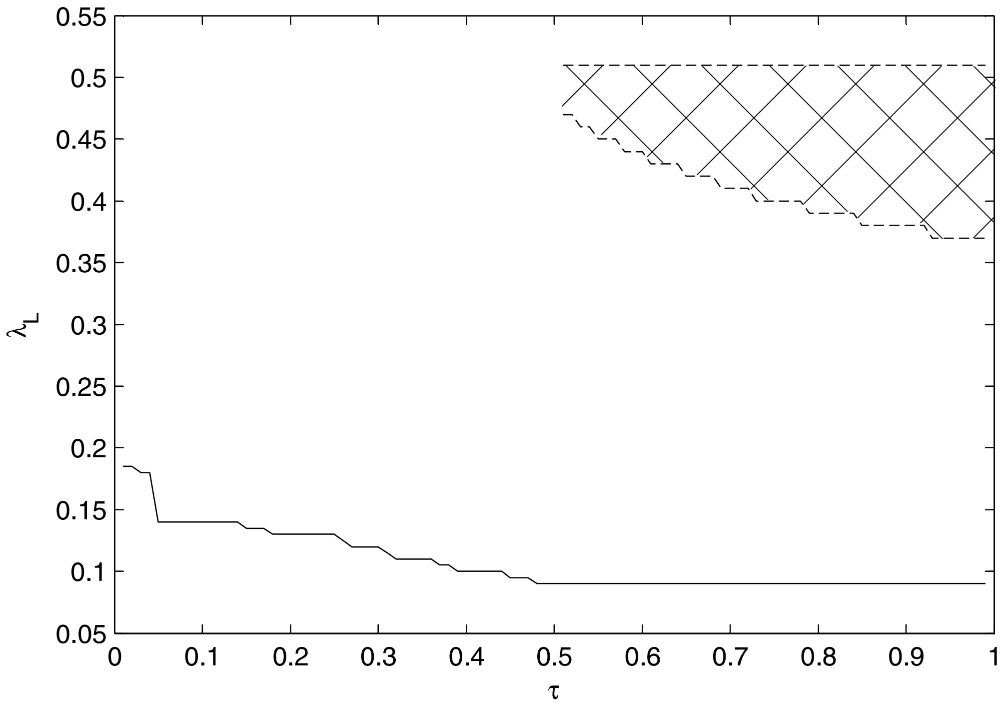

Figure 3: Trousers bifurcation with mobile unskilled labor and $\lambda_S = 0.25$.

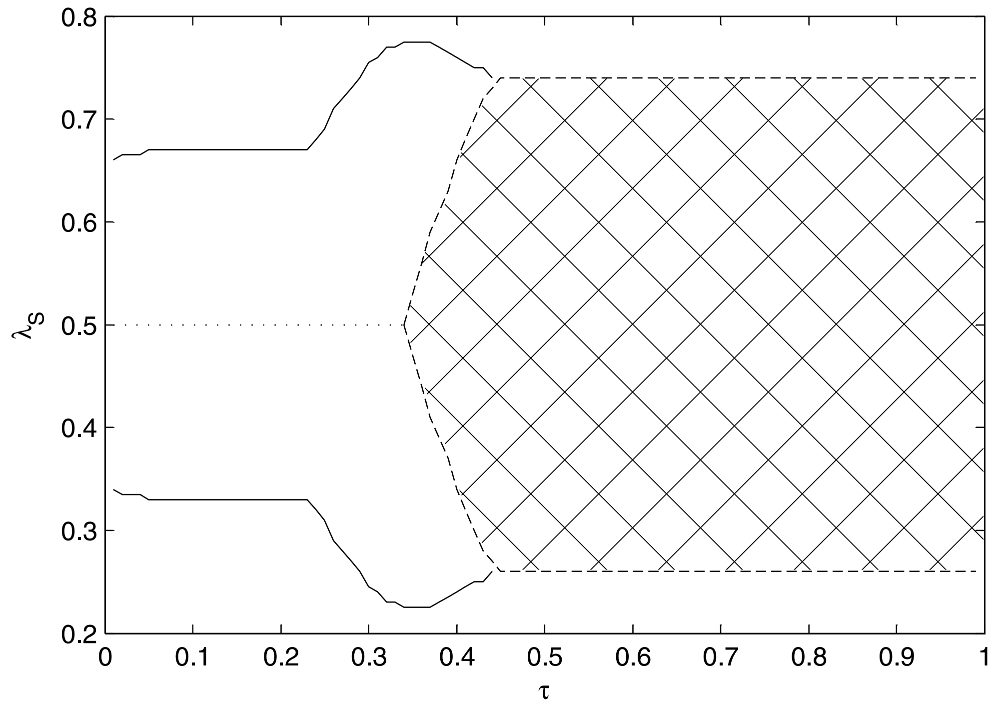

Figure 4: Lampshade bifurcation with mobile skilled labor and $\lambda_L = 0.5$.

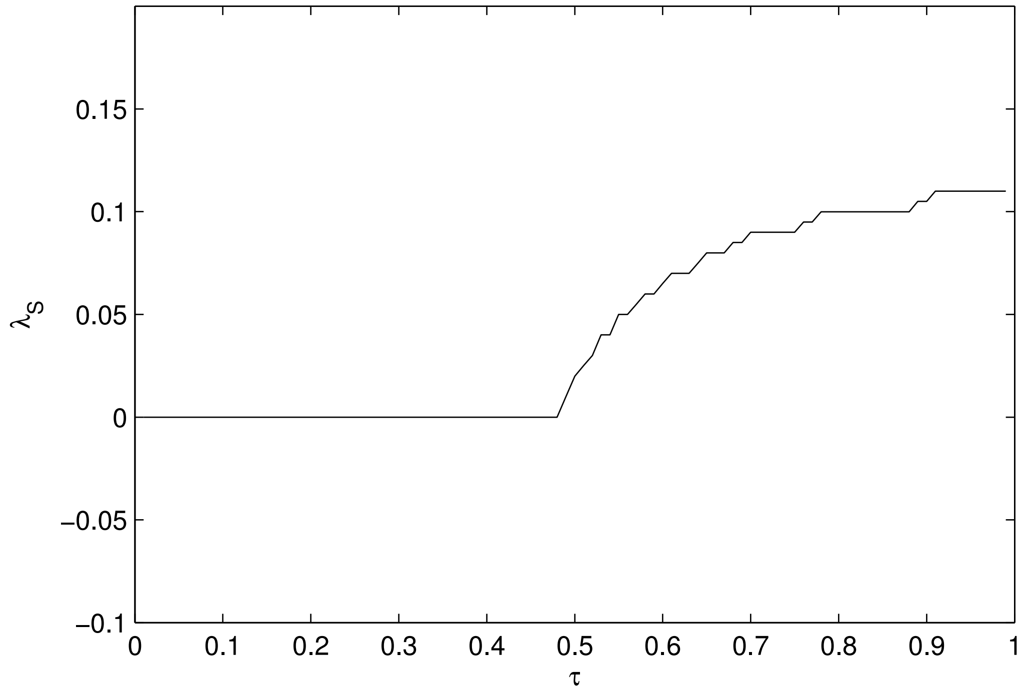

Figure 5: Muscleshirt bifurcation with mobile skilled labor and $\lambda_L = 0.25$.

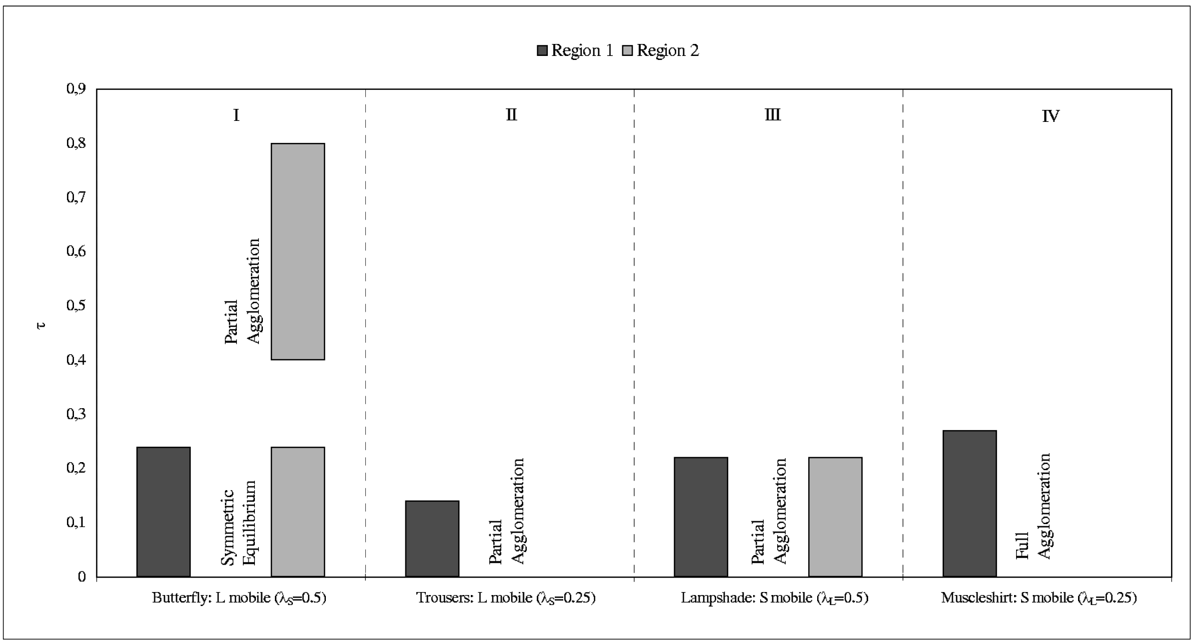

Figure 6: Regions of trade costs where Pareto-improvements are possible.

