

Tafenau, Egle

Conference Paper

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50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Tafenau, Egle (2010) : The effects of regional subsidies to the spatial distribution of economic activity and welfare in the constructed capital model, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden, European Regional Science Association (ERSA), Louvain-la-Neuve

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The effects of regional subsidies to the spatial distribution of economic activity and welfare in the constructed capital model

Paper for the ERSA 2010 conference, Jönköping

Egle Tafenau*

June 18, 2010

Abstract

The paper asks whether subsidies aiming to redistribute economic activity across regions can be justified with the welfare argument. Different tax systems are compared with respect to the size of the subsidy needed for achieving a certain spatial distribution of economic activity, and achievable welfare level. The analysis relies on the constructed capital model known from the new economic geography literature. The paper shows that with an appropriate tax system the adverse effects of subsidies can be alleviated. The Rawlsian and utilitarian welfare function, and the compensated Pareto criterion are applied for welfare analysis. It is shown that welfare improvements are possible with the help of a simple tax-subsidy policy.

Keywords: regional disparities, regional policy, new economic geography

JEL: H71, R12, R13, R58

*University of Tartu (Estonia) and Christian Albrechts University of Kiel (Germany). Contact: Egle.Tafenau@ut.ee. Financial support from the Estonian Science Foundation (research grant No. 7756) and the Estonian Ministry of Science and Education (grant No. SF0180037s08) is gratefully acknowledged.

1 Introduction

Questions about social welfare and efficiency are central to economics. For a long time, the impact of geographical distribution of economic activity to these phenomena was neglected in the economic literature. Of course, there were economists like von Thünen (1921/1842) or Lösch (1940) who handled questions related to the optimal location of economic activities. However, their analysis was done in a partial equilibrium framework. Only the new economic geography models starting with Krugman (1991*b,a*) rely on the concept of general equilibrium (Bröcker 2007) and enable, thus, a welfare analysis considering also income effects. Moreover, in those models the spatial distribution of economic activity arises endogenously in the interplay of agglomeration and dispersion forces.

The NEG models have become popular as the basis of regional policy discussions (Martin 1999, Berthold & Neumann 2005). Also the recent World Development Report that concentrates on regional issues (World Bank 2009) relies heavily on the NEG models. However, the range of policy tools that are analysed in the context of the NEG models is pretty narrow. The discussion focusses mainly on the effects of infrastructure improvements (Martin & Rogers 1995). Another policy related topic has been tax competition.

As there are market imperfections in the NEG models and regional inequality arises under certain conditions, the NEG models have been applied for welfare analysis. In most of the cases the social optimality of the spatial distribution of economic activity achieved as the market outcome is analysed by asking which share of firms would be chosen by a benevolent social planner who maximises a utilitarian social welfare function. It has been shown that the society might prefer less or more agglomeration than achieved in the market outcome (see e.g. Ch. 11 in Baldwin et al. 2003, Ottaviano et al. 2002). The specific tools of achieving a spatial distribution of firms that diverges from the market outcome have been rarely analysed. The closest work in this line is Dupont & Martin (2006) and also the tax competition literature is related. Moreover, reliance on a utilitarian welfare function implies that

the results depend on the assumed aversion to inequality and are, thus, subjective. It is a priori unclear whether welfare could be increased if the spatial distribution of economic activity is influenced by implementing distortionary policy measures like taxes and subsidies.

The purpose of the paper is to show how the NEG models foster understanding on the effects of regional policies to social welfare in regions on the one hand and in the whole country on the other hand. The analysed policy is in the form of a subsidy that increases the return to capital and is financed by a proportional tax on the final consumption expenditures. The underlying model is the constructed capital model due to Baldwin (1999). The model has been chosen as in comparison to other simple NEG models there is a higher potential for a welfare improvement in the model.

The welfare analysis relies on three criteria. First, based on the Pareto criterion it is shown that welfare cannot be improved with the help of the above mentioned policy. Second, the analysis of utilitarian welfare function shows that a larger welfare improvement is attainable if the richer region is subsidised instead of the poorer one. Third, when compensation is allowed, the Pareto criterion supports implementing the regional policy.

The rest of the paper is organised as follows. In the second section the constructed capital model is presented in the basic form. The section after that gives a short overview on the social optimality of the market outcome in the NEG models, concentrating on the welfare criteria used in the literature and applying the criteria to the constructed capital model. In the fourth section the constructed capital model is augmented with the tax-subsidy policy and the fifth section presents the welfare effects of this policy. The final section concludes.

2 The basic constructed capital model

The constructed capital model, due to Baldwin (1999), is an analytically tractable NEG model delivering similar results as the basic core-periphery model of Krugman

(1991*b*). It belongs to the so-called DCI (Dixit-Stiglitz monopolistic market for industrial goods, constant elasticity of substitution (CES) utility functions and iceberg trade costs) family of NEG models. Another model from this family and the most similar one to the constructed capital model is the footloose capital model by Martin & Rogers (1995). The most important distinguishing feature of the constructed capital model is the assumption of depreciable capital and endogenous construction of capital stock. Moreover, in this model the economic agents differ only with respect to their residence, there are no pure labour and capital owners.

The NEG models are usually applied to two symmetric regions. Here we assume that the regions are of unequal size and are called, thus, the large and the small region. In the following representation of the basic constructed capital model the notation of Baldwin et al. (2003) is used.

2.1 Basic assumptions

There are two regions, three sectors (called agricultural, intermediate and manufacturing sector) and two production factors: physical capital K and labour L . Share s_K of the capital stock and share s_L of labour is owned by the residents of the large region; the shares owned by the residents of the small region are $s_K^* = 1 - s_K$ and $s_L^* = 1 - s_L$, respectively (also in the following the starred variables refer to the features of the small region). Labour and capital are both immobile across regions. Labour can be employed in any of the sectors, but capital is used only in the manufacturing sector.

The agricultural or traditional sector produces a homogeneous output with a constant returns to scale technology, needing a_A units of labour per a unit of output. The units of the good are chosen such that one unit of labour is needed per unit of the agricultural output ($a_A = 1$). There are no trade costs incurred neither in case of intra- nor in case of interregional trade of the agricultural good. Moreover, this good is taken as the numeraire ($p_A = 1$), fixing thus also the labour wage $w_L = 1$. Due to

the costless trade the labour wage is identical in the two regions.¹

In the manufacturing sector there are altogether $n^w = n + n^*$ firms, each producing a unique variety of the manufacturing good. The firms are engaged in monopolistic competition. The production incurs fixed costs such that there arise increasing returns to scale: average costs decrease with the firm size. The fixed costs are caused by the capital input requirement: each manufacturing firm has to employ one unit of capital in order to be able to produce the variety. This implies that in each region the number of firms equals to the amount of capital available in the respective region. For the whole economy $n^w = K^w$, where K^w denotes the total capital stock in the economy.² The variable costs arise due to labour input: a_M units of labour have to be employed per a unit of a variety. The manufacturing goods can be traded costless in the region of production. In order to supply one unit of the region in the foreign region, $\tau > 1$ units of the good have to be shipped. Thus, the interregional trade costs are in the form of an iceberg that “melts down” during transportation.

The crucial assumptions distinguishing the constructed capital model from other simple NEG models consider capital depreciation and construction. Each capital unit can depreciate and, thus, turn useless at any time moment with probability δ . If a capital unit turns useless, also the manufactured variety to which the capital unit is associated vanishes. Due to the continuum of varieties, the share of capital stock disappearing in each period is equal to δ .

A new unit of physical capital can be constructed from labour in a perfectly competitive capital construction intermediate sector. A unit of capital can be produced with a_I units of labour. Thus, the intermediate sector’s technology is

$$F = w_L a_I \text{ and } Q_K = \frac{L_I}{a_I} \quad (1)$$

with F denoting the cost of a new unit of capital and Q_K the intermediate sector’s

¹This holds if no region is large enough for satisfying alone the demand for the agricultural good: agricultural production takes place in both regions.

