Innovation, Herd Behavior and Regional Development[1]

G.C. Geerdink

&

P.J. Stauvermann

1 Introduction

"Innovation is the key to a region's competitiveness in a globalized economy. It attracts further investment and opens the door to sustainable growth and quality employment. We need to create the right conditions for enterprises to innovate", noted Danuta Hübner[2]. She added that EUR 700 million will be invested through structural funds in the best project ideas which can help to foster innovations in the area. Those projects will be selected by the government, local authorities and the social and economic partners.

In our paper we want to investigate the question whether it will make sense for regions to compete for new high-tech industries to settle down in their region. The justification for giving subsidies is based on the general believe in politics that attracting high-technology firms will cause positive externalities in the sense of Arrow (1962) and of course will directly create working places and an additional tax revenue in the long run. Additionally, it is a general believe in politics that competition between regions will enhance the efficiency of local authorities and local administration. At the moment such new high technologies are bio-technology firms, ICT firms, nanotechnology firms etc.

In principle, many policy-makers believe, that it is possible to create high-technology clusters like Silicon Valley. Local policy-makers are eager to attract these high-technology firms, and they are willing to facilitate these kinds of firms in many

[1] We like to thank Gert-Jan Hospers for contributing in the discussion in an earlier stage of this paper, see Geerdink, Hospers & Stauvermann (2006).

[2] Speech 13 September 2006, Regional Policy Commissioner Danuta Hübner Lower Saxony, Germany

ways. At the end the question remains whether this policy is welfare increasing or maybe welfare decreasing.

To analyze this question we have developed a new model, which is based on well-known theories. To incorporate positive externalities created by new firms we use the Dixit-Stiglitz approach of Romer (1990). The fundamental idea of this model is that an increasing diversity of intermediate goods will increase the productivity of all existing intermediate good producing firms.

To model the behavior of policy-makers we make use of the so-called “information cascades” model, which is based on Bannerjee (1992), Welch (1992) and Bikhchandani, Hirshleifer & Welch (1992). This approach explains why, under uncertainty, it is rational to copy the behavior of other agents.

We make use of economic conflict theory to model the competition between different regions. This approach goes back to Hirshleifer (1989) and Skaperdas (1996)[3], who model in principle a competition which is based on efforts of the competitors. We will show why such a competition between regions emerges and probably will fail in the sense that it does not contribute to increase in welfare, but only creates economic distortions. Our thesis is based on three arguments, first the competition between regions creates a windfall gain for the owner of the firms without any reasoning, secondly policy-makers are not able to oversee if positive externalities will be created or not, and at third the firm is able to exploit the regions with a moral-hazard behavior.

In the second section we focus on the behavior of representative policy-makers, who want to attract a high-technology firm. In the following section we analyze the impact of the settling of innovative firms and their additional contribution to the local economy. Finally we focus on the moral hazard problem with respect to investment behavior of the attracted innovative firm and if this could be avoided.

2 Herd Behavior of Policy-Makers, Innovations and Welfare Gains

The decision of a firm to settle down in a specific region is determined by the expected profitability. However, for the policy-maker the overall impact of attracting investments from outside on welfare gains is of major importance. Policy-makers have

[3] For an overview and details see Stauvermann (2007), Garfinkel & Skaperdas (2006) and Konrad (2007)

to form an idea what the contributions of an innovative firm will mean for their region. That means that policy-makers should take into account all indirect and direct effects for their region of attracting an additional firm. Mostly it is expected that settling of innovative firms is accompanied by positive externalities which will increase the overall economic performance of a region.

On the other hand, policy-makers are self-interested and they want to be re-elected. To increase the probability to be re-elected they try to enhance their reputation as good and successful policy-makers. One way of doing this is to attract additional firms to settle down in their region, because a settlement means additional working places, higher tax revenue and maybe an increasing productivity of all existing firms. In so far attracting a new firm will enhance the overall welfare of the region. Due to positive externalities associated with innovations, other firms operating in the region will encounter a decrease in average costs, because of something what Arrow called "learning by doing". The idea is based on an example from the airplane industry in Atlanta/ USA, where Arrow (1962) found out that such a cluster building of firms will enhance the productivity of all firms. With that believe in the background, most regions in Europe and the USA are offering subsidies to attract such kind of firms. The problem however is that no policy-maker knows ex-ante which technology will be successful or not.

It should be noted that policy-makers are risk-averse regarding their own position, but they are at best risk-neutral regarding spending tax money, because if it is wasted policy-makers are not personal liable. One could say that the policy maker is bailed out by the tax payer if the chosen policy does not generate the expected results. Of course, policy-makers dislike failing, and one strategy to reduce the risk of failing or to make it less obvious that the policy has failed, is to copy the behavior of other regional policy-makers. In some sense policy-makers behave like a member of a herd. This "herd" behavior however seems to be rational, because if the whole herd fails then it is less spectacular as if only one policy-maker, who did not follow the herd, would fail. The reason is that it is much worse for a policy-maker if only he fails instead that all policy-makers fail. In so far each policy-maker has an incentive to copy other policy-makers.