Supplementary Material to: Knowledge-Capital Meets New Economic Geography

(not intended for publication)

Peter Egger*, Stefan Gruber§,

Mario Larch§, Michael Pfaffermayr§

February 4, 2004

In the supplement, we investigate the sensitivity of our results in several respects. In the first section, we provide the figures of real factor rewards for the trade liberalization scenarios discussed in and underlying Figure 6 of the paper. In Section S2, we shed light on the role of MREs by analyzing the model with REs only (i.e., forbidding MREs). Third, we illustrate how changes in the parameters μ, ρ and σ affect the outcome.

S1 Figures of Real Factor Rewards

Figures 7 to 10 show the real factor rewards in the long-run stable equilibria of the butterfly, lampshade, trousers and muscleshirt bifurcation diagrams. From these figures, we learn for which values of trade costs trade liberalization is Pareto-improving. These regions are depicted in Figure 6 in the paper.

*Helen Kellogg Institute for International Studies at the University of Notre Dame, 130 Hesburgh Center, Notre Dame, Indiana 46556-5677, USA.

§University of Innsbruck, Department of Economics, Universitätsstraße 15, A-6020 Innsbruck, Austria.

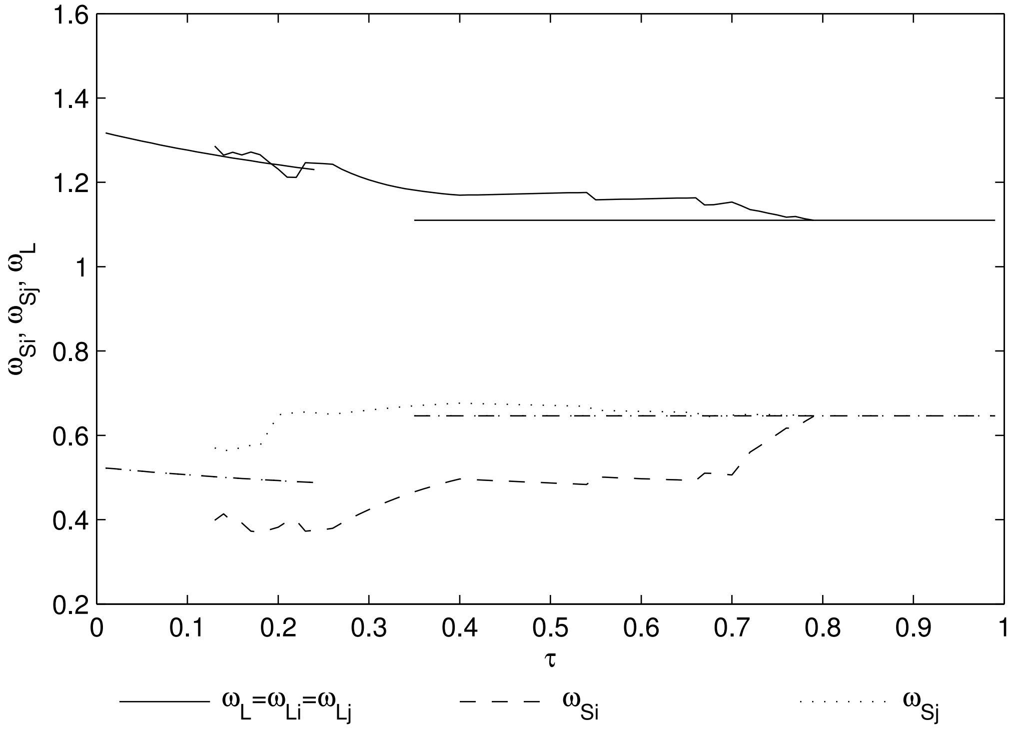

Figure 7: Real factor rewards in stable equilibria of the butterfly bifurcation.

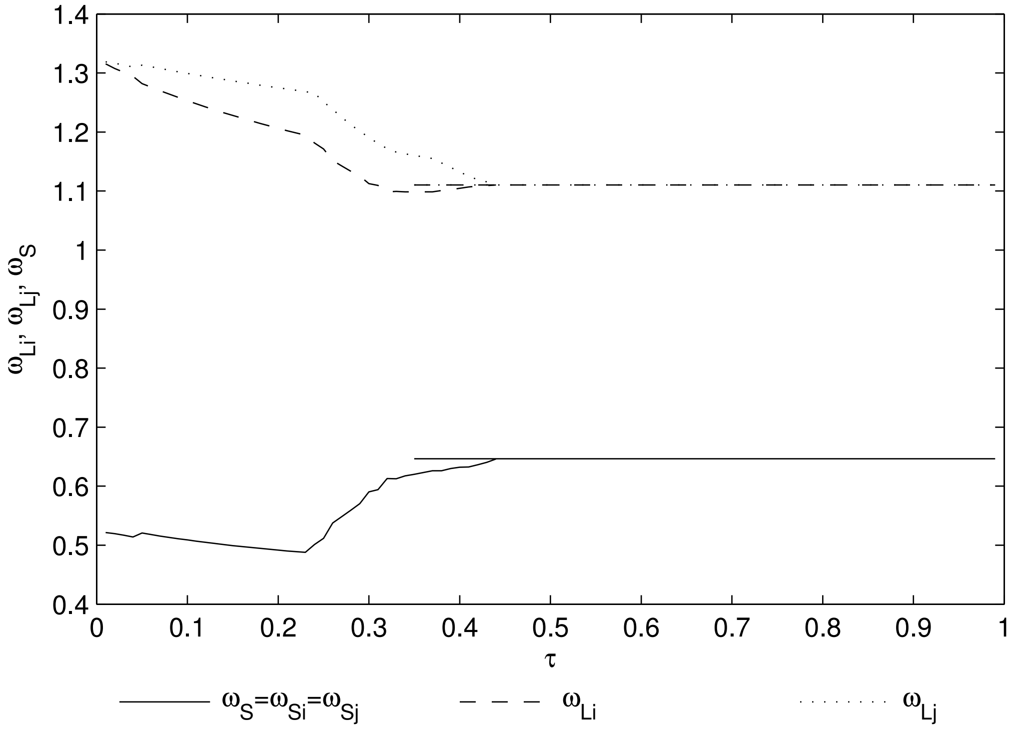

Figure 8: Real factor rewards in stable equilibria of the lampshade bifurcation.

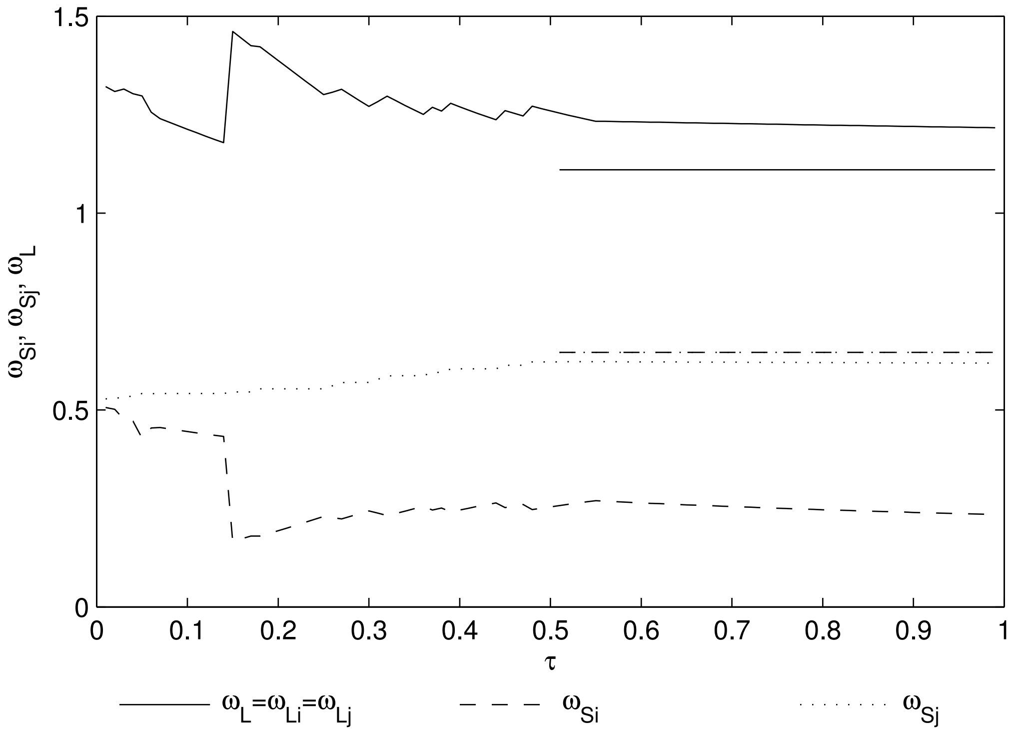

Figure 9: Real factor rewards in stable equilibria of the trousers bifurcation.