²The w in the notation refers in the literature often to the world (assumed to consist of two countries). In our case, it refers to the whole economy (the sum of the two regions: the national economy).

output (the amount of newly constructed capital).

Capital is assumed to be immobile between the regions, such that it has to be employed in its region of construction. Thus, the share of firms located in a region coincides with the region's share of capital stock: $s_n = s_K$. If it is profitable to invest into the capital construction in a region, all residents of the respective region do it, so that everybody owns a proportionate share of the capital. Therefore, if there is some capital in the region, everybody earns some capital income in addition to the labour income.

The preferences of the consumers residing in the large region are given by

$$\begin{aligned} \max U &= \int_{t=0}^{\infty} e^{-\rho t} C_M^\mu C_A^{1-\mu} dt, \\ C_M &= \left(\int_{i=0}^{n^w} c_i^{1-1/\sigma} di \right)^{\frac{1}{1-1/\sigma}}; \\ 0 &< \mu < 1 < \sigma. \end{aligned} \quad (2)$$

Thus, the utility is drawn from consuming the agricultural good C_A and a composite of the manufacturing varieties, C_M , whereby the latter is a standard CES composite over all available varieties. The demand for a manufacturing variety i , c_i is in the large region:

$$\begin{aligned} c_j &= \frac{p_j^{-\sigma} \mu E}{n^w \Delta}, \\ n^w \Delta &\equiv \int_{i=0}^{n^w} p_i^{1-\sigma} di, \\ E &= \pi K + w_L L, \end{aligned} \quad (3)$$

where p_i is the price of the variety i in the large region, E the large region's final consumption expenditures, K the capital stock and π the capital return in the large region. Finally, L is the labour available in that region. Isomorphic equations hold for the small region with the region-specific variables being replaced by their starred counterparts.

An important characteristic of this preference structure is the 'preference for variety': consumers' utility is the higher the more varieties of the manufacturing good are available and increases, thus, with the capital stock. This is revealed by the perfect

price index P , which decreases with the number of varieties:

$$P = p_A^{1-\mu} (n^w \Delta)^{\frac{\mu}{1-\sigma}}. \quad (4)$$

2.2 Short-run results

In the short run analysis the spatial distribution of firms (s_n and s_n^*) and the national capital stock K^w are fixed.

As mentioned above, the agricultural good is chosen as the numeraire and this fixes also the labour wage in both regions to 1. Due to the assumption of Dixit-Stiglitz monopolistic competition the manufacturing firms use mill pricing and, thus, set prices at a mark-up over the marginal cost. If a variety is sold in another region than the region where it was produced, the price of the variety includes also the trade cost and is multiplied with τ . Moreover, the units of the manufactured goods are chosen such that the technology parameter $a_M = (\sigma - 1)/\sigma$. Given these assumptions, the price of a typical manufactured variety is

$$p = 1 \text{ and } p^* = \tau, \quad (5)$$

where the star refers to the price of an manufactured good produced in the other region than the region of production. The price index in the large region (4) can therefore be expressed as

$$P = (s_n K^w + s_n^* K^w \tau^{1-\sigma})^{\frac{\mu}{1-\sigma}}. \quad (6)$$

Due to the mark-up pricing there arise operating profits, which are paid as the return to capital. The pure profits are zero due to the assumption of Dixit-Stiglitz monopolistic competition. Using Eq. (5) and the demand functions (3), the operating profits are

$$\pi = bB \frac{E^w}{K^w}, \quad \pi^* = bB^* \frac{E^w}{K^w}; \quad b \equiv \frac{\mu}{\sigma} \quad (7)$$

with

$$\begin{aligned} B &\equiv \frac{s_E}{\Delta} + \phi \frac{s_E^*}{\Delta^*}, & B^* &\equiv \phi \frac{s_E}{\Delta} + \frac{s_E^*}{\Delta^*}; \\ \Delta &\equiv s_n + \phi s_n^*, & \Delta^* &\equiv \phi s_n + s_n^*. \end{aligned}$$

E^w denotes the national expenditures, K^w the national capital stock, s_E is the large region's share of expenditures, $s_E^* = 1 - s_E$ and $s_n^* = 1 - s_n$. The parameter $\phi = \tau^{1-\sigma}$ is used for simplifying the notation and interpreted as a measure of trade freeness. If $\phi = 0$, the trade costs are restrictively high for any trade to take place ($\tau \rightarrow \infty$ or $\sigma \rightarrow \infty$; the latter means that the goods are very close substitutes such that any price difference would mean consuming only the cheapest, that is the home-produced varieties). The profits are then larger in the region that has a higher share of final consumption expenditures if the two regions have each a half of the capital stock.³ In case of $\phi = 1$, trade is without any restrictions ($\tau = 1$ or $\sigma = 1$). For operating profits this implies that they are always equal in the two regions, the share of firms in each region does not matter.

National income is the sum of the labour and capital income: $Y^w = w_L L^w + bE^w$. This does not coincide with the national final consumption expenditures as a part of it, $w_L L_I^w$, has to be invested in constructing new capital. Thus, in order to derive the national final consumption expenditures, these costs have to be subtracted from the national income. Using the normalisation $w_L = 1$, national final consumption expenditure is

$$E^w = L^w + bE^w - L_I^w \Rightarrow E^w = \frac{L^w - \delta K^w a_I}{1 - b}, \quad (8)$$

where it has been used that the necessary amount of investment goods for maintaining the national capital stock is δK^w and the amount of labour necessary for producing it $L_I = \delta K^w a_I$. The total income is, needless to say, the higher the larger the economy is. In addition, a low depreciation rate of capital δ and a small input requirement a_I in the intermediate sector leave more finances for final consumption expenditures. Larger capital stock reduces the expenditures as the depreciated capital stock has to be exactly replaced by newly constructed capital, in order to keep the capital stock constant as assumed for the short run.

The large region's expenditure E can be expressed as

$$E = s_L L^w + s_n b E^w - s_n \delta K^w a_I, \quad (9)$$

³The long-run equilibrium would require the profits to be equal in the two regions and thus, under no trade each region's share of capital should equal its share of final expenditures.

where the first term is labour income, the second capital income according to Eq. (7) and the last term comprises the investments costs necessary for keeping the region's capital stock constant. Dividing Eq. (9) by Eq. (8) and simplifying the result gives for the large region's share of final expenditures

$$s_E = \frac{b\phi s_n/\Delta^* + (1-b)\frac{s_L L^w - s_n \delta K^w a_I}{L^w - \delta K^w a_I}}{1 - b s_n/\Delta + \phi b s_n/\Delta^*}. \quad (10)$$

Therefore, the relative market size is dependent on the endogenous variables s_n and K^w . Moreover, it rises with the region's share of labour and slightly with its share of capital.

2.3 Long-run results

In the long run, the capital stock in each region and the spatial distribution of capital can change. The equilibrium capital stock in each region is achieved if the cost of constructing a unit of capital equals exactly the present value of the expected flow of operating profits (in the following, it is called short the present value of capital). In the steady-state equilibrium the new capital is used only for replacing the depreciated capital. If the capital construction costs are equal to the present value of capital in both regions, capital construction would take place and manufacturing firms would locate correspondingly in both regions, so that there would arise an interior equilibrium with $0 < s_n < 1$. Alternatively the above condition is fulfilled in only one of the regions, such that in the other one the present value of capital would not cover the construction costs. In that case there would emerge a core-periphery pattern with full agglomeration in the first region.

Formally, the location condition is given by:

$$\begin{aligned} v = F, \quad v^* = F^*; \quad 0 < s_n < 1 \\ v = F, \quad v^* < F^*; \quad s_n = 1, \end{aligned} \quad (11)$$

where v is the present value of capital and F its construction cost. From Eq. (1) it is known that $F = F^* = a_I$ in an internal equilibrium as $w_L = 1$ and the regions are assumed to have identical capital construction technology.