The problem is, if all policy makers are applying this strategy regarding giving subsidies, the outcome is a regional competition and whether this will lead to an improvement in the overall welfare is a quite difficult question. Regarding to their own re-election the relative performance resulting from their policy is important. Consequently, policy-makers have an incentive for "herding". In principle this kind of behavior is well-known in financial economics (see e.g. Bannerjee (1992), Bikhchandani, Hirshleifer & Welch (1998), Bikhchandani & Sharma (2001), Anderson & Holt (1996)). Or in the words of Mackay (1841) words, *"Men, is has been well said, think in herds; it will be seen that they go mad in herds, while they only recover their senses slowly, and one by one.*"

To explain "herd" behavior and the decision process we start with an example adopted from Bannerjee (1992). A man and his wife are searching for a good restaurant in an unknown city. They are walking in a street with two restaurants, of which they do not know the quality. On beforehand they assume that the restaurants are of equal quality. During the time that they are discussing where to go they notice that customers are entering one restaurant. Observing this they will adjust their belief about the quality of the two restaurants. After observing customers going to one of the restaurants, they will assume that the quality of that particular restaurant is superior. Let us now assume that the man has to decide where to go. If the man would choose a restaurant, which is not full with customers and the meal would taste bad, the wife would argue, that he could have known that the quality of the restaurant was low, because nobody else is visiting it. However, if the husband would choose for an overcrowded restaurant and the meals would taste bad, the woman would argue that the meals do taste not so good, but it is probably the best restaurant in town. In the first case the man runs into trouble with his wife, and in the second the wife assumes that her husband can not be hold responsible for the bad food. Under these assumptions the man would always to choose the overcrowded restaurant. It seems to be most rational to follow previous decision makers to choose for the same options. This kind of behavior seems to be on "average" the most successful strategy.

However, this strategy has one disadvantage, because if all decision makers trying to attract a firm by offering subsidies, the expected pay-offs will decrease. If everybody is betting on the same horse the pay-off gets rather low. The logic behind that is that the number of firms which could be attracted is rather small and in so far the competition between regions is like an auction. So the fundamental problem is that the additional information gathered by policy-makers may lead to information cascades which lead to "herd" behavior that means the copying of the policy of the successful regions.

Let us go into the details. To do that we assume that policy makers can decide to offer a subsidy and attract an innovative firm on the one hand or on the other hand invest for example in public utilities. The expected pay-offs of both investments are equal, with respect to attracting innovative firms. It is however not clear whether it generates the expected positive externalities. If it generates positive externalities the expected pay-off is positive and in the other case if no externalities arise the expected pay-off is negative. Let us assign a probability $p = P(Y) > 0$ that positive externalities are generated where Y is the occurrence of positive externalities due to the innovative firm. In a similar way we denote the probability that no externalities (N) will occur by $(1-p) = P(N) > 0$ Notice that the probabilities are mutually exclusive. To gain additional information policy makers are looking how other regions are performing. Are they observing positive externalities in case an innovative firm has settled, or are there no positive externalities? The presence of externalities cannot directly be observed. The only thing that can be seen is whether the region has subsidized innovative firms or invested in public utilities. From this observation it is inferred whether innovation is accompanied with positive externalities or not. Let us call the information they receive signal s. This public information, signal s, can have two states, namely good signal reporting positive externalities $(s = G)$ and bad signal when no externalities appear $(s = B)$. In the first case the region subsidized an innovative firm and in the second case invested in public utilities. The signals are of course conditional on the appearance or non appearance of externalities. The probability of receiving a positive signal given positive externalities equals $P(G \mid Y) = q > \frac{1}{2}$. Complementary to that, the probability receiving a good signal given no externalities equals $P(G \mid N) = 1 - q < \frac{1}{2}$. In the same way the conditional probability of a bad signal can be calculated. They are respectively $P(B \mid N) = q > \frac{1}{2}$.and of course $P(B \mid Y) = 1 - q < \frac{1}{2}$. We can summarize the above conditional probabilities and the associate appearance of externalities in the matrix below

State of externality

Y N

Signal	*G*	*q*	*(1-q)*
Signal	*B*	*(1-q)*	*q*

Suppose a region has to decide about subsidizing innovative firms. Additional to its private information the region gathers additional information. It takes as an example a region which also has faced the same decision making process. It is likely however that this region has applied the same strategy. This can of course be repeated where only the first decision maker can not make use of public information resulting from previous decision makers. The problem that arises when this strategy is applied, is that decision maker can end up in an information cascade.

Let us see how this works along the introduced example The first (initial) decision maker decides on her own private signal. Depending on that they decide to invest in innovation or public utilities. Suppose the decision is in favor of innovation how will other decision makers react on this decision? The second decision maker has her private information. Depending on the pay-offs of the two alternatives the decision will be in favor of innovation or not. In case where the pay-offs are equal the decision maker is indifferent and additional information has to be gathered.

What are the consequences of this additional public information? After a signal is received the decision maker will adjust their beliefs and as a result the expected pay-offs will change. Of course the decision maker will choose in favor of innovation in case the signal is good (s=G) and in case the received signal is bad (s=B) the decision will be in favor of public utilities.

To see this we can use Bayes rule to calculate the conditional probability of positive externalities (state=Y) give a good signal (s=G). After that it is easy to see how public information influences the decision process. According to Bayes rule we get;

$$P(Y|G) = \frac{P(Y) * P(G|Y)}{P(G)} = \frac{pq}{pq + (1-p)(1-q)} > p \qquad (1)$$

This result can also be verified from the previous table. Because $P(Y|G) > p$ the expected pay-off from innovation exceeds that of public investment.

This has two important consequences; firstly, after the information cascade occurs decision makers just imitate the behavior of others. The other important consequence is that because if all are investing in attracting innovative firms, competition between regions is increasing. This definitely leads to non desirable inefficient solution.