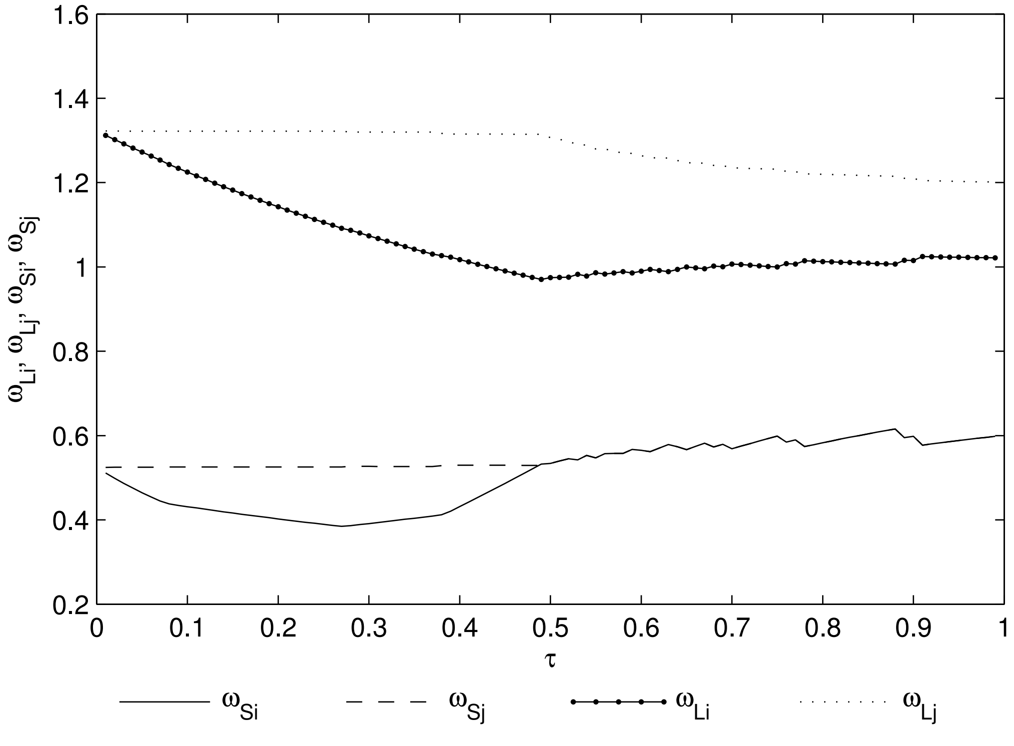

Figure 10: Real factor rewards in stable equilibria of the muscleshirt bifurcation.

S2 Only Regional (Exporting) Enterprises (REs)

Figures 2RE and 4RE refer to the case of REs only (MREs are not allowed to come into existence although it might be optimal).[1] In the standard core-periphery model, only capital is needed in the differentiated sector. The resulting bifurcation diagram became known as the tomahawk-bifurcation. Capital mobility in this traditional model corresponds to skilled labor mobility in our knowledge-capital setting. As it can be seen from Figure 4RE, our model produces a similar pattern, despite the fact that we do not find full agglomeration for low values of transport costs.

Concerning the case of unskilled labor mobility, we find that the symmetric equilibrium is the only long-run stable one, irrespective of the level of transport costs. The reason is that a one unit shift of unskilled labor leads to concentration of firms in the larger region (this is the well known home market effect). In turn, this leads to both, higher skilled labor rewards and prices, thereby lowering real unskilled labor rewards. Accordingly, the symmetric equilibrium is stable.

[1]These are the corresponding figures to the butterfly and lampshade bifurcation diagrams.

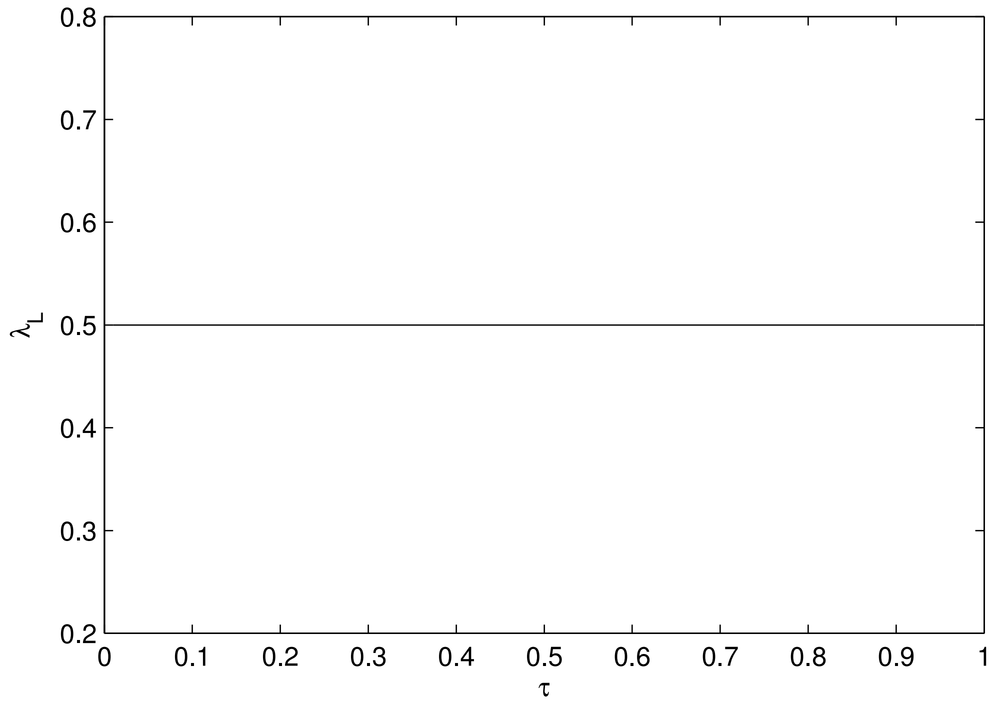

Figure 2RE: Only exporting firms allowed with mobile unskilled labor and $\lambda_S = 0.5$.

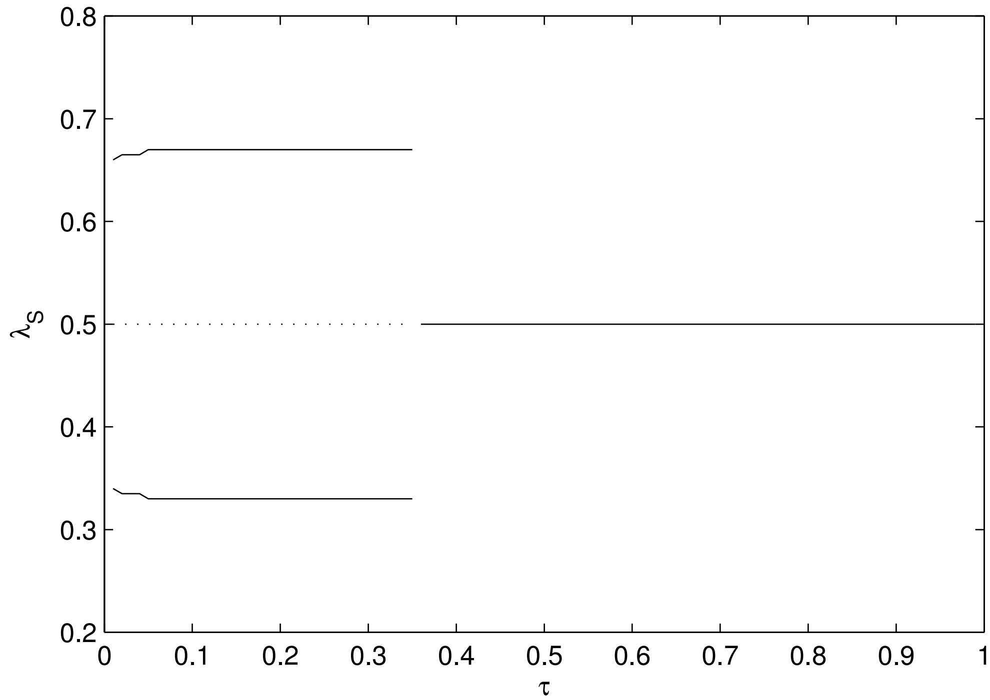

Figure 4RE: Only exporting firms allowed with mobile skilled labor and $\lambda_L = 0.5$.

S3 Robustness

In the following, we investigate our analysis presented in the paper regarding the robustness of our model to changes of the parameters. We discuss variations of the parameters μ, ρ and σ. For every new parameter value, we analyze the effects with respect to our two reference cases for unskilled as well as skilled labor mobility, where the respective immobile factor is equally allocated between the two regions. These reference cases correspond to Figures 2 and 4 in the paper.

S3.1 Alternative Values of μ

In our model we let consumers spend 80% of their income on manufactured goods ($\mu = 0.8$). We lower this value to (i) $\mu = 0.5$ and (ii) $\mu = 0.3$, which is the value frequently used in new economic geography models, for instance in Krugman (1991b) or Ekholm and Forslid (2001).

Note that for both, mobile unskilled labor (Figures $2\mu(0.3)$ and $2\mu(0.5)$) and mobile skilled labor (Figures $4\mu(0.3)$ and $4\mu(0.5)$), we find that for lower values of μ, MREs become more important, because skilled labor is abundant and therefore the additional fixed costs for setting up a plant abroad are low (remember that skilled labor is only used in differentiated goods production and for setting up plants). For $\mu = 0.3$, skilled labor factor rewards become even low enough to make MREs attractive over nearly the whole range of transport costs.