The present value of capital is⁴

$$v = \frac{\pi}{\rho + \delta}, \quad v^* = \frac{\pi^*}{\rho + \delta}. \quad (12)$$

The variables π and π^* are here the steady-state operating profits in the large region and the small region, respectively.

From Eq. (11) and Eq. (12) follows that at any interior equilibrium $\pi = \pi^*$. Solving Eq. (7) for the share of firms in the large region delivers

$$s_n = \frac{1}{2} + \left(\frac{1 + \phi}{1 - \phi} \right) \left(s_E - \frac{1}{2} \right). \quad (13)$$

In case of equally sized regions ($s_L = s_L^* = 1/2$), also the firms are distributed equally between the regions. If one region is larger than the other, measured by the share of workers, its share of the manufacturing firms is more than proportionally larger. This effect increases with decreasing trade costs (these effects are called the home market effect and its magnification by Baldwin et al. 2003). Moreover, $s_n = 0$ if $s_E \leq \frac{\phi}{1+\phi}$ and $s_n = 1$ if $s_E \geq \frac{1}{1+\phi}$.

In order to determine the steady-state spatial distribution of expenditures, the stock of national capital has to be derived. As discussed above, at any long-run equilibrium all the capital earns identical income (either $\pi = \pi^*$ in case of an interior equilibrium⁵ or all of the capital is located in just one of the regions and earns, thus, π or π^*). Thus, the capital reward is always bE^w/K^w , the average reward across the regions. If there is capital in a region, it follows from Eq. (11) and Eq. (12) that its reward has to be

$$\pi = \pi^* = a_I(\rho + \delta). \quad (14)$$

Rearranging Eq. (7) gives $K^w = \frac{bE^w}{a_I(\rho+\delta)}$. Solving together with Eq. (8) results in

$$K^w = \frac{\beta L^w}{(1 - \beta)\rho a_I}, \quad E^w = \frac{L^w}{1 - \beta} \quad (15)$$

where $\beta \equiv \frac{b\rho}{\rho+\delta}$. The equations say that the economy is the richer (the more final consumption expenditures and the more capital) the higher are the share of manufacturing goods in the consumption basket and the time preference rate. The elasticity

⁴See Baldwin (1999) for the derivation.

⁵In that case $B = B^*$

of substitution between the manufactured varieties, capital's probability to turn useless, and the input requirement of the intermediate sector have a negative impact at the total capital stock and expenditures.

In case of a steady state interior equilibrium s_n the variable B from Eq. (7) solves to unity after substituting in Eq. (15) and Eq. (14). Therefore, $E = s_L L^w + s_n b E^w - s_n \delta K^w a_I$. Using (15), the distribution of the expenditures corresponds to

$$s_E = \frac{1}{2} + \beta \left(s_n - \frac{1}{2} \right) + (1 - \beta) \left(s_L - \frac{1}{2} \right) \quad (16)$$

or $s_E = \beta s_n + (1 - \beta) s_L$. Therefore, a region's share of expenditures is a weighted average of the region's share of manufacturing firms and labour.

Substituting the share of expenditures into Eq. (13) enables us to solve for the spatial distribution of the manufacturing firms and final expenditures in closed form:

$$s_n = \frac{1}{2} + \frac{(s_L - \frac{1}{2})(1 - \beta)}{\frac{1-\phi}{1+\phi} - \beta}, \quad (17)$$

$$s_E = \frac{1}{2} + \frac{(s_L - \frac{1}{2})(1 - \beta)}{1 - \beta \frac{1+\phi}{1-\phi}}. \quad (18)$$

These equations are, however, valid only for trade freeness below

$$\phi_f = \frac{(1 - \beta) s_L^*}{s_L + \beta s_L^*}, \quad (19)$$

where ϕ_f denotes the critical level of trade freeness above which full agglomeration in the non-starred region occurs. Above this critical level ($\phi > \phi_f$), the large region ($s_L \geq 1/2$) gets all of the manufacturing firms and its share of expenditures is $s_E = \beta + (1 - \beta) s_L$. In the small region there are then no manufacturing firms and its share of expenditures is $s_E^* = (1 - \beta) s_L^*$. For the symmetric case, $\phi_f = \frac{1-\beta}{1+\beta}$ marks the degree of trade freeness at which catastrophic agglomeration occurs in either of the regions (it is the break- and sustain point). Above this level of trade freeness, the stability of the symmetric equilibrium is broken and full agglomeration is sustainable.

3 Welfare criteria used in the NEG literature and the social optimality of the market outcome in the constructed capital model

The spatial distribution of firms achieved in the market outcome is not necessarily optimal from the viewpoint of the society. First, if the manufacturing firms are fully or partially agglomerated in one of the regions, there arises inequality. In general, there is some preference for equality in the society. Second, the market outcome might be inefficient due to externalities. Though there are usually no pure externalities in the NEG models, there arise pecuniary externalities: one person's location decisions or in the constructed capital model, the decisions to construct capital have impact on the welfare of all economic agents, whereby both positive and negative external effects arise contemporaneously. Thus, it is impossible to say a priori whether an alternative spatial distribution of firms would be preferred by the society.

In analysing welfare effects, the concepts of Pareto improvement, social welfare function and compensated Pareto improvement have been applied in the context of the NEG models. In most of the models it is not possible to order different spatial distributions of firms according to the Pareto criterion as in response to changes in the spatial distribution of firms there are always both gainers and losers (Baldwin et al. 2003). Exceptions are models where dispersion forces have been strengthened compared to the simple NEG models (Krugman 1991*b*, Martin & Rogers 1995, Forslid & Ottaviano 2003) or there are additional positive externalities in the models. Examples are firstly, the models with congestion costs (Helpman 1998, Tabuchi 1998), where market has been found to deliver under-agglomeration for a range of high trade costs. Secondly, this is also characteristic to models with localised spillovers, that is models with additional positive externalities which have spatially restricted impact (Martin & Ottaviano 1999, Fujita & Thisse 2003) and to the vertical linkages models where the manufacturing firms use the sector's composite as an input (Ottaviano & Robert-Nicoud 2006, Robert-Nicoud 2006). Also here the market can deliver

agglomeration to an insufficient extent over certain ranges of model parameters.

The constructed capital model is an example of the models where the Pareto criterion does not enable to decide whether it is desirable for the society to diverge from the spatial distribution of economic activity obtained as the market outcome. In order to analyse social optimality of the market outcome, the following simplifying assumptions have been done. Firstly, there is a benevolent social planner who relies in her decisions only on the effects to the utilities of the consumers. Secondly, in order to avoid changes in the total capital stock, it is assumed that she decides alone in which region capital is constructed, collects all capital revenues and redistributes those between the two regions according to the chosen share of capital and manufacturing firms in each region. This intervention is in the following called location permits policy.

For welfare analysis the indirect utilities of the residents of the two regions are used. Due to the assumed preference structure the indirect utility of a consumer is equal to his real income: the region's final consumptions expenditures divided by the number of its residents and the price index. Formally, the indirect utilities of the residents of the two regions (V^M and V^{M*}) in the market outcome are given as

$$\begin{aligned} V^M &= \left(\frac{\beta s_n}{(1-\beta)s_L} + 1 \right) \left(\frac{\beta L^w \Delta}{\rho(1-\beta)a_I} \right)^{\frac{\mu}{\sigma-1}}, \\ V^{M*} &= \left(\frac{\beta s_n^*}{(1-\beta)s_L^*} + 1 \right) \left(\frac{\beta L^w \Delta^*}{\rho(1-\beta)a_I} \right)^{\frac{\mu}{\sigma-1}}. \end{aligned} \quad (20)$$

It is evident that the utility of a region's resident rises with the region's share of manufacturing firms and that share decreases if the other region's share of firms increases. Therefore, in case of changes in the spatial distribution of the manufacturing firms the residents of the regions whose share of manufacturing increases gain and the residents of the region where firms disappear lose. This implies that it is not possible to achieve a Pareto improvement by "redistributing" the firms between the two regions. However, it is also not possible to say that spatial distribution of the manufacturing firms in the market outcome is better than any other distribution of the firms between the two regions.