Keeping this kind of behavior in mind it is clear that there is a lot of competition between regions to attract innovative firms in order to make the own region as successful as Silicon Valley. On the other hand firms are aware of these facts and will try to benefit. From the view of a policy-maker who has to decide now, it looks like, that he should adopt the subsidy policy of all other regions. So we can conclude, given our assumptions are correct that a representative policy-maker is willing to subsidize the settling of an apparent high-technology industry. The problem is that all regions compete to attract these kinds of firms. If we look for e.g. at the development of East-Germany[4] in the period 1990-2005, it is easy to see that the results there coincide with our theory. Nowadays, East-Germany has many airports, which mostly realize losses, full of developed industrial estates, which were financed by subsidies, but without firms and other facilities. In this paper we assume for simplicity that only 2 regions compete. Below we will work out the mentioned consequences of this kind of policy strategy more in detail. First we pay attention to the possible contribution of innovative firms to the overall economic performance of the region (positive externality of innovative firms). Next the resulting competitive behavior will be described.

3 Firms, Innovations and Welfare Gains

In this section we will pay attention on the role of the innovative firm and its contribution the overall regional economic activity. An important aspect of innovation is the appearance of externalities. These externalities can lead to an overall decrease in the average costs of other firms. This increases the productivity of the region which is in the interest of regional policy makers. Our approach to model externalities induced by innovations we follow and make use of Romer (1986, 1989 & 1990). First we will pay some attention to the main features of the model. There are three basic premises underlying of the Romer model. The first one is that technological change lies at the core of economic growth. The second is that technological change is based on knowledge creation. However knowledge differs from other economic goods. It has the property that it is a non-rivaling good and can be accumulated without bounds per capita.[5] Treating knowledge as a non-rivaling good makes it possible to incorporate externalities. The third premise is that technological change arises of intentional actions taken by firms responding on market incentives.

Innovations and externalities

To model the behavior of innovative firms we make use of a standard Dixit-Stiglitz model of monopolistic competition in line with Romer (1990). The purpose is to find out the gains of an additional firm settling down in the region. It is assumed that the economy consists of two sectors. First there is a final goods sector, which is producing under perfect competition. Because of that, the aggregate production function of the final goods sector can be represented by;

$$Y = L^{a} \sum_{j=1}^{m} k_j^{1-a} \ , \tag{2}$$

Aggregate labor input of the final goods sector is represented by L. Next to that this sector uses the quantity of k_j units of intermediate inputs, which could be interpreted as capital goods, which are depreciated within one period by 100%. These m intermediary inputs are produced by m intermediate good producing firms. The production function is additively separable in the different types of intermediate capital goods. We normalize without loss of generality the price of the final product to one. Then the following profit maximization problem for the final goods sector with respect to labor and intermediate goods results:

$$\max_{L,k_j} L^{\alpha} \sum_{j=1}^{m} k_j^{1-\alpha} - wL - \sum_{j=1}^{m} p_j k_j \tag{3}$$

Maximizing with respect to the labor input we can derive the following overall wage rate from the first order condition:

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[4] East-Germany is a good example, because the local policy-makers have to decide more or less in a relative short time period and the initial economic position of many regions was relatively similar.

[5] The same idea was developed by Arrow (1962) and Lucas (1988).

$$w = aL^{a-1}\sum_{j=1}^{m} k_j^{1-a} \tag{4}$$

In the final goods sector there is perfect competition what means; profits reduces to zero and therefore the wage rate for each firm is the same and is equal to the marginal product of labor. The other FOC's with respect to all *m* intermediate goods, leads to the equation below;

$$p_j = L^a(1-a)k_j^{-a}, \qquad \forall j \in \{1,\ldots,m\} \tag{5}$$

Equation (5) represents the inverse demand curve from the final goods sector for *m* intermediate goods.

Now we look at the intermediate good sector, where we assume that each producer of an intermediate good is a monopolist. The reason is that each producer of an intermediate good has an infinitely lasting patent, after having invested in developing an innovation. Because of the fact that there are many intermediate good producers, the market structure results in monopolistic competition on the intermediate good market. Further on, we assume that the production of one intermediate good is produced by one unit of output. Additionally, we assume that a fixed investment of *fi* units of the final product is necessary to invent an intermediate good. This results in the following total cost function for the producer; $tc_j = x_j + fi$. All intermediate goods producing firms maximize their profits. This leads to the following maximization problem of the *m* intermediate good producing firms;

$$\max_{k_j} p_j(k_j)k_j - k_j - fi = \max_{k_j}(1-a)L^a k_j^{1-a} - k_j - fi \quad \forall j \in \{1,\ldots,m\} \tag{6}$$

Equation (5) has been used for substitution of $p_j(k_j)$. The necessary condition of this maximization problem is given by

$$(1-a)^2 L^a k_j^{-a} - 1 = 0 \qquad \forall j \in \{1,\ldots,m\} \tag{7}$$

Because the symmetry of all *m* intermediate goods firms, we derive the equilibrium values for all intermediate good firms;

$$k_j = \bar{k} = (1-a)^{\frac{2}{a}} L, \qquad \forall j \in \{1,\dots,m\} \qquad (8)$$

Notice that now $\sum_{j=1}^{m} k_j^{1-a} = m\bar{k} = \bar{K}$, and the production function of the final goods sector reduces to $Y = L^a \bar{K}^{(1-a)}$.