Noteworthy, for the equilibrium area with only horizontal MREs, the potential differences in the size of the two regions diminish, if we decrease μ to 0.3 ($0.22 < \lambda_L < 0.78$ for $\mu = 0.5$ compared to $0.33 < \lambda_L < 0.67$ for $\mu = 0.3$). This is due to the fact that for lower values of μ, concentration of MREs in one region is more likely. This leads to full agglomeration of headquarters in the larger region and, therefore, factor price equalization is no longer ensured.

As mentioned in the paper, full agglomeration is a rather unlikely outcome in our framework. Nevertheless, if μ and τ are both low enough, full agglomeration occurs in the case of skilled labor mobility (see Figures $4\mu(0.3)$ and $4\mu(0.5)$).

These results are fully in line with the findings of Raybaudi-Massilia (2000). She states that high levels of expenditure on manufactures favor concentration of production, but on the other hand horizontal multinationals restrict the possibility of concentration.

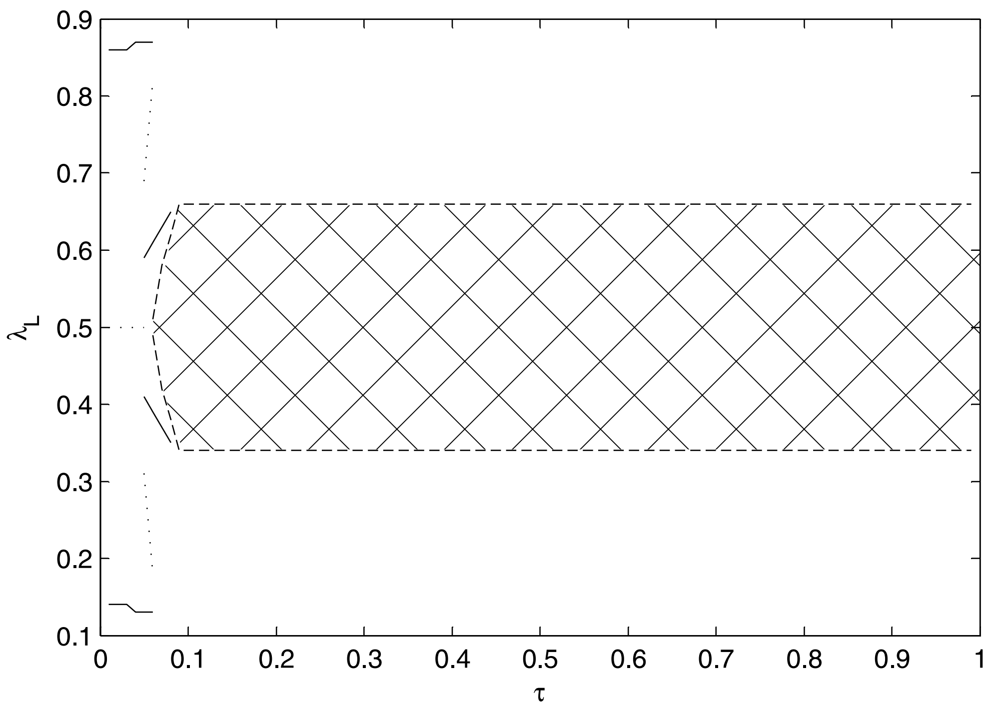

Figure $2\mu(0.3)$: Butterfly bifurcation with $\mu = 0.3$, mobile unskilled labor and $\lambda_S = 0.5$.

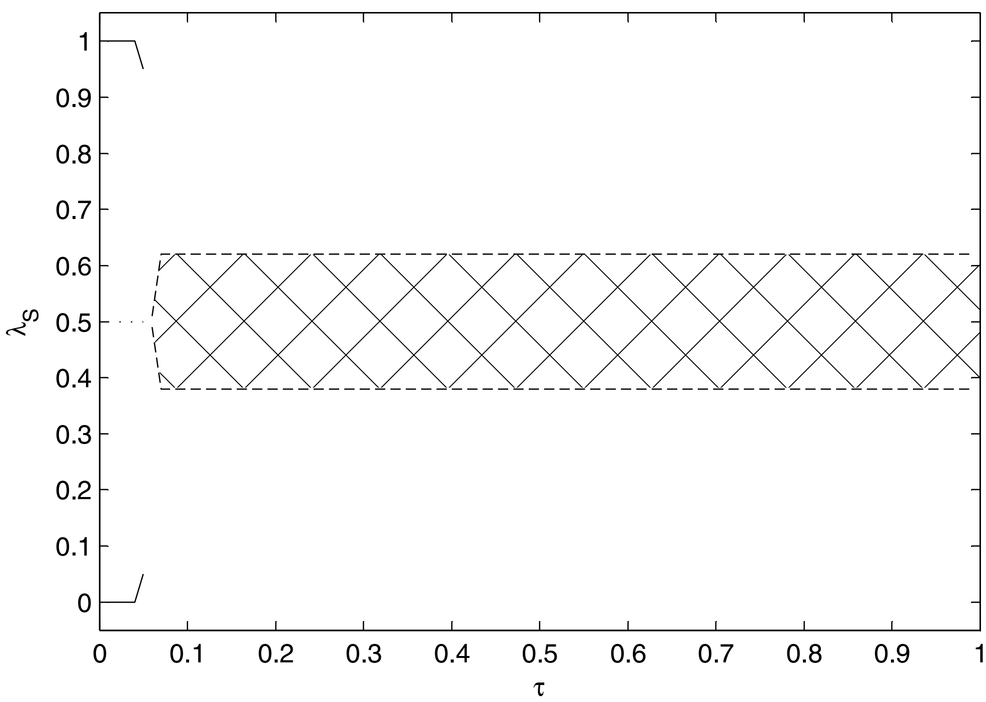

Figure 4μ(0.3): Lampshade bifurcation with $\mu = 0.3$, mobile skilled labor and $\lambda_L = 0.5$.

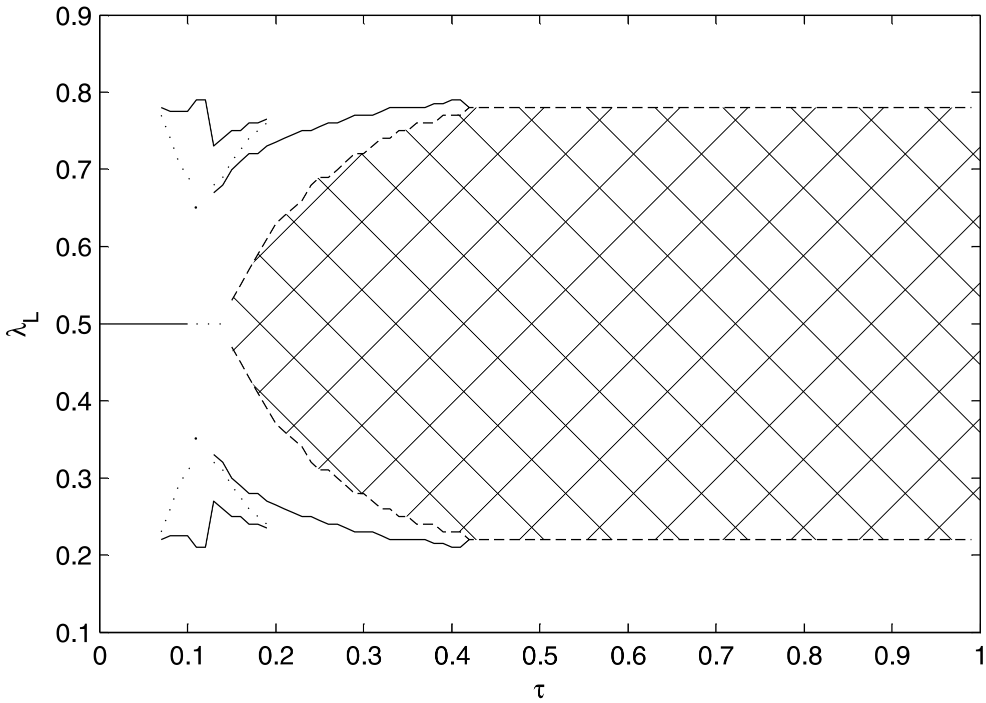

Figure 2μ(0.5): Butterfly bifurcation with $\mu = 0.5$, mobile unskilled labor and $\lambda_S = 0.5$.