The second way of analysing the preference order across different spatial distributions

of firms is application of social welfare functions. This has been the most popular method in the NEG literature. Relying on the utilitarian social welfare function, the market can deliver both under- and over-agglomeration, depending on the trade costs. For the simple model of Martin & Rogers (1995) with asymmetric regions Baldwin et al. (2003) show that there is too much agglomeration in the economy if the larger region owns more than a proportionate share of capital. In the model of Forslid & Ottaviano (2003) the market can deliver too much or too little agglomeration for a range of intermediate trade costs, depending on the strength of the agglomeration forces in the model. Charlot et al. (2006) show for the Krugman (1991*b*) model that the social optimum might diverge from the market outcome above all in the range of trade costs where both the symmetric and full agglomeration are stable equilibria.

Alternative specifications of the social welfare functions have rarely applied to the NEG models. In some cases (Charlot et al. 2006, Tabuchi & Thisse 2002), the Rawlsian social welfare function has been used, leading to the conclusion that there is too much agglomeration in the economy as in this welfare function only the welfare of the worst-off consumer matters.

The results of a welfare analysis based on a social welfare function depend, thus, strongly on the aversion to inequality in the chosen social welfare function. This applies also to the constricted capital model. In the following, the results rely on a numerical analysis. The assumed values of parameters are presented in Table 1.

Table 1: Values of parameters

Parameter	Numerical value
μ	0.3
σ	6
ρ	0.05
δ	0.1
a_I	1
s_L	0.6
L^w	1

For the analysis based on social welfare functions, two forms of utilitarian welfare function are assumed. In the first version only the average real income matters: each additional unit of real income has the same weight in the social welfare function, independent of the income level of the person who becomes it (social welfare $W = LV + L^*V^*$). In the second version an identical weight is given to an identical change in the income, $W = L \ln V + L^* \ln V^*$. Thus, a rich person's income has to increase more in absolute terms than the income of a poor person in order to obtain an equal increase of the social welfare. The effects of amending the spatial distribution of firms to diverge from the market outcome are illustrated in Figure 1, with the stricter version of the utilitarian welfare functions on the left and the more egalitarian welfare function on the right panel. On the figure the grey areas denote the combinations

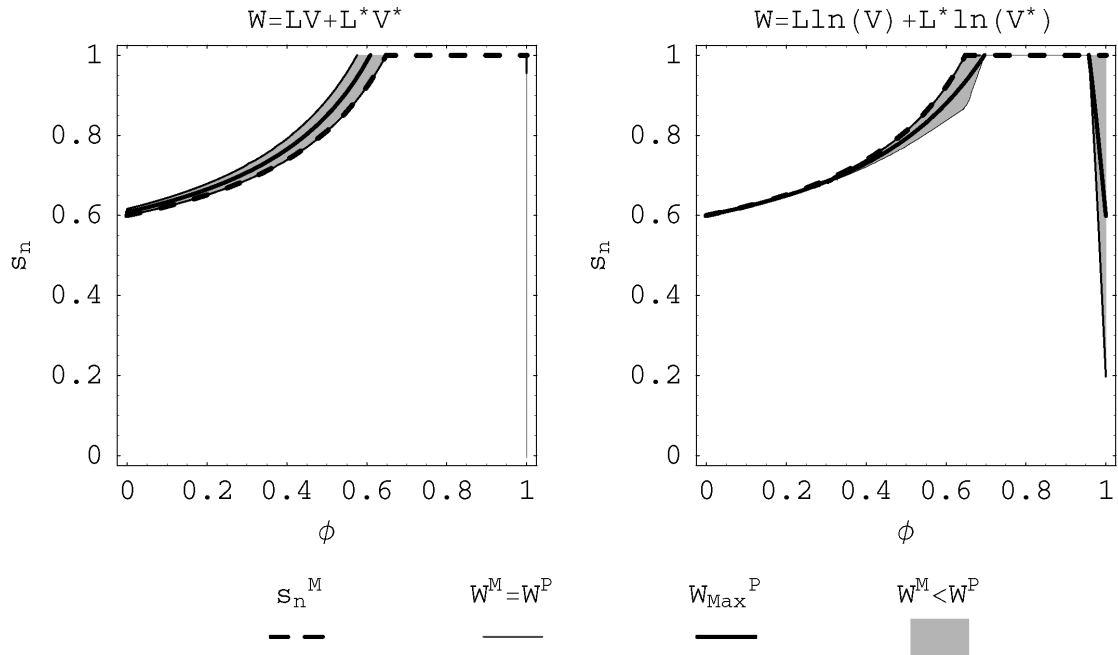


Figure 1: Utilitarian social welfare: comparison of welfare under market solution (W^M) and location permits policy (W^P).

of trade costs and share of firms in the large region, for which a welfare increase is achievable in response to diverting the spatial distribution of firms from the market outcome. The dashed curves correspond to the large region's share of firms under the market outcome and the fat solid lines to the large region's share of firms that delivers the maximum social welfare under the respective specified social welfare function. The figure shows that in case of the strict utilitarian welfare function the size effect of

the large region dominates, such that the society should prefer locating more firms to the large region than given by the market outcome. For the case of the more egalitarian welfare function, the results are turned around the society would prefer more firms to be in the small region than in case of the market outcome. In both cases there is a range of trade costs where the market delivers full agglomeration in the large region and that is also preferred by the society to alternative spatial distributions of firms. All in all, the spatial distribution of manufacturing firms achieved in the market outcome does not necessarily correspond to the socially preferred one and therefore, implementation of regional policies might be recommendable.

The third method that has been applied in the NEG models for welfare analysis considers potential Pareto improvements. Specifically, it is asked whether it is possible to achieve a situation, such that no one is worse off and at least one consumer is better off if compensating transfers from the winners to the losers are allowed. This analysis has been applied for example in Charlot et al. (2006), Martin & Ottaviano (1999), Ottaviano & Robert-Nicoud (2006), Robert-Nicoud (2006). In these analyses it is concluded that the market tends to deliver too little agglomeration.

In applying the compensated Pareto criterion, the two alternative situations have to be compared to each other taking both of them as the basic situation. Only if in exactly one of them the winners can compensate the losers compared to the other situation, a clear preference order can be derived (Scitovszky 1941). The results for the location permits policy are presented in Figure 2. It appears that the residents of the small region are never able to compensate the residents of the large region for diverting the spatial distribution of manufacturing firms from the market outcome, while the residents of the large region are able to compensate the residents of the small region for not implementing the policy. Thus, it appears that aiming an alternative spatial distribution of economic activity is not welfare increasing.

The results might change, however, if the policy would increase the capital stock and, thus, the number of varieties. In order to analyse the effects of such a policy, the basic constructed capital model is augmented with a capital subsidy financed by a consumption tax in the following section.