Now we are able to calculate the equilibrium prices of the intermediate goods. Using equation (8) to insert in equation (5) we get the following result[6]:

$$p_j = \bar{p} = \frac{1}{1-a}, \qquad \forall j \in \{1,\dots,m\} \qquad (9)$$

Now we are able to calculate the profit of an intermediate good firm:

$$p_j = \bar{p} = \frac{a}{1-a}\bar{k} - fi = a(2-a)(1-a)^{\frac{1}{a}} L - fi \qquad \forall j \in \{1,\dots,m\} \qquad (10)$$

From this we derive the profit factor R of a representative intermediate good producer.

$$R = \frac{\frac{a}{1-a}\bar{k} - fi}{\bar{k} + fi} \qquad (11)$$

[6] $p_j = L^a (1-a)\left[(1-a)^{\frac{2}{a}} L\right]^{-a} = L^a L^{-a} (1-a)(1-a)^{-2} = (1-a)^{-1}$

Consequently the equilibrium wages are given by;

$$w_m = aL^{a-1} m\bar{k}^{1-a} \tag{12}$$

Please note that the wage rate depends on the number (m) of existing intermediate good firms. Therefore we have attached the subscript to the wage rate. Now we have determined all equilibrium prices and quantities of the static model.[7] From the view of a policy-maker the aggregate income of a region is an indicator for its welfare. This aggregate income is given by the sum of the wage income of the final goods sector plus the profits of the intermediate good sector. From equation (12) we see that total wage income equals $Lw_m = aL^a m\bar{k}^{1-a}$. Let us define Y_m as the regional net income of the region with m intermediate goods producing firms. Then we get total income as the sum of total labor income and aggregate profits of the intermediate goods sector

$$Y_m = aL^a m\bar{k}^{1-a} + \frac{a}{1-a} m\bar{k} - mfi \tag{13}$$
[8]

Obviously, the regional net income depends positively o the number (m) of intermediate good producing firms.

Welfare effects of innovative firms

In order to find the contribution of a new firm on the regional economic activity, we calculate the effect on the regional net income if a new firm will enter the intermediate good sector. After settling on aggregate we have m+1 intermediate goods producing firms. The total regional income with m+1 intermediate firms settled in a region can be denoted as follows:

$$Y_{m+1} = aL^a (m+1)\bar{k}^{1-a} + \frac{a}{1-a}(m+1)\bar{k} - (m+1)\, fi \tag{14}$$

[7] A dynamic version of the model can be found in Stauvermann (1997), where an OLG approach is used.. See also Obstfeld and Rogoff (1996) pp and further

[8] The subscript at the *Y* indicates the number of intermediate good firms in the region.

The resulting increase in the regional net income is of course just the difference in income with *m* and *m*+1 innovative firms. It is easy to see that the additional income of a region amounts to;

$$\Delta Y = aL^a \bar{k}^{1-a} + \frac{a}{1-a}\bar{k} - fi \quad where \ \Delta Y = Y_{m+1} - Y_m \tag{15}$$

The difference is obviously positive, because as noted above an increasing number of intermediate good firms increase the production and this results in an increase of wages of the region. Summarizing we can say that the additional innovative firm leads to a) an increase in the wage rate (see equation (12). b) an increase in overall wage income and c) an increase in capital income (profit of innovative firm).

4 Competition between Regions

As we explained in section 2, "herd" behavior of policy makers leads to an increase in competition to attract innovative firms. In the previous section we showed that the net regional income increases if an innovative settles in the region. Both arguments deliver the necessary incentives for regions to compete with each other in order to attract an innovative firm. Below we formalize this regional competition.

Let us suppose for simplicity that our world consists of two regions (1 and 2). So we note that $m_1 + m_2 = m$ and $L_1 + L_2 = L$. Both regions are identical, regarding inhabitants and intermediate good producers. In each region there are $m_1 = m_2 = \frac{m}{2}$ intermediate good producers and $L_1 = L_2 = \frac{L}{2}$ individuals are living in both regions. Let us further assume that the government of each region has an interest in increasing its regional income as showed in the previous sections. This consists of the profits in the intermediate good industry and the aggregate wage incomes in the region. The regional income of region *j* is given by:

$$Y_{j,m_j} = w_m L_j + m_j \frac{a}{1-a}\bar{k} - m_j fi \text{, where } m_j = \frac{m}{2} \ and \ L_j = \frac{L}{2} \text{ for } j = 1,2 \tag{16}$$

In this situation the regional incomes of both regions are identical. Let us also assume that workers are able to work in both regions, but they will stay at their original region. The mobility of workers plays no role and the wage income will always be spent in the home region. What will happen if one new intermediate good will be produced in one of the two regions. Let us assume, without loss of generality that the new firm settles in region 1. Of course this will change the regional income of both regions. As can be seen from the previous section the aggregate wages will increase. Due to one additional intermediate firm the wage rate becomes; $w_{m+1} = aL^{a-1}(m+1)\bar{k}^{1-a}$. The increase in wage income in both regions equals $\frac{1}{2}\alpha L^{\alpha}(m+1)\bar{k}^{1-\alpha}$ and additionally, aggregate profits of the intermediate sector in region *j* will also increase. Now the regional income of region 1 if it succeeds in attracting an innovative firm is:

$$Y_{1,m_1+1} = \frac{1}{2} aL^a (m+1)\bar{k}^{1-a} + (m_1+1)\left[\frac{a}{1-a}\bar{k} - fi\right] \tag{17}$$