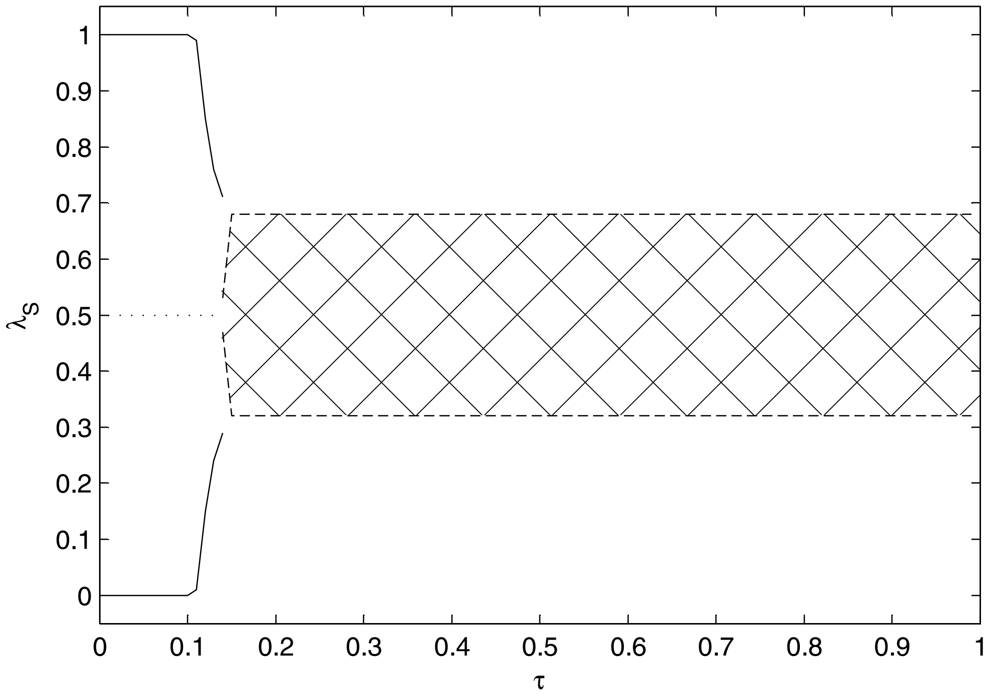

Figure $4\mu(0.5)$: Lampshade bifurcation with $\mu = 0.5$, mobile skilled labor and $\lambda_L = 0.5$.

S3.2 Alternative Values of ρ

We continue by analyzing the effects of a change of ρ, the substitutability between the two input factors for producing manufactures. First, we change ρ from -0.5 to -5 (i.e., changing the technical rate of substitution from 2/3 to 1/6.). The lower substitutability between skilled and unskilled labor causes skilled labor to become more expensive. Thus, setting up MREs becomes less attractive and, therefore, the equilibrium area with only horizontal MREs gets smaller and only exists at high transport costs (see Figures 2ρ(-5) and 4ρ(-5)). Moreover, the spreading equilibrium remains stable for a relatively large range of transport costs in the case of unskilled labor mobility (until $\tau \approx 0.45$). There is also a less pronounced sustain range for the partially agglomerated equilibria.

Lowering ρ even further to -20 (i.e., changing the technical rate of substitution to 1/21), i.e., making it even more difficult to substitute production factors, intensifies the pattern described above. The equilibrium area with only horizontal MREs nearly vanishes, also the partially agglomerated equilibria exist only for higher values of transport costs, and the spreading equilibrium remains stable until $\tau \approx 0.63$ (see Figures 2ρ(-20) and 4ρ(-20)).

Moreover, we find that the long-run stable, partially agglomerated equilibria are present over the whole range of transport costs, and that the agglomeration pattern itself is more pronounced. The reason is that more firms have incentives to relocate to the skilled labor abundant region.

Making factors in production of manufactured goods more substitutive (changing ρ from -0.5 to 0.5 (implying a TRS of 2) and 5/6 (which corresponds to a TRS of 6), respectively, leads to lower factor prices and, thus, makes MREs ceteris paribus more attractive (see Figures 2ρ(0.5), 2ρ(5/6), 4ρ(0.5) and 4ρ(5/6)). The higher substitutability leads the partially agglomerated equilibria to be more pronounced and the equilibrium area with only horizontal MREs appears for a larger range of transport costs.

Overall, we can conclude that lower (higher) values of ρ shift the bifurcation diagrams to the right (left).

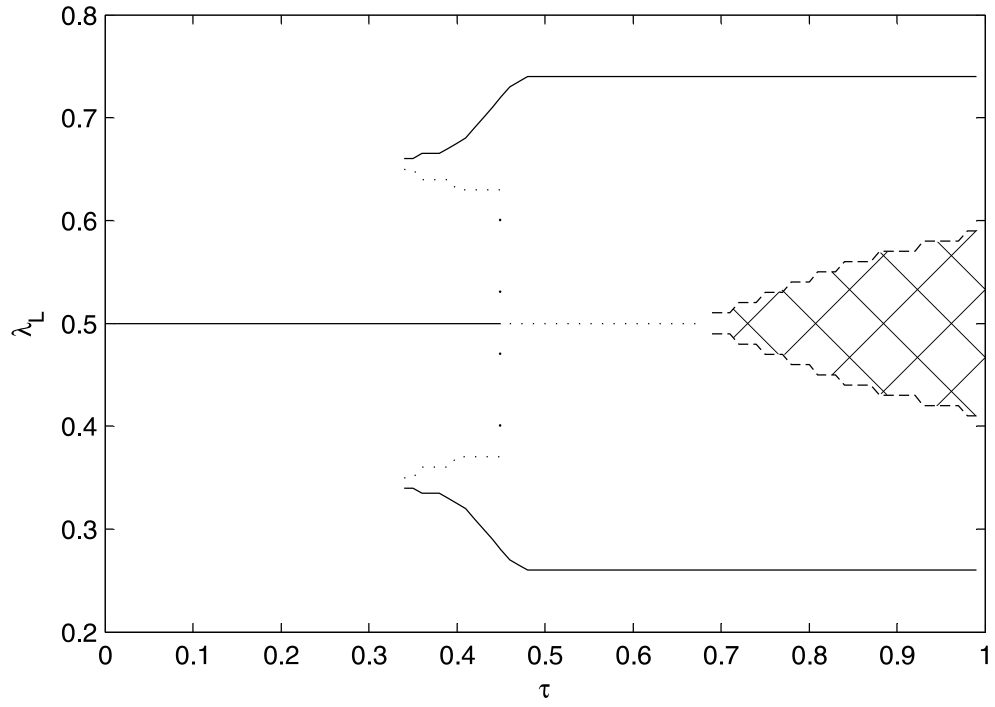

Figure 2ρ(-5): Butterfly bifurcation with $\rho = -5$, mobile unskilled labor and $\lambda_S = 0.5$.

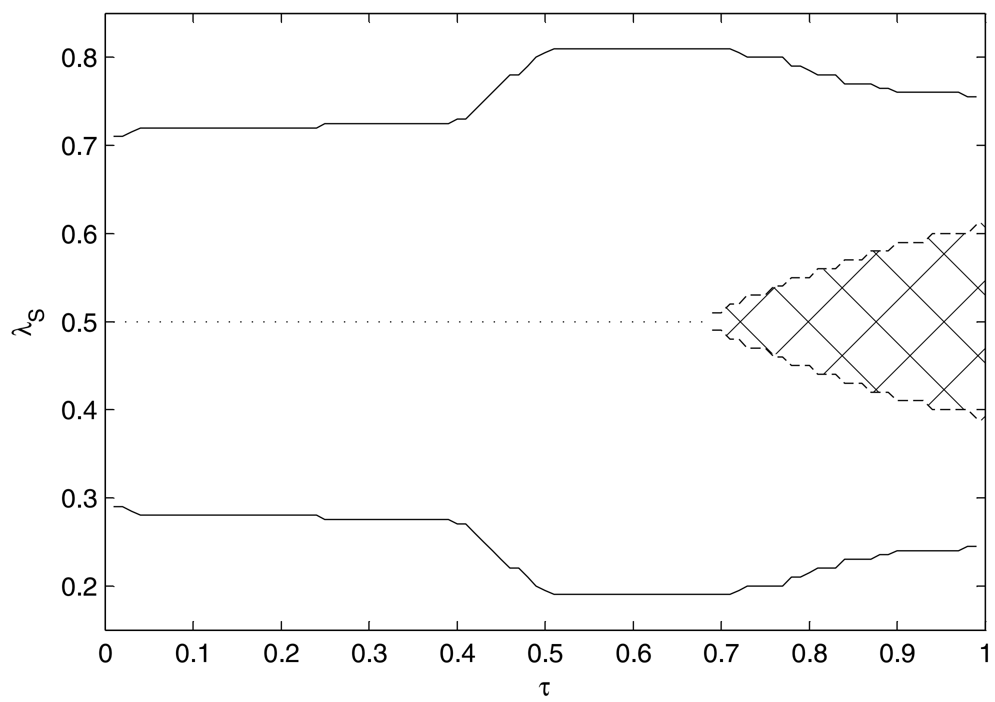

Figure 4ρ(-5): Lampshade bifurcation with $\rho = -5$, mobile skilled labor and $\lambda_L = 0.5$.