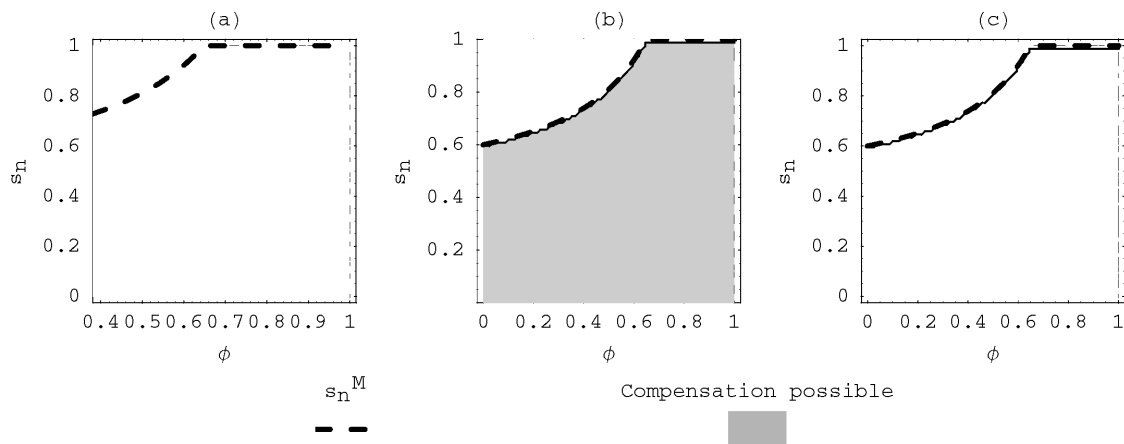


Figure 2: Compensation mechanism in case of the permits policy: (a) Are the residents of the small region able to compensate the residents of the large region when the policy is implemented? (b) Are the residents of the large region able to compensate the residents of the small region for not implementing the policy? (c) Do the two criteria overlap?

4 Constructed capital model augmented with a tax-subsidy policy

The constructed capital model is extended in this section with a possibility of influencing the spatial distribution of the manufacturing firms with a market-based tool. The subsidy is assumed to be paid proportionally to operating profits in the small region and increases, thus, the capital return. In order to finance the subsidy, a proportional tax is imposed on the final consumption expenditures. The same tax-subsidy system has been used by Dupont & Martin (2006) in the footloose capital model of Martin & Rogers (1995).

Compared to the basic constructed capital model, the equations for operating profit have to be amended: the national expenditures have to be replaced with the after-tax national expenditures. For the location condition, the profits of the non-subsidised region with the profits in the subsidised region have to be equalised, taking into account the rate of the subsidy z^* :

$$\pi = (1 + z^*)\pi^*. \quad (21)$$

Solving this equation for the spatial distribution of firms, s_n , using the operating profit equations (7), where the expenditures have been replaced with after-tax final consumption expenditures E_{AT}^w and, correspondingly, the share of final consumption expenditures with the share of after-tax final consumption expenditures (still denoted by s_E), we get

$$s_n = \frac{s_E(1 - \phi^2) - \phi(1 + z^* - \phi)}{(1 - \phi)[1 + z^* - \phi - z^*s_E(1 + \phi)]}. \quad (22)$$

This expression for the spatial distribution of firms in case of a profit subsidy and proportional taxes is the same as in the footloose capital model (Dupont & Martin 2006). The distribution of firms does not depend directly on the tax rate, it depends on the distribution of after-tax expenditures, the subsidy and trade freeness. The share of firms in the large region increases with its share of consumption expenditures and trade freeness. As can also be seen at Figure 3, a high rate of subsidy to the manufacturing firms locating in the small region implies a decrease in the large region's share of firms. In case of high trade costs the effect of the subsidy is negligible. Nevertheless, if a certain threshold has been exceeded, the subsidy motivates the firms to move to the subsidised region, such that in case of very free trade all firms agglomerate in the smaller region.

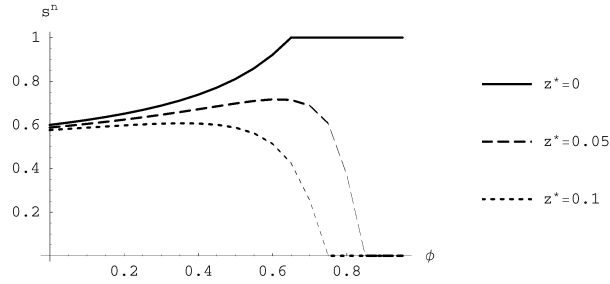


Figure 3: The ‘tomahawk’ diagram for the constructed capital model with uniform taxes on expenditures. Assumptions: $\mu = 0.3$, $\sigma = 6$, $\rho = 0.05$, $\delta = 0.1$, $s_L = 0.6$.

The equilibrium operating profits corresponding to that distribution of firms and capital are

$$\begin{aligned} \pi &= b \frac{E_{AT}^w (1 + z^*)(1 - \phi)(1 - \phi + z^*(1 - s_E - s_E\phi))}{K^w (1 + z^* - \phi)(1 - \phi - z^*\phi)} \\ &= b \frac{E_{AT}^w}{K^w} \frac{1 + z^*}{1 + s_n z^*}, \end{aligned} \quad (23)$$

which is again identical to the corresponding equation in the footloose capital model with profit subsidies and proportional income or expenditure taxation. *Ceteris paribus*, the subsidy increases the capital return in the large region in short run. This motivates to invest into constructing new capital also in the large region until the present value of capital equals again its production costs.

Imposing a uniform proportional tax rate on final expenditures (on incomes less the investment into capital construction), the national after-tax final consumption expenditures can be expressed as

$$E_{AT}^w = (1 - t)(wL^w + \pi K^w - \delta K^w a_I), \quad (24)$$

where π is now the adjusted capital return taking into account the subsidies.

The factor markets have to be kept in equilibrium after imposing the tax. Capital market is automatically in equilibrium due to the assumption that there are as many manufacturing firms and varieties as capital units. For labour market, the following constraint has to hold:

$$L^w = (1 - \mu)E_{AT}^w + \mu \left(1 - \frac{1}{\sigma}\right) E_{AT}^w + \delta K^w a_I. \quad (25)$$

The terms at the right hand side are the national labour employment in the agricultural, manufacturing and capital construction sector, respectively. Substituting in the after-tax expenditure from Eq. (24) gives after rearranging

$$L^w = (1 - b)(1 - t)(L^w + \pi K^w - \delta K^w a_I) + \delta K^w a_I. \quad (26)$$

In case of the footloose capital model the adjustment takes place through an increase in the capital return (Dupont & Martin 2006). Here, as known from the basic model, in the long run $\pi = a_I(\rho + \delta)$, which has to hold also if taxes and subsidies are introduced to the economy. In the above equation, there is only one variable that can change in response to the taxes, the national capital stock. It has to increase in order to keep the labour market in equilibrium. The response of the capital stock to the taxes can be shown to be

$$\frac{\partial K^w}{\partial t} \Big|_{dL^w=0} = \frac{(1 - b)(L^w + (\pi - a_I\delta)K^w)}{(1 - b)(1 - t)(\pi - a_I\delta) + a_I\delta} > 0, \quad (27)$$

as $0 \leq t < 1$, $0 < b < 1$ and $\pi > \delta a_I$.

Solving the labour market equilibrium condition (Eq. 25) for the after-tax expenditures gives

$$E_{AT}^w = \frac{L^w - a_I \delta K^w}{1 - b}. \quad (28)$$

This equation is identical to that of the national final consumption expenditures in the basic model. However, as the policy results in an increased capital stock K^w , the after-tax consumption expenditures have to be smaller than the consumption expenditures in case of no policy.

The tax rate for financing the subsidy is solved from the government budget constraint

$$\frac{t}{(1-t)} E_{AT}^w = z^* \pi^* (1 - s_n) K^w \quad (29)$$

with $\pi^* = \frac{\pi}{1+z^*}$.

Substituting into the above equation profits from Eq. (23) and solving for the equilibrium tax rate yields

$$t = \frac{b s_n^* z^*}{1 + s_n z^* + b s_n^* z^*}. \quad (30)$$

The equilibrium tax rate increases with the rate of the subsidy. The share of manufacturing goods in the consumption expenditures and the share of manufacturing firms locating in the small region have as well a positive impact on the tax rate.