That means the founding of the new intermediate good producing firm will increase the regional income of region 1. Because of the fact that the producer sells the intermediate goods in both regions, the new intermediate good will also enhance the regional product of region 2. This is caused by an overall increase in wage rate (see above);

$$Y_{2,m_2} = \frac{1}{2} aL^a (m+1)\bar{k}^{1-a} + m_2\left[\frac{a}{1-a}\bar{k} - fi\right] \tag{18}$$

Of course the increase of the regional income in region 2 is lower than in region 1, because the number of intermediate good producing firms is lower. The increase in regional income for region 1 equals

$$\Delta Y_1 = \frac{1}{2} aL^a \bar{k}^{1-a} + \frac{a}{1-a}\bar{k} - fi \tag{19}$$

For region 2 there is still an increase due to externalities resulting in an overall wage increase. For region 2 we get:

$$\Delta Y_2 = \frac{1}{2} a L^a \bar{k}^{1-a} \qquad (20)$$

The overall increase due to the settling of the firm equals $\Delta Y_1 + \Delta Y_2$ which on aggregate is the same as the increase in the previous section. Notice however that the distribution of the income between the regions has changed ($\Delta Y_1 > \Delta Y_2$).

Now let us investigate whether the two regions have an incentive to attract the new firm with help of subsidies. Both regions know that the additional regional income could be $\frac{1}{2} a L^a \bar{k}^{1-a} + \frac{a}{1-a}\bar{k} - fi$, if the firm will settles in the region To make the analysis as easy as possible, we assume that both regions make use of lump-sum taxes and that they redistribute all tax revenues minus the subsidy as lump-sum transfers to the workers and intermediate producing firm owners. Notice that there will be an increase in income for both regions no matter where the firm will settle. This is due to the overall increase in wages. We assume that the regions are not aware of this externality and will not take this in account in their decision making. We will assume that regions will offer innovative firms subsidies to settle in the region. Here we define subsidy in a very broad sense. It is any action of the regions which increases the profit of the firm. If one region offers a subsidy another interested region will also try to attract the firm and offer a subsidy As a consequence, regional competition via subsidies will take place. Both regions are able to offer subsidies to attract the firm. To model this competition, we make use of the model of Skaperdas (1996) and Skaperdas & Gan (1995), which is based on Tullock’s (1980) contest success function (CSF). Actually there are two different types of this kind of games which can be played. The first one is sometimes called full liability and the second one is called limited liability. We will pay attention successively to both types of games.

The competition game with full liability

This type of game is also called a “winner take all” game. Both regions pay a subsidy to the firm. The firm decides for one of the two regions. There is a winning region and a loosing region. The losing region has invested in subsidies to attract the firm but these investments are lost because the firms settle elsewhere. In principle we have a subsidy in mind like firm-specific infrastructure investments which could only be used by the competed firm.

The winning region has invested in subsidies and receives the price (additional income, employment, positive externalities) of the settling of an innovative firm. Next we look at the competition game between the two regions.

In order to calculate the optimal subsidies, the regions have to calculate the expected payoff of attracting a firm. This consists of the probability to attract the firm times the additional regional income associated with the new firm. However, the probability to attract a firm depends positively on the amount of subsidies. On the other hand the probability of the firm to settle down also depends on what the competing region is offering. That means that the probability to settle down depends on the relative effort (relative amount of subsidies) of the region. Using the CSF approach, that means that the two regions have the following expected pay-off of attracting a firm;

$$E(PO_j) = \frac{e_j}{e_1 + e_2}\Delta Y_j - e_j \quad \text{where} \quad j = 1,2 \tag{21}$$

For the two regions this results in the following maximization problem;

$$\max_{e_j}\left\{\frac{e_j}{e_1 + e_2}\Delta Y_j - e_j\right\}. \quad \text{where} \quad j = 1,2 \tag{22}$$

Where, e_1, e_2 is the amount of resources spent by the two regions (1,2). Here it is the amount of subsidy offered to the firm to settle in the region. The variables $E(PO_1), E(PO_2)$ are the expected net pay-offs of the regions resulting from attracting the innovative firm. Obviously, this competition is like a Cournot-Nash competition. Alternatively we could also assume that it is a Stackelberg competition, under the given assumptions both approaches are equivalent.[9] The first order conditions are given by;

$$\frac{\partial E(PO_1)}{\partial e_1} = \frac{e_2}{(e_1 + e_2)^2}\Delta Y_1 - 1 = 0 \quad \text{and} \quad \frac{\partial E(PO_2)}{\partial e_2} = \frac{e_1}{(e_1 + e_2)^2}\Delta Y_2 - 1 = 0$$

[9] For a proof see Stauvermann (2007).

Solving this system of equations gives the following two best response functions:

$$e_1 = -e_2 + \sqrt{e_2(\Delta Y_1)} \text{ and} \tag{23}$$

$$e_2 = -e_1 + \sqrt{e_1(\Delta Y_2)} \tag{24}$$

The gains from an additional innovative new firm are the same for both regions namely $\Delta Y_1 = \Delta Y_2 = \Delta Y$. If we look at the equations (23) and (24) it is easy to see that, $e_2 = e_2$. The amount of subsidies offered by the two regions is the same because they are symmetric. Solving these two best response function simultaneously we get the equilibrium effort levels (subsidies offered by the regions to the firm):

$$e^*{}_j = \frac{1}{4}\Delta Y \text{ for} \qquad j = 1,2 \tag{25}$$

This means that 25% of the gains if the firm settles, is offered as subsidy by the regions to the firm. Given these results we are able to calculate the probabilities for the regions to attract innovative firms. In the view of the policy makers, The equilibrium probability of the region to win the game is $P_j = \frac{e_j}{e_1 + e_2}$, $j = 1,2$. From the view of policy makers it is equal to;

$$P_1^* = P_2^* = \frac{1}{2} \tag{26}$$

After calculating the probability it is easy to see what the expected payoff of the competition in terms of additional regional income will be. Using equation (19), (21) and (25) we find the following expected pay offs for the regions;

$$E(PO_j) = \frac{1}{4}(\Delta Y) = \frac{1}{4}\left(\frac{a}{1-a}\bar{k} - fi\right) + \frac{1}{8}aL^a\bar{k}^{1-a}, \; j = 1,2 \tag{27}$$