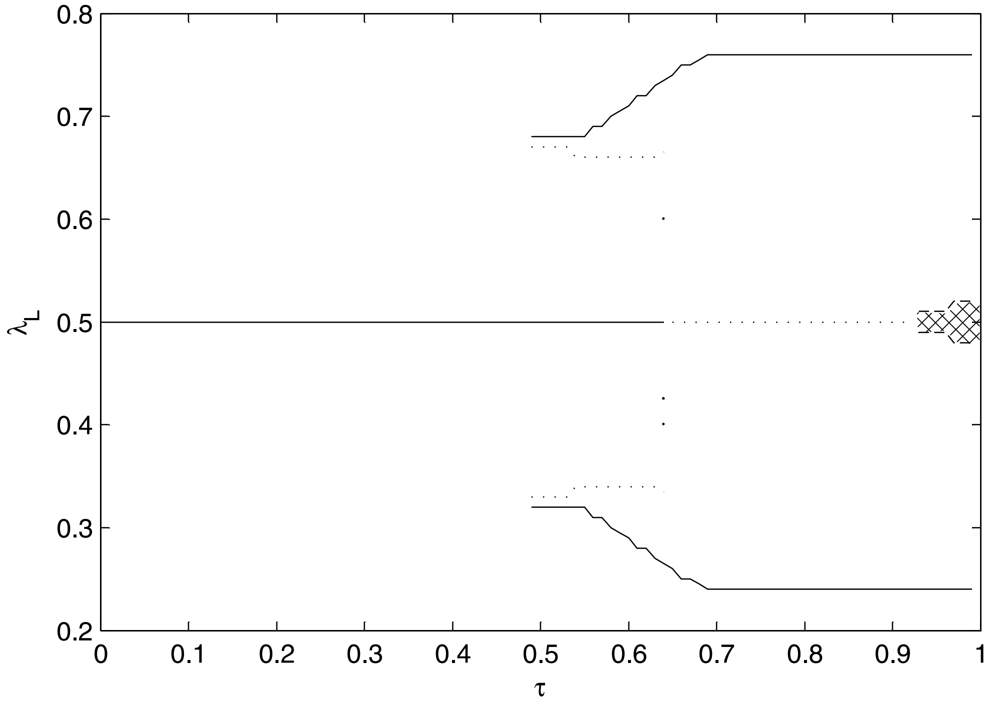

Figure 2ρ(-20): Butterfly bifurcation with $\rho = -20$, mobile unskilled labor and $\lambda_S = 0.5$.

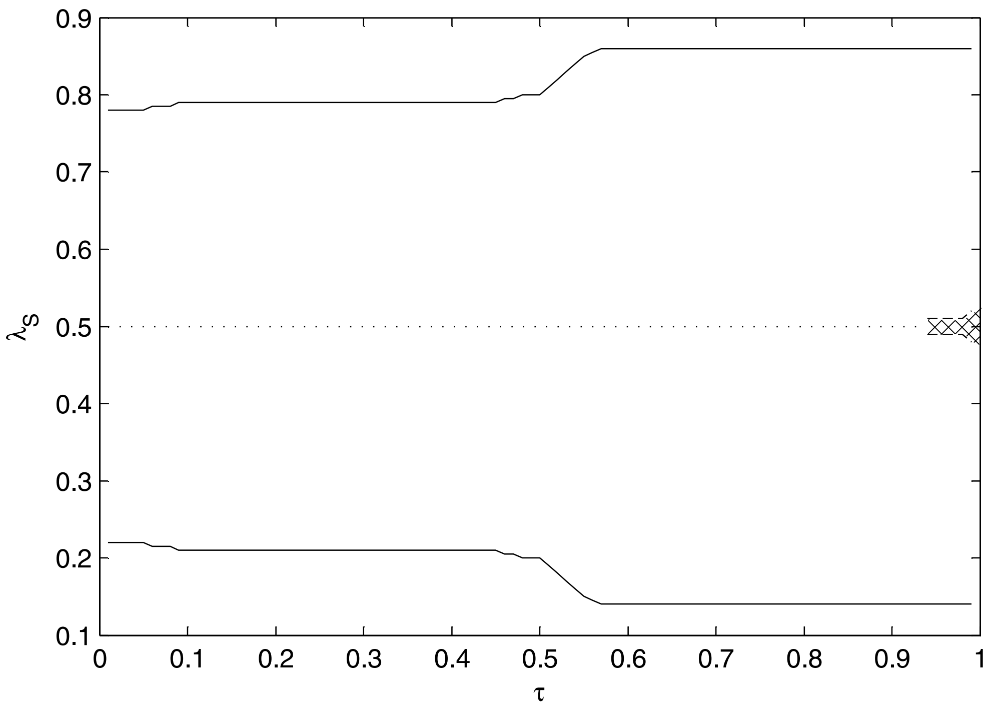

Figure 4ρ(-20): Lampshade bifurcation with $\rho = -20$, mobile skilled labor and $\lambda_L = 0.5$.

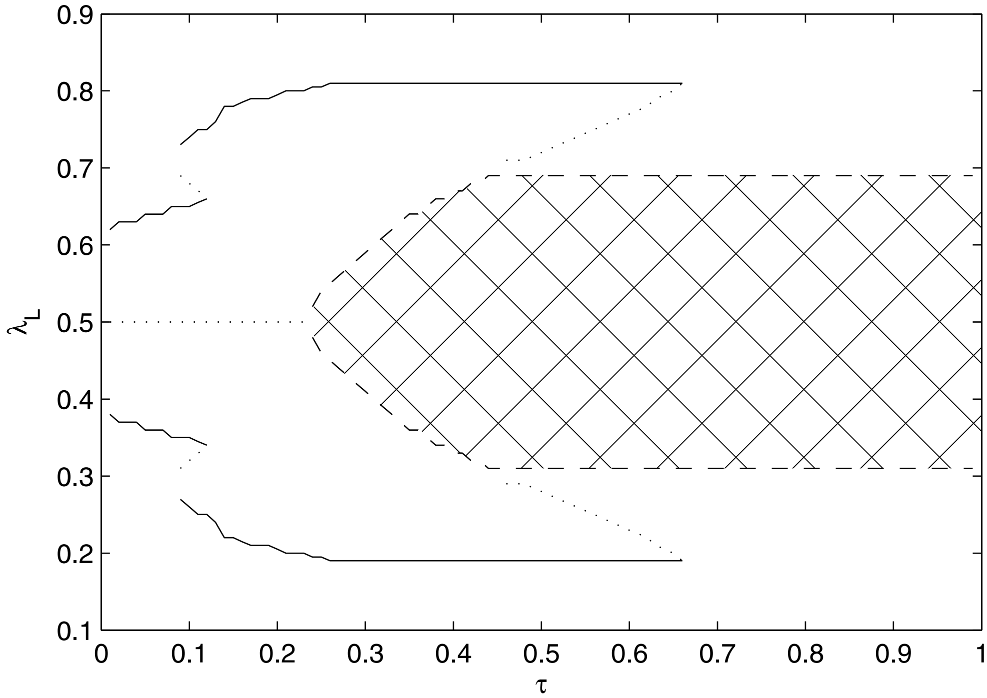

Figure $2\rho(0.5)$: Butterfly bifurcation with $\rho = 0.5$, mobile unskilled labor and $\lambda_S = 0.5$.

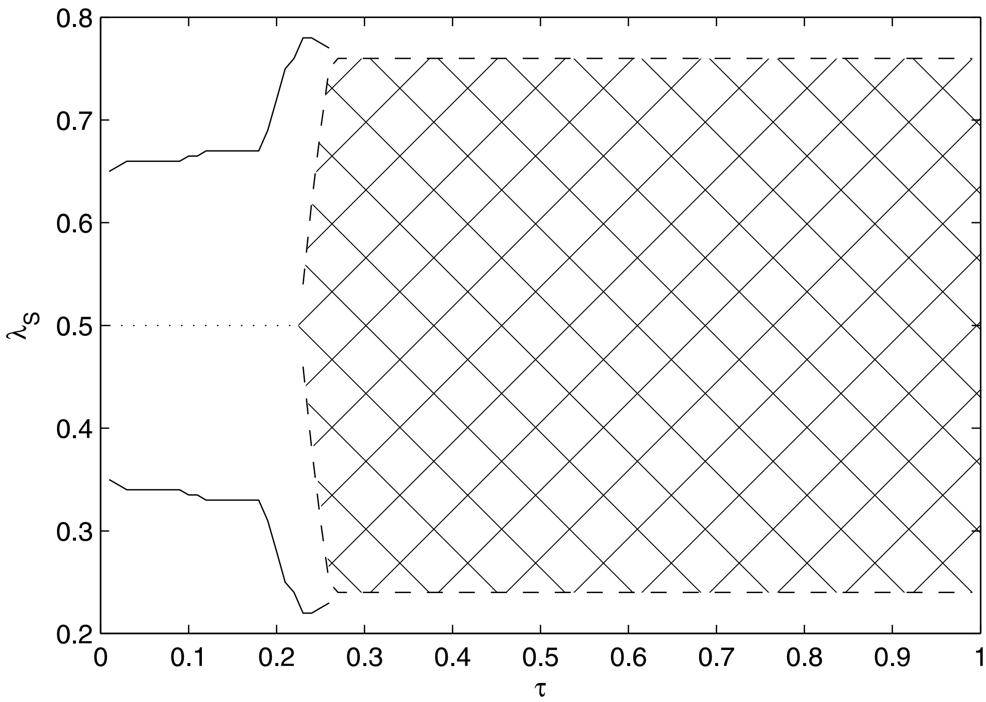

Figure $4\rho(0.5)$: Lampshade bifurcation with $\rho = 0.5$, mobile skilled labor and $\lambda_L = 0.5$.