In order to find the distribution of after-tax expenditures, the size of the equilibrium capital stock has to be determined. For this purpose the capital return from Eq. (14) is equalised to the capital return corresponding to the equilibrium spatial distribution of manufacturing firms (Eq. 23) and the resulting equation is solved for K^w :

$$K^w = \frac{\beta L^w}{(\Omega - \beta) \rho a_I}, \quad (31)$$

where $\Omega = (1 + s_n z^* + b s_n^* z^*) / (1 + z^*)$.

Substituting this expression into the national after-tax expenditures equation (28) and rearranging the result gives

$$E_{AT}^w = \frac{1 + s_n z^*}{1 + z^*} \frac{L^w}{\Omega - \beta}. \quad (32)$$

Comparing these results to those of the basic model (Eq. 15), it is possible to show that $E_{AT}^w < E^w$ and the capital stock is larger than in case of no policy as $b > \beta$ and $b < 1$. Therefore, as argued above, the subsidy augments the capital stock. This is beneficial for the consumers due to their preference for variety. However, they have less income for consumption expenditures, due to taxes and higher share of income that has to be invested into constructing new capital. Thus, the total effect to their utility cannot be determined intuitively.

In order to solve for the large region's share of after-tax expenditures s_E , the region's after-tax expenditures have to be determined. Substituting Eq. (31), (14) and (30) into the large region's after-tax expenditures $E_{AT} = (1 - t)(ws_L L^w + \pi s_n K^w - a_I \delta s_n K^w)$, dividing the result with the national after-tax expenditures from Eq. (28) and rearranging gives for the large region's share of after-tax consumption expenditures

$$s_E = (1 + z^*)(\Omega - \beta)s_L + \frac{\beta}{\Omega}s_n. \quad (33)$$

the large region's share of expenditures rises with its share of labour and capital. If the region's share of labour exceeds its share of capital ($s_L > s_n$), its share of after-tax expenditures rises also with the rate of depreciation and the elasticity of substitution, and decreases if the discount rate, the subsidy to the firms locating in the other region or the share of capital goods in expenditures increases.

Figure 4 is the scissors diagram for the case of taxing final expenditures in the constructed capital model. The curves have been plotted for three levels of trade freeness (ϕ): prohibitive trade costs, intermediate trade costs and very low trade costs. As the distribution of expenditures does not depend on the level of trade costs, the EE curve corresponding to Eq. (33) stays always at the same place. Therefore, the economy responds to the decrease in trade costs by relocating economic activity (the NN curve, corresponding to Eq. 22). It can be seen that for prohibitive trade costs ($\phi = 0$) the spatial distribution of expenditures and manufacturing firms corresponds exactly to the distribution of labour. In case of intermediate trade costs ($\phi = 0.5$)

the assumed size of the subsidy is not sufficient to motivate capital construction in the smaller region and manufacturing is agglomerated in the large region. In case of high trade freeness ($\phi = 0.9$), in equilibrium the whole capital stock and thus, all manufacturing firms would locate in the smaller region: with decreasing trade costs the effect of the subsidy increases.

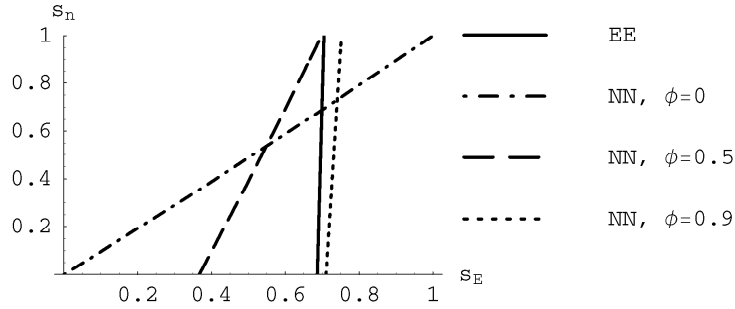


Figure 4: The scissors diagram for the constructed capital model with uniform taxes on expenditures. Assumptions: $a_I = 1$, $\mu = 0.3$, $\sigma = 6$, $\rho = 0.05$, $\delta = 0.1$, $s_L = 0.7$, $z^* = 0.05$.

Therefore, for each level of trade costs an appropriate rate of subsidy should be chosen if the government wants to achieve a specific spatial distribution of manufacturing firms. The subsidy can have a noticeable direct effect on the spatial distribution of manufacturing firms, but it has only a minor effect on the distribution of expenditures.

5 Welfare effects of the tax-subsidy policy

Dupont & Martin (2006) have shown for the footloose capital model that capital subsidies to firms locating in the smaller region and financed by proportional taxes on expenditures or incomes benefit mainly capital owners, whereby the workers bear the bulk of the tax burden. Therefore, the aim of reducing inequality might not be achieved, but rather worsened. It is possible to counteract this problem for example by taxing only the capital owners. However, the utility of the workers residing in the non-subsidised region would still decline due to the relocation of industry and the accompanying increase of the price index.

In the constructed capital model there is no distinction between capital and labour owners. It is assumed instead that all consumers derive income from both of the production factors. Thus, it is not possible to study welfare effects of the policy by factor groups. Moreover, even if a region loses manufacturing firms as a result of the policy, the effects to the welfare of its residents are not necessarily as negative as in the footloose capital model due to the capital augmenting effect of the policy. This becomes evident in the indirect utility functions without replacing in the expressions for capital stock and final consumption expenditures:

$$\begin{aligned} V &= \frac{E_{AT}}{L} P^{-1} = \frac{E_{AT}}{L} K^{w \frac{\mu}{\sigma-1}} (s_n + \phi s_n^*)^{\frac{\mu}{\sigma-1}}, \\ V^* &= \frac{E_{AT}^*}{L^*} P^{*-1} = \frac{E_{AT}^*}{L^*} K^{w \frac{\mu}{\sigma-1}} (\phi s_n + s_n^*)^{\frac{\mu}{\sigma-1}}, \end{aligned} \quad (34)$$

where the constant $\mu^\mu(1-\mu)^{1-\mu}$ has been omitted and P (P^*) is the price index.

Thus, a capital subsidy that induces the national capital stock to grow would be beneficial for the residents of both regions due to the preference for variety as a larger capital stock means more varieties. On the other hand, there are first potentially changes in the spatial distribution of expenditures. This comes from the changed spatial distribution of capital ownership. Because of capital immobility also the spatial distribution of the manufacturing firms changes. This, in turn, brings along changes in the price indices: the living cost rises in the non-subsidized region and decreases in the subsidized region. The residents of the subsidized region benefit and the residents of the other region lose due to this effect. Moreover, if everybody has to finance the subsidy, also the disposable incomes are smaller than under no policy. Thus, it is in this moment still unclear whether there would be gainers and losers due to the policy.

Substituting in Eq. (34) the expressions for capital stock and after tax expenditures (Eqs. 31 and 32, respectively) gives as the indirect utility of a resident of the large region

$$V^{UT} = \frac{1}{\Omega} \frac{(1 + s_n z^*)}{(1 + z^*)} \left(\frac{\beta s_n}{(\Omega - \beta) s_L} + 1 \right) \left(\frac{\beta L^w \Delta}{\rho (\Omega - \beta) a_I} \right)^{\frac{\mu}{\sigma-1}}, \quad (35)$$

and of a resident of the small region

$$V^{*UT} = \frac{1}{\Omega} \frac{(1 + s_n z^*)}{(1 + z^*)} \left(\frac{\beta s_n^*}{(\Omega - \beta) s_L^*} + 1 \right) \left(\frac{\beta L^w \Delta^*}{\rho (\Omega - \beta) a_I} \right)^{\frac{\mu}{\sigma-1}}. \quad (36)$$

$\Omega = (1 + s_n z^* + b s_n^* z^*) / (1 + z^*)$ and the superscript UT denotes the policy of uniform taxation.