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From the view of the new producer the profit will change because it will receive a subsidy. This subsidy will be the same irrespective where the firm will settle down. Both regions will offer the same amount namely $e^{*}{}_{j}=\frac{1}{4}\Delta Y$ for $j=1,2$. Where $\Delta Y=\frac{1}{2}aL^{a}\bar{k}^{1-a}+\frac{a}{1-a}\bar{k}-fi$ the pay-off when the firm settles. Because policy makers take as a reference point the gains if the firm settles down. The offered subsidies will be equal because of the symmetry of both regions in the initial situation;

$$e^{*}{}_{j}=\frac{1}{8}aL^{a}\bar{k}^{1-a}+\frac{1}{4}\left(\frac{a}{1-a}\bar{k}-fi\right)\ \text{for}\ j=1,2 \tag{28}$$

If this is taken into account the profit of the new innovative firm will increase to;

$$p^{*}{}_{m+1}=\frac{5}{4}\left(\frac{a}{1-a}\bar{k}-fi\right)+\frac{1}{8}aL^{a}\bar{k}^{1-a}. \tag{29}$$

Due to the increased profit, the profit factor also will increase. What will happen under these circumstances with the regional welfare? Let us look at the change of the regional incomes. At first we look at the winning region 1: If it wins the game then it has to pay for the subsidy. So if region 1 wins the game the overall increase in income would be $\Delta Y_{1}-\frac{1}{4}\left(\frac{1}{2}aL^{a}\bar{k}^{1-a}+\frac{a}{1-a}\bar{k}-fi\right)$. Then the increase in income can be given by the following equation;

$$\Delta Y^{*}{}_{1}=\frac{3}{8}aL^{a}\bar{k}^{1-a}+\frac{3}{4}\left(\frac{a}{1-a}\bar{k}-fi\right) \tag{30}$$

That means the founding of the new intermediate good producing firm will increase the regional income of region 1. However, because of the fact that the producer sells his intermediate goods in both regions, the new intermediate good will also enhance the regional product of region *2*: However the loosing region has also invested in subsidies which are foregone because the firm settles in the competing region. This results in the overall gains of the loosing region of;

$$\Delta Y^{*}{}_{2} = \frac{3}{8} aL^{a} \bar{k}^{1-a} - \frac{1}{4}\left(\frac{a}{1-a}\bar{k} - fi\right) \tag{31}$$

It is not clear for the loosing region whether the overall welfare effect compensates the amount of subsidies invested in attracting the innovative firm. If the increase of the overall wage incomes is relatively large then also the loosing region will experience an overall increase in welfare. From (31) this can be easily observed that this is the case if;

$$aL^{a} \bar{k}^{1-a} > \frac{2}{3}\left(\frac{a}{1-a}\bar{k} - fi\right) \Rightarrow \Delta Y_{2} > 0$$

When the labor share of income exceeds 67% then the loosing region will benefit too, due to positive externalities which exceeds the paid subsidies. Notice that in the view of the policy maker the loosing region is always worse of because the externality of the wage increase in not taken into account.

We see in comparison to the case where the firm has settled down in region 1 without any subsidy, that the “winning” and the loosing region are both worse off because of competing with subsidy about the firm. This is caused by the fact that 25% of the possible surplus has been paid to facilitate the firm. For the winning region there remains always a positive overall welfare effect. This need not be the case for the loosing region where due to competition the welfare effect can be negative.

If we look at the overall picture that we have to conclude that competition has lead to a lower increase of income if compared with no competition.

To see that, we add up the two equations (30) and (31). This gives us total increasing in income.

$$\Delta Y^{*} = \Delta Y^{*}{}_{1} + \Delta Y^{*}{}_{2} = \frac{3}{4}\left(aL^{a} \bar{k}^{1-a}\right) + \frac{2}{4}\left(\frac{a}{1-a}\bar{k} - fi\right) < \Delta Y \tag{32}$$

If we compare therefore equation (32) with (15) we see the difference in income between the regions increases. Introducing competition leads to a lower increase in income and therefore causes a welfare loss for both regions. This is also the case if the intermediate goods would only be sold in the region where it is produced. The only difference is that only the income increases in the region where the new firms settle. So we come to the following proposition:

Proposition 1: *From an efficiency point of view regional competition to attract innovative firms with the help of subsidies is always inefficient. Next to that it also leads to an increase in differences in economic development and welfare*

There is one more point where we want to focus attention on. In our example there are only two regions competing for innovative firms. We can see that whatever region wins the competition, there is still an overall welfare increase due to externalities. Policy-makers determine the amount of subsidies offered to the firm on the basis of the welfare gain of the region. They do not take into account the possible externality for other regions. As a result the offered amount of subsidies to the firm is too high. We can see this by comparing equation (19) for the winning region and equation (20) for the losing region. We can see that the actual gains for the winning region by deducting (19) from (20). So the welfare gain equals;

$$\Delta Y = \frac{a}{1-a}\bar{k} - fi$$

From that we conclude that besides the fact that offering subsidies leads to a welfare loss, the actual amount offered by policy-makers exceeds the gains from having the firm settle in the region. Actually policy-makers are double counting part of the externalities which will be realized anyway wherever the firm will settle.