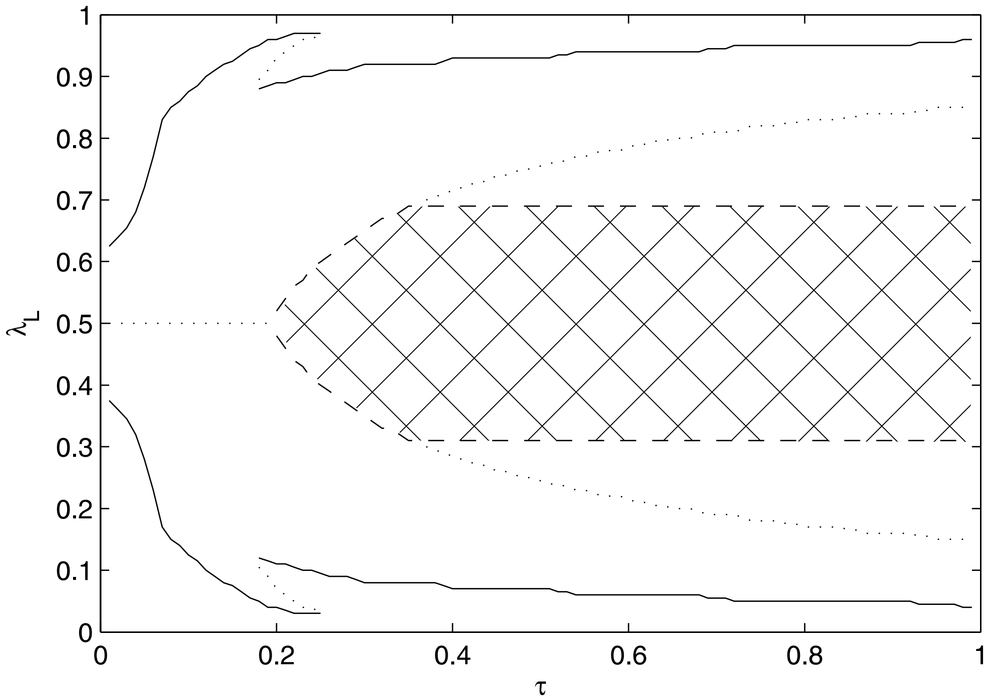

Figure 2ρ(5/6): Butterfly bifurcation with $\rho = 5/6$, mobile unskilled labor and $\lambda_S = 0.5$.

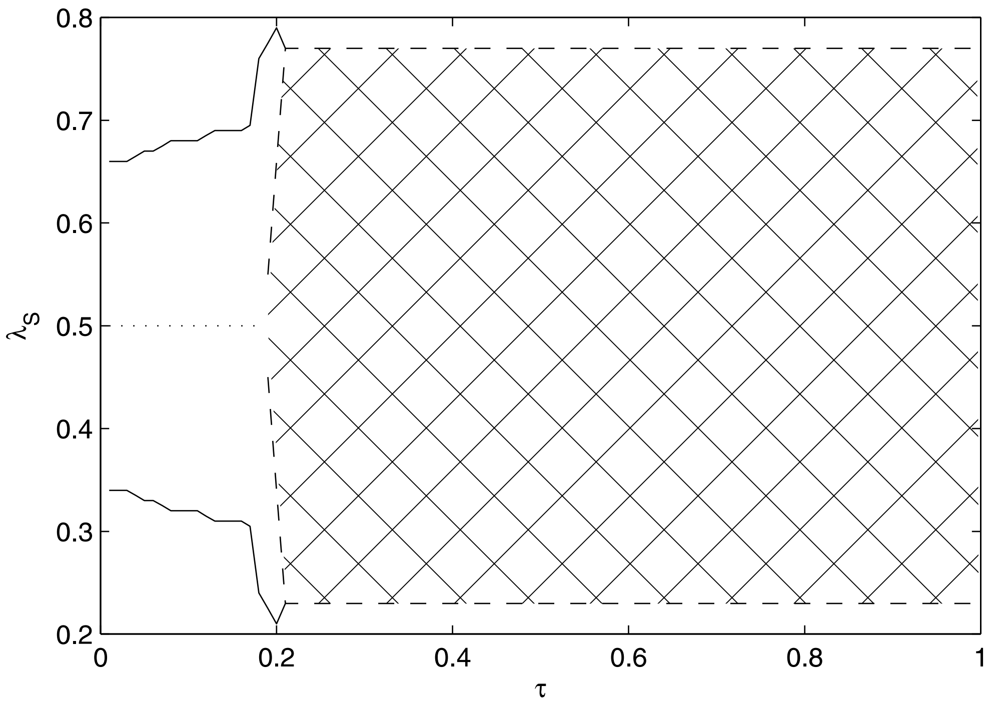

Figure 4ρ(5/6): Lampshade bifurcation with $\rho = 5/6$, mobile skilled labor and $\lambda_L = 0.5$.

S3.3 Alternative Values of σ

Lowering the elasticity of substitution between varieties of the manufactured good (σ), we find that the equilibrium area with only horizontal MREs becomes smaller (comparing Figure $2\sigma(6)$ with Figure 2 in the paper) or even vanishes (see Figures $2\sigma(2)$ and $4\sigma(2)$). This is due to the fact that consumers are less able to substitute between varieties of the manufactured good. Thus, demand for manufactures is less sensitive to price changes, which makes it less attractive for firms to produce in both countries. This is because the advantage of horizontal MREs to be able to avoid transport costs diminishes strongly. In other words, transport costs are of less importance. This is in line with the result of Markusen (2002, p. 116), who finds that the likelihood of horizontal multinational firms rises with the elasticity of substitution.

When unskilled labor is mobile, the partially agglomerated equilibria are observable from $\tau \approx 0.12$ for all chosen values of σ. Gradually lowering σ, the partial agglomerated equilibria become more diverse as transport costs increase, since it becomes more attractive for firms to move into the larger region (see Figures $2\sigma(6)$, 2 and $2\sigma(2)$). A long-run stable symmetric equilibrium persists over the whole range of transport costs, if unskilled labor is mobile and σ is sufficiently low (see Figure $2\sigma(2)$).

For skilled labor mobility, the partially agglomerated equilibrium remains sustainable for a larger range of transport costs as σ gets lower, and even exists for all values of transport costs for $\sigma = 2$ (see Figures $4\sigma(6)$, 4 and $4\sigma(2)$).

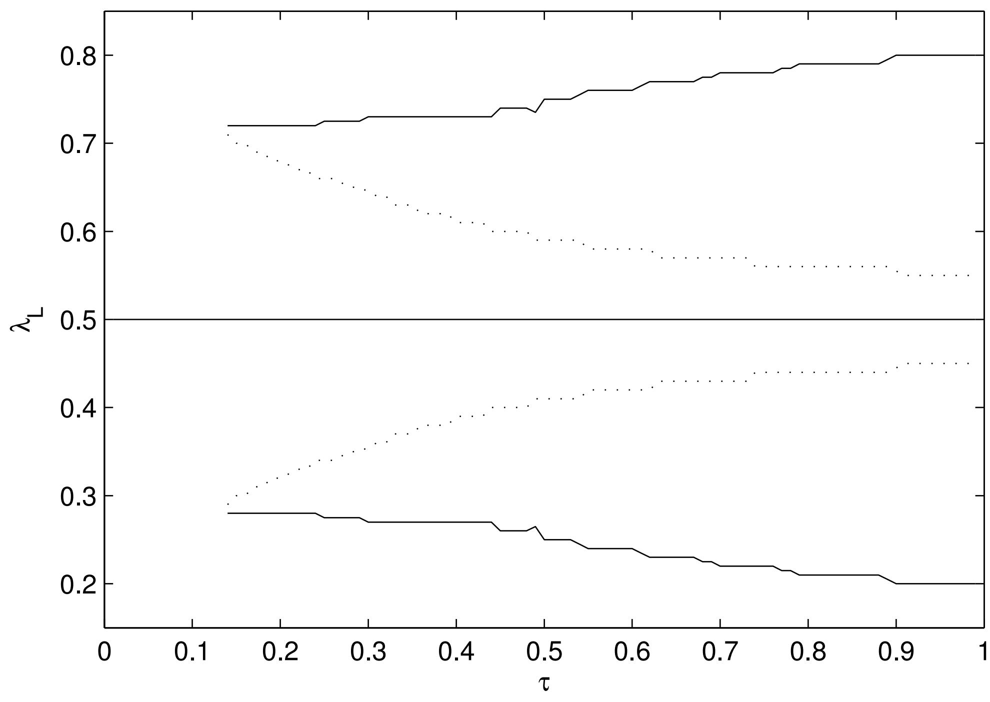

Figure 2σ(2): Butterfly bifurcation with $\sigma = 2$, mobile unskilled labor and $\lambda_S = 0.5$.