The achievable utility under the tax-subsidy policy depends on the spatial distribution of firms and the size of the subsidy, which is in turn a function of s_n . The subsidy is assumed to be chosen such that it corresponds to the aimed spatial distribution of firms: s_n is the choice variable for the benevolent social planner. Thus, the subsidy z^* is solved from Eq. (22) and (33) as a function of the aimed spatial distribution of firms. The resulting expression is too complicated to present here, but its behaviour with respect to the spatial distribution of firms and trade costs is shown at Figure 5.

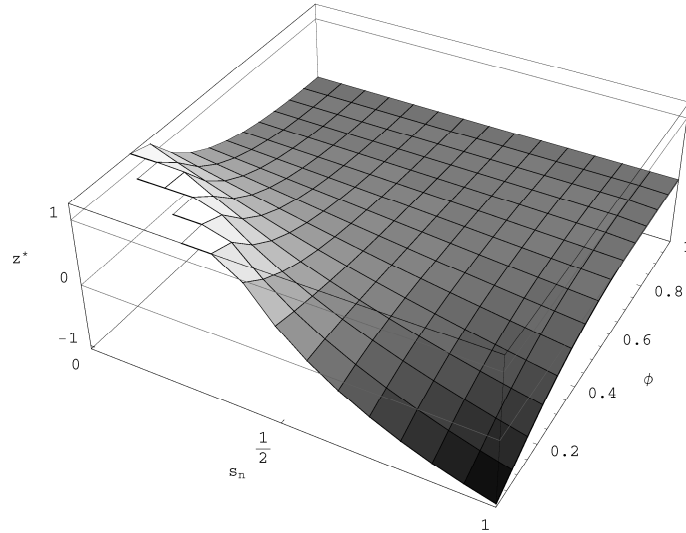


Figure 5: The size of capital subsidy in case of uniform taxation of final expenditures.

The rate of capital subsidy that has to be implemented for achieving a given spatial distribution of manufacturing firms is monotonically decreasing with trade freeness and increasing in the share of manufacturing firms in the subsidized region. In interpreting the figure, it has to be kept in mind that in the range $s_n > s_n^M$ the social planner aims a higher concentration of economic activity in the large region than obtained in the market equilibrium. Therefore, in that range a negative subsidy (a tax) to firms locating in the small region has to be applied or a positive subsidy has to be paid to the firms of the larger region.

Using z^* in Eq. (35) and (36) and comparing the result to the utilities achievable in the market equilibrium reveals that a tax-subsidy policy increasing s_n (s_n^*) is favourable to the residents of the larger region (the smaller region), while at the same time reducing the utility of the residents of the other region. Thus, also in case of the tax-subsidy policy the Pareto criterion does not help to decide whether the policy is welfare increasing.

Using the utilitarian welfare functions as defined in Section 3, it appears that the range of welfare improving spatial distributions of manufacturing firms is larger than in the case of permits policy (compare Figure 6 to Figure 1). Moreover, the maximum welfare achievable under the policy of uniform taxation of final consumption expenditures and operating profit subsidies to the firms locating in the smaller region is higher than the maximum welfare achievable under the permits policy for low and intermediate levels of trade freeness (see Figure 7).⁶ This comes from the positive effect of the subsidies on the variety of manufactured goods supplied. There is only a small range of trade costs where the permissions' policy enables to achieve a slightly higher welfare than the tax-subsidy policy if the extreme form of utilitarianism is assumed. However, if the large region is subsidised instead of the small one, the

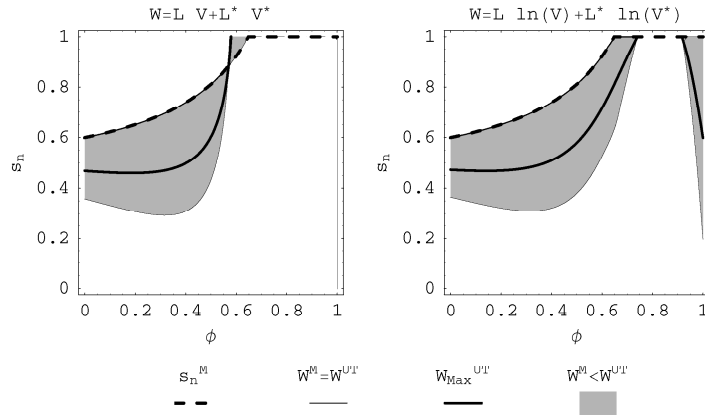


Figure 6: Utilitarian welfare function: comparison of welfare under market solution (W^M) and uniform taxation of final expenditures (W^{UT}).

⁶For calculating the maximum achievable welfare under each policy, we found the distribution of firms equalizing the first derivative of the welfare function to zero for 31 levels of trade costs, ranging at equal steps from 0.00001 to 1, using the constraint $0 \leq s_n \leq 1$. Those values were then used for calculating the welfare.

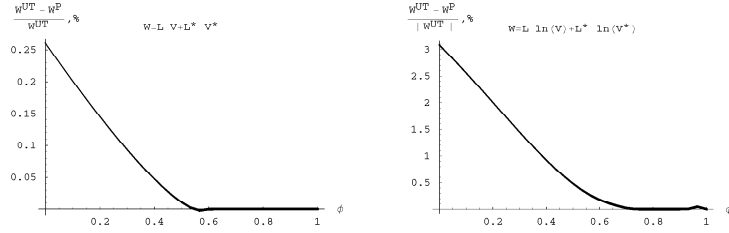


Figure 7: Comparison of maximum achievable welfare under uniform taxation of final expenditures (W^{UT}) and permits policy (W^P): percentage difference with respect to the welfare achievable under the uniform taxation policy.

achievable social welfare is even higher than when subsidising the small region as demonstrated in Figure 8.

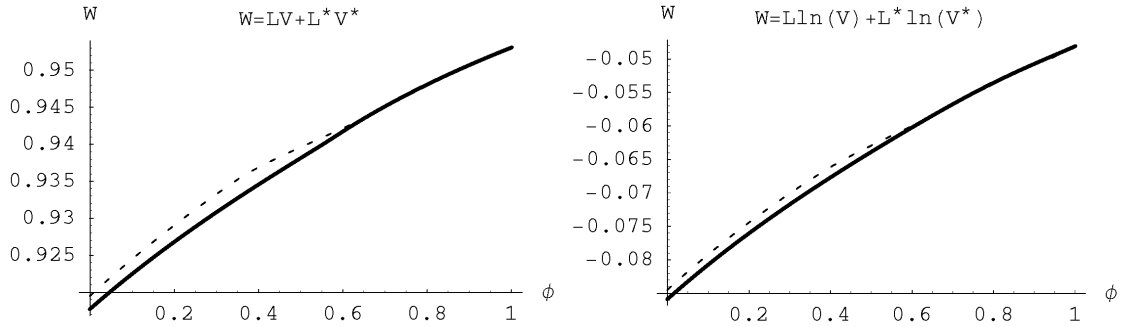


Figure 8: Maximum achievable social welfare: subsidising the small (solid line) vs. the large region (dotted line).

This can be explained with the higher weight of the large region in the social welfare function due to its size and moderate aversion to inequality. Moreover, if operating profits are subsidised in the large region, the capital stock extending effect is larger than in case of subsidising operating profits of manufacturing firms that locate in the small region. However, if a social welfare function with high aversion to inequality like the Rawlsian welfare function would be applied, the society would prefer to subsidise the small region as long as the utility of the residents of the large region does not fall under that of the residents of the small region.

Turning to the compensated Pareto criterion as the basis of welfare decisions, it is clear that due to the increased capital stock the potential of the residents of the small region to compensate the losers of the policy of subsidising the small region is higher

than under the location permits. Similarly, for the residents of the large region it is more difficult to compensate the winners of the policy for not implementing the policy. This is illustrated at Figure 9.