Finally we can determine whether this kind of competition can be avoided. Therefore we have to know whether regions have an incentive to compete with each other for innovative firms. To see that, we have to compare the expected pay-offs in case of no competition and the case where regions compete. As soon as one of the regions offers a small amount of subsidy the probability of the settling down of the firm will increase and that of competing regions will decrease. The other region will notify this and will have to offer the firm also a subsidy. That means they are stuck in a prisoners' dilemma, and competition can not be avoided. The best solution is of course no competition. That means the two regions have to cooperate. This cooperative strategy however is not credible as is shown before.

The competition game limited liability

In the second competition game a region only has to pay if the firm decides to settle. Conversely, to the full-liability case, here we assume that the firm will only get a subsidy from the region when it will settle. This means that the expected pay-offs and the maximization problem differs from the previous one. If the firm decides to accept the proposed subsidy of one region other competing regions do not have to pay. Below we will work out this kind of competition for the case of two regions. In this case, limited liability, we have the following adjusted expected pay-off for the regions;

$$E(PO_j) = \frac{e_j}{e_1 + e_2}(\Delta Y_j - e_j) \quad \text{where} \quad j = 1,2 \tag{33}$$

Notice that the expected pay-off exceeds that of the full liability case because $\frac{e_j}{e_1 + e_2} e_j < e_j$. Both regions again face the same maximization problem namely;

$$E(PO_j) = \max_{e_j} \left\{ \frac{e_j}{e_1 + e_2}(\Delta Y_j - e_j) \right\}. \text{ Where } \; j = 1,2 \tag{34}$$

Where, e_1, e_2 are again the amounts of resources spent by the two regions (1, 2). Here it is the amount of financial support is paid after the firm becomes settles. The variables $E(PO_1), E(PO_2)$ are the expected net pay-offs of the regions resulting from attracting the innovative firm. The first order conditions are given by:

$$\frac{\partial E(PO_1)}{\partial e_1} = \frac{e_2}{(e_1 + e_2)^2}(\Delta Y_1 - e_1) - \frac{e_1}{e_1 + e_2} = 0 \text{ and}$$

$$\frac{\partial E(PO_2)}{\partial e_2} = \frac{e_1}{(e_1 + e_2)^2}(\Delta Y_2 - e_2) - \frac{e_2}{e_1 + e_2} = 0$$

The gains of a new firm are the same for both regions.

As well as the full as limited liability case the gains are $\Delta Y_1 = \Delta Y_2 = \Delta Y$. Using the two first order conditions we can derive two best response functions[10] of the two regions:

$$e_1 = -e_2 + \sqrt{e_2(\Delta Y + e_2)} \text{ and} \tag{35}$$

$$e_2 = -e_1 + \sqrt{e_1(\Delta Y + e_1)} \tag{36}$$

Looking at the two best response functions it is easy to see that this results in $e_1 = e_2$. The offered subsidy to the firm is the same for both regions. This is obvious because as in the previous case the regions are identical. Next we can solve the above equations and find the optimal effort level for the two competing regions. This becomes;

$$e^{\#}{}_j = \frac{1}{3}\Delta Y \qquad j = 1,2 \tag{37}$$

Given these results we are able to calculate the probabilities, $P_j = \dfrac{e_i}{e_1 + e_2}$, $j = 1,2$, of region 1 and 2 of winning the competition from the view of the policy-makers:

$$P_1^{\#} = P_2^{\#} = \frac{1}{2} \tag{38}$$

On forehand it is not clear where the firm will settle. Let us assume that the firm decides to settle in region one. What will be the consequences of this kind of competition for the two regions? If we insert the optimal effort level (equation (37) in equation (33) the expected increase in income for both is attained namely;

[10] Using the FOC we get $e_2(\Delta Y_1 - e_1) = e_1(e_1 + e_2)$ because region 1 is reacting on region 2, e_2 and ΔY are fixed. This leads to $e_1^2 + 2e_2e_1 - e_2\Delta Y = 0$. The solution equals

$$e_1 = \frac{-2e_2 + /- \sqrt{(2e_2)^2 + 4e_2\Delta Y}}{2}$$

$$E(PO_j) = \frac{1}{2}\left[\Delta Y_j - \frac{1}{3}\Delta Y_j\right] = \frac{1}{3}(\Delta Y_j) = \frac{1}{3}\left(\frac{a}{1-a}\bar{k} - fi\right) + \frac{1}{6}aL^a \bar{k}^{1-a}, \quad j = 1,2 \quad (39)$$

Although the optimal effort level in this limited liability case exceeds the ones in the full liability case this is also the case with the expected income increase. This can be seen if we compare equation (29) with equation (39) above ($\frac{1}{3}(\Delta Y) > \frac{1}{4}(\Delta Y)$). The difference is the result of the fact that in the latter case the effort level for the region reduces to zero if the firms decides to settle elsewhere.

From the view of the new producer the profit will change because it will receive a subsidy irrespective where it will settle. Both regions will offer the same amount of subsidies to the innovative firm ($e^{\#} = \frac{1}{3}\Delta Y$, where as in the previous section, $e^{*} = \frac{1}{4}\Delta Y$). The profit of the new innovative firm will increase with the amount of subsidies received. Than the profits tally up to;

$$p^{\#}{}_{m+1} = \frac{4}{3}\left(\frac{a}{1-a}\bar{k} - fi\right) + \frac{1}{6}aL^a \bar{k}^{1-a}. \quad (40)$$

Comparing the result with the full liability case we see an increase in profit for the firm.