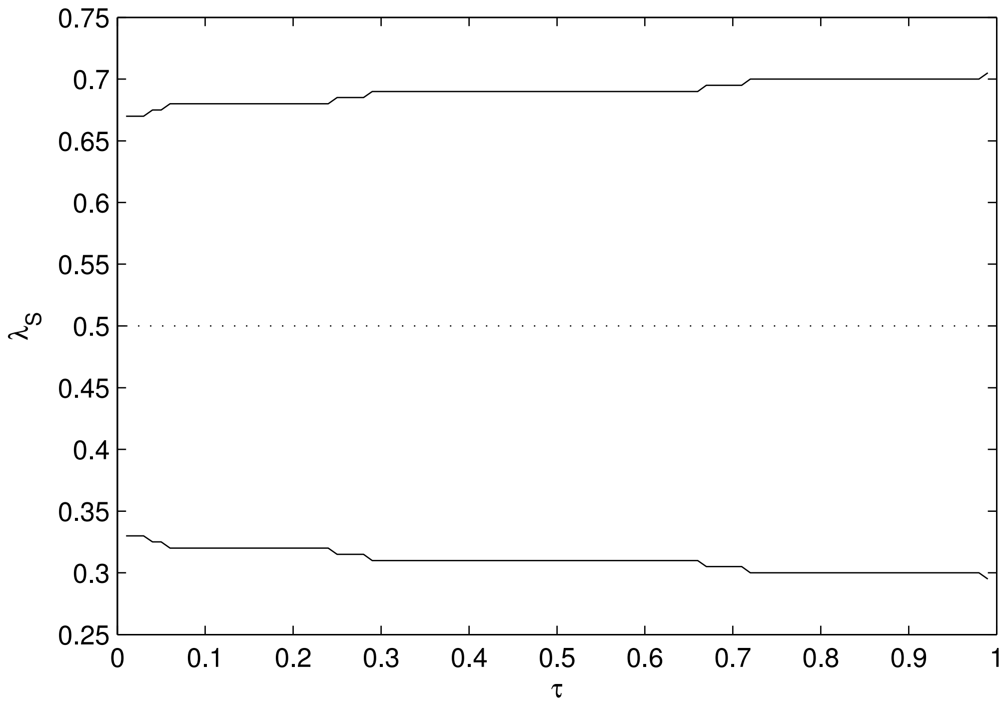

Figure 4σ(2): Lampshade bifurcation with $\sigma = 2$, mobile skilled labor and $\lambda_L = 0.5$.

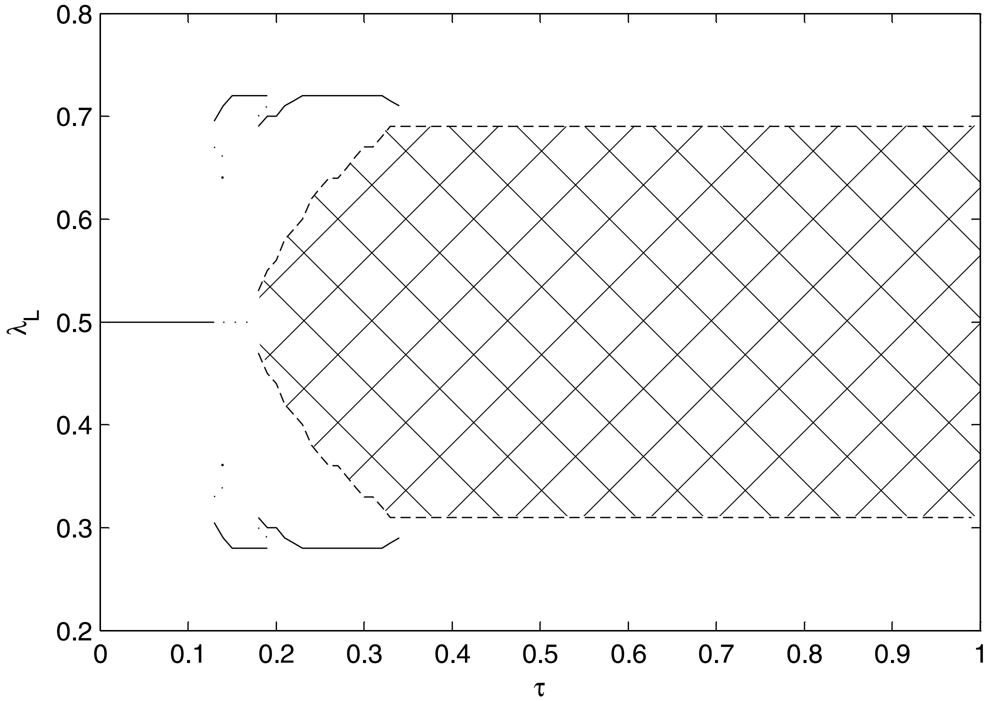

Figure 2σ(6): Butterfly bifurcation with $\sigma = 6$, mobile unskilled labor and $\lambda_S = 0.5$.

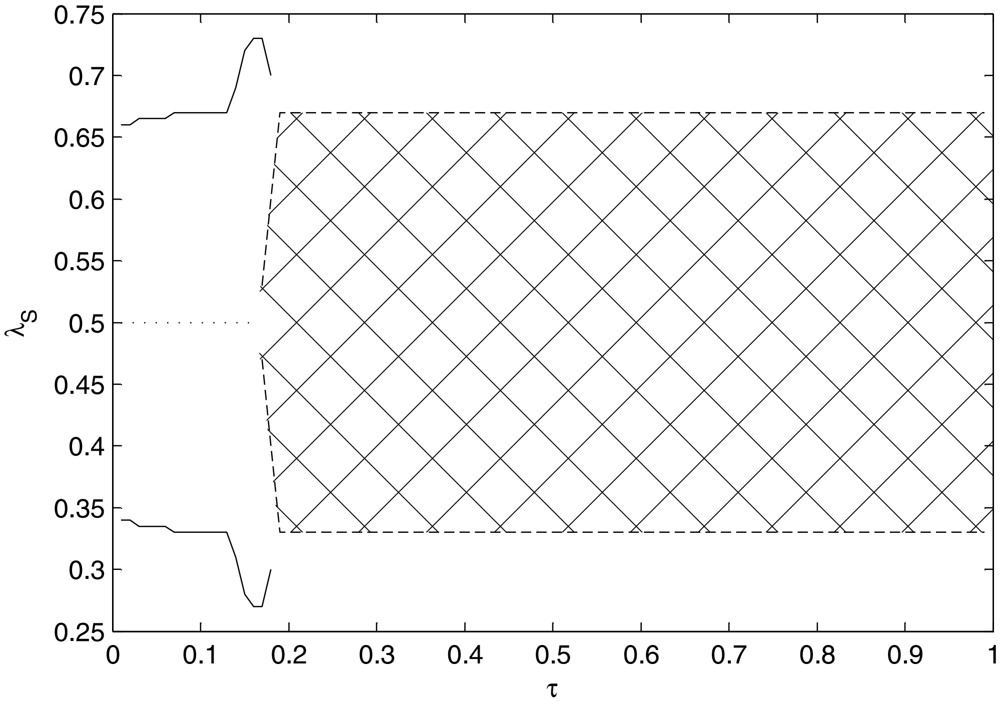

Figure 4σ(6): Lampshade bifurcation with $\sigma = 6$, mobile skilled labor and $\lambda_L = 0.5$.

S4 References

Ekholm, K., Forslid, R. (2001), Trade and Location with Horizontal and Vertical Multi-region-Firms, *Scandinavian Journal of Economics* 103(1), pp. 101-18.

Krugman, P. (1991b), Increasing Returns and Economic Geography, *Journal of Political Economy* 99(31), pp. 483-99.

Markusen, J.R. (2002), Multinational Firms and the Theory of International Trade, The MIT Press, Cambridge, Massachusetts.

Raybaudi-Massilia, M. (2000), Economic Geography and Multinational Enterprise, *Review of International Economics* 8(1), pp. 1-19.

Zuletzt erschienen **Recent Discussion Papers**

2002/01 **Peter Egger and Michael Pfaffermayr:** The Pure Effects of European Integration on Intra-EU Core and Periphery Trade.

2002/02 **Peter Egger and Michael Pfaffermayr:** Foreign Direct Investment and European Integration in the 90´s

2002/03 **Peter Egger and Michael Pfaffermayr:** Two Dimensions of Convergence: National and International Wage Adjustment Effects of Cross-Border Outsourcing in Europe

2002/04 **Gerald Huber, Martin Kocher and Matthias Sutter:** Government strength, power dispersion in governments and budget deficits in OECD-countries. A voting power approach

2002/05 **Peter Egger and Michael Pfaffermayr:** Long Run and Short Run Effects in Static Panel Models

2002/06 **Rupert Sendlhofer:** Does Restructuring the Taxation of Labour Affect Real Wages?

2003/01 **Martin Kocher, Sabine Strauss and Matthias Sutter:** Bargaining Under Time Pressure in an Experimental Ultimatum Game

2003/02 **Peter Egger and Michael Pfaffermayr:** The Counterfactual to Investing Abroad: An Endogenous Treatment Approach of Foreign Affiliate Activity

2003/03 **Matthias Sutter and Hannelore Weck-Hannemann:** An Experimental Test of the Public - Goods Crowding – Out Hypothesis When Taxationis Endogenous

2003/04 **Jürgen Huber, Michael Kirchler and Matthias Sutter:** Vom Nutzen zusätzlicher Information auf Märkten mit unterschiedlich informierten Händlern –eine experimentelle Studie

2003/05 **Peter Egger and Michael Pfaffermayr:** Estimating Long Run and Short Run Effects in Static Panel Models (revised version)

2003/06 **Mario Larch:** The Home Market Effect in Models with Multinational Enterprises

2003/07 **Peter Egger, Mario Larch and Michael Pfaffermayr:** On the Welfare Effects of Trade and Investment Liberalization

2004/01 **Peter Egger, Stefan Gruber, Mario Larch and Michael Pfaffermayr:** Knowledge-Capital Meets New Economic Geography