As can be observed from panels (a) and (b), there are areas where financial compensation is possible. Moreover, the panel (c) reveals an overlap-area where the residents of the smaller region would be able to compensate the residents of the larger region if the policy is implemented, but the residents of the larger region are not able to compensate for not implementing the policy. This would mean that the policy would be welfare improving in case of sufficiently high trade costs. However, also the material balance conditions should be studied. Differently from Charlot et al. (2006) who based their analysis on Krugman's (1991*b*) model and compared the preference order of full agglomeration and symmetric distribution in case of symmetric regions, here any monetary transfer between the regions distorts the spatial distribution of expenditures, which has in turn an effect on the spatial distribution of economic activity. Therefore, the distribution of firms under the tax-subsidy policy is not the same before and after the compensation. This means in turn that after the compensation the utility levels of the residents of both regions are not necessarily at least equal to those under the market equilibrium.

Turning the argument around and studying, whether the market outcome can be said to be preferred to the one achieved through implementing the policy, it appears, that this is indeed so in case of sufficiently low trade costs. As can be observed from panel (b) in Figure 9, for high trade freeness the residents of the larger region are able to compensate the residents of the smaller region for not implementing the policy. They are able to do it without distorting the spatial distribution of firms if the social planner is not aiming for a distribution where most of the firms locate in the small region. This is due to the observation that in this range of trade costs small changes in the distribution of after-tax expenditures do not have a strong impact on the distribution of the manufacturing firms. It is known from panel (a) of the figure that at this area the residents of the smaller region would not be able to compensate the residents of the larger region, if the tax-subsidy policy is implemented. Therefore, it can be concluded as in Charlot et al. (2006): in case of sufficiently low trade

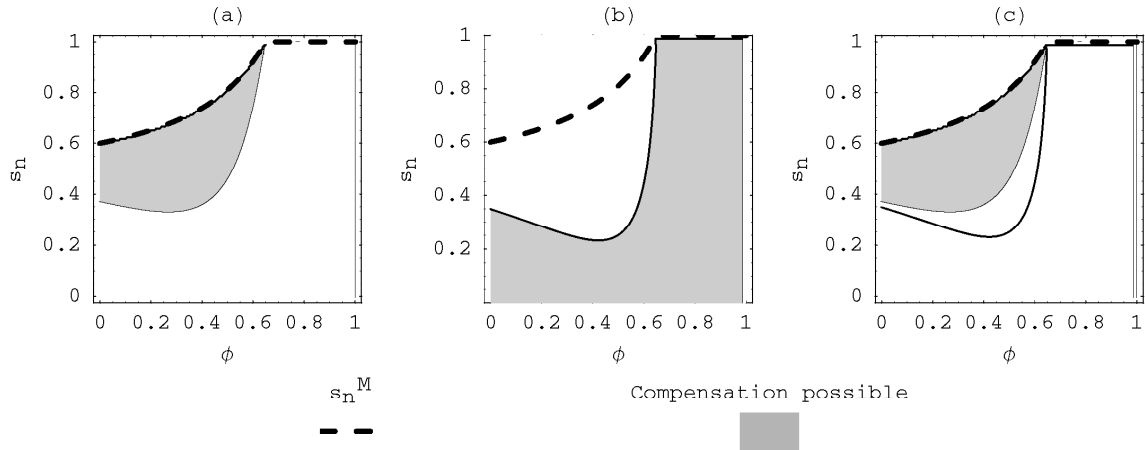


Figure 9: Compensation mechanism in case of the uniform taxation and profit subsidy: (a) Are the residents of smaller region able to compensate the residents of the larger region when the policy is implemented? (b) Are the residents of the larger region unable to compensate the residents of the smaller region for not implementing the policy? (c) Do the two criteria overlap?

costs, agglomeration is preferred to any less unequal spatial distribution of economic activity.

In order to check the desirability of the policy from the viewpoint of the society, the problem has also been solved by backward induction. In this case it is assumed that the benevolent planner set her aimed spatial distribution of manufacturing firms taking into account the effects of compensation. In other words, the aimed share of manufacturing firms in each region should realise after compensation. The subsidies and taxes are then set in such a way that the small region gets more firms than aimed after compensation. The results of this analysis are given in Figure 10, which shows that if the benevolent social planner takes in her decision into account the effects of compensation, it is possible to achieve a Pareto improvement with the help of the tax-subsidy policy.

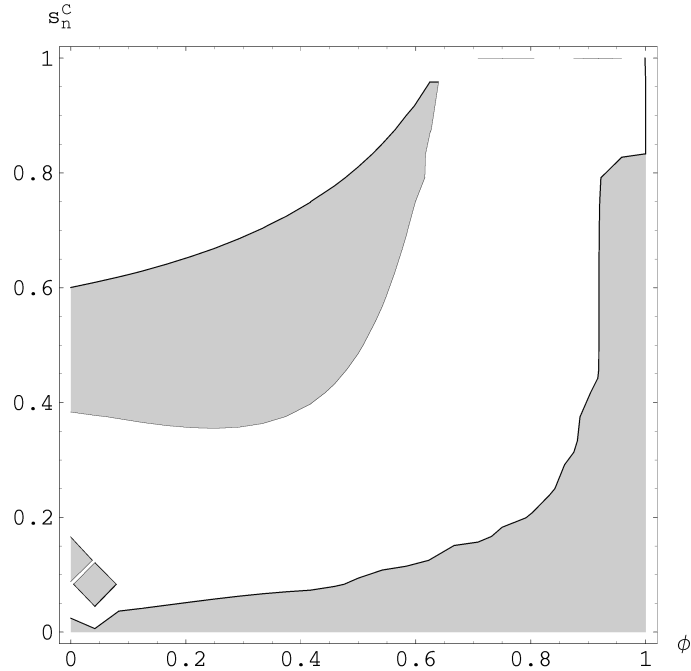


Figure 10: Utility of the small region's residents after compensation compared to market solution when a spatial distribution of firms after compensation is aimed. The upper grey area denotes a higher utility level than under the market outcome.

6 Conclusions

The paper aimed to show how the models of NEG models foster understanding of welfare effects of regional policies both at the regional and national level of an economy. It was first discussed based on the NEG literature that the spatial distribution of manufacturing firms achieved as the market outcome might not correspond to the socially preferred one. This is valid also for the constructed capital model that was analysed in this paper. However, the results depend on the underlying welfare criterion.

It is well known from the NEG literature that usually it is impossible to achieve a Pareto improvement by simply redistributing the existing firms between the regions: the residents of the region whose share of firms is reduced suffer a utility loss, while the residents of the region with increasing share of firms gain. Moreover, the gain of the gainers is not sufficient to compensate the loss of the losers. Even though according to social welfare functions a welfare improvement is possible, the direction

of redistribution of the firms—more firms to the large or to the small region—depends on the society’s aversion to inequality. Only in case of sufficient aversion to inequality it is recommendable to implement a policy that increases the small region’s share of manufacturing firms.

If the policy does not have a purely redistributive character, but motivates to increase the capital stock, aiming more agglomeration than in the market outcome obtains even more support. Subsidising the large region has larger positive welfare effects than subsidising the small region due to a larger positive effect on the variety of the consumption goods. Also, the positive welfare effect of more concentrated production arises naturally due to the larger weight of the larger region in the social welfare function. If the implemented policy enhances expansion of the capital stock also by fostering dispersion it is possible to achieve a welfare increase compared to the market outcome.

As in case of a redistribution by command, also here no pure Pareto improvements are possible. However, if compensating transfers between the regions are allowed and taken into account in implementing the policy, it is possible to achieve a situation where no one loses, but the residents of one region are better off than under the market outcome.

The NEG models are clearly too abstract and stylised for drawing strong policy conclusions like supporting flourishing regions instead of backward ones. However, considering that in the real world there arise inefficiencies in implementing policies—due to imperfect information, other motivating factors than the utility of consumers—, caution is needed when regional policies are implemented. Also, in the light of imperfect information it is difficult to determine the necessary extent of intervention, as small changes in policies can have large effects in case of changes in the economic environment.

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