Now we turn and look what are the benefits for the regions. What will happen with the regional incomes? Let us assume that the firm decides to settle in region one. If the region wins the game it has to pay for the subsidy and otherwise not. In this case, the overall increase in income for region 1 would be $\Delta Y_1 - \frac{1}{3}\Delta Y$. Then the increase in income can be given by the following equation

$$\Delta Y^{\#}{}_1 = \frac{1}{3}aL^a \bar{k}^{1-a} + \frac{2}{3}\left(\frac{a}{1-a}\bar{k} - fi\right) \quad (41)$$

That means the founding of the new intermediate good producing firm will increase the regional income of region 1. However, because the overall wages are also increasing the regional product of region 2 also increases. But on the contrary to the previous section no subsidies are paid if the region looses the competition.

$$\Delta Y^{\#}{}_{2} = \frac{1}{2} a L^{a} \bar{k}^{1-a} \tag{42}$$

We see in comparison that the "winning" region has gained relative little. This is caused by the fact that 1/3 of the surplus has been paid to the firm. The "loosing" region benefits from an overall increase in the wage rate and therefore the regional wage income increases. It does not have to pay any subsidies or compensation to the innovative firm. Whether the gain of the winning region exceeds the gain of the loosing region is not clear. Depending on the relative magnitude of wage income and profits we have

$$\Delta Y^{\#}{}_{1} \leq \Delta Y^{\#}{}_{2} \quad \text{if} \quad \left(\frac{a}{1-a} \bar{k} - fi \right) \leq \frac{1}{4} a L^{a} \bar{k}^{1-a}$$

What the final benefits for the winning region will be is not clear at the end. If however the capital share (profits) is below 25% of total income then the winning region is worse off than the loosing region.

If we look at the overall picture that we have to conclude that competition has lead to a lower increase of income if compared with no competition. If we add up equations (41) and (42), this gives us total increasing in income.

$$\Delta Y^{\#} = \Delta Y^{\#}{}_{1} + \Delta Y^{\#}{}_{2} = \frac{5}{6} \left(a L^{a} \bar{k}^{1-a} \right) + \frac{2}{3} \left(\frac{a}{1-a} \bar{k} - fi \right) \tag{43}$$

It is easy to see that competition compared with no competition result is a welfare loss. If we compare therefore equation (15) with (43) we can see the difference in income increase due to introducing competition. This result also holds if we would assume that the intermediate goods would only be sold in the region where it is produced. The only difference is then that only the regional income of the region where the new firms settle will be increased. So we come to the following proposition:

Proposition 2: *From an efficiency point of view regional competition to attract innovative firms with the help of subsidies is always inefficient. This also holds in the limited liability case where the subsidies are paid when the firm settles.*

Like in the previous case, also in case of limited liability the policy maker will over estimate the gains from the settling of an innovative firm due to the appearance of positive externalities.

Comparison and consequences

To compare the two types of competition we have summarized the main results in Tabel 1 Summary.

Insert table 1

If we compare the two different types of competition we can see that the regions will prefer the first type of competition because the expected gains exceed the gains of the second type of competition. (Compare equation (30) with equation (41)). From a welfare point of view this is the worst possible outcome. Aggregate income is lowest in case of full liability. The next question is will region engage in this kind of competition. Because the expected pay offs are highest for the winner of the game regions will start with this kind of competition. Other regions have to follow otherwise they will lose the game on forehand. If how ever a firm is the first mover, most probably competition with limited liability will be the result because in this case the profits of the firm are the highest. This can easily be seen by comparing equation (29) and (40). However the best option of the regions is not to compete at all. But every contract between the involved region not to compete is not a credible one. This can be easily shown with the help of a game matrix or a game tree. The two strategies available for the two regions are respectively to compete with $e^* = \frac{1}{4}\Delta Y$ ($e^\# = \frac{1}{3}\Delta Y$) or not to compete with $e = 0$ ($e = 0$). The corresponding pay offs can be found by substituting the effort levels in equation (21) and (33). If both regions decide not to compute they have both equal probabilities that an innovative firm will settle. We have summarized the expected pay offs in the table below

Table 2: Competition strategy and the corresponding expected pay offs

Full Liability competition game

Player 2

Player 1

	$e_2 = 0$	$e_2^{\#} = \frac{1}{3}\Delta Y$
$e_1 = 0$	$\frac{1}{2}\Delta Y, \frac{1}{2}\Delta Y$	$0, \frac{2}{3}\Delta Y$
$e_1^{\#} = \frac{1}{4}\Delta Y$	$\frac{3}{4}\Delta Y, 0$	$\frac{1}{4}\Delta Y, \frac{1}{4}\Delta Y$

Limited Liability competition game

Player 2

Player 1

	$e_2 = 0$	$e_2^{\#} = \frac{1}{3}\Delta Y$
$e_1 = 0$	$\frac{1}{2}\Delta Y, \frac{1}{2}\Delta Y$	$0, \frac{2}{3}\Delta Y$
$e_1^{\#} = \frac{1}{3}\Delta Y$	$\frac{2}{3}\Delta Y, 0$	$\frac{1}{3}\Delta Y, \frac{1}{3}\Delta Y$

Notice here that we have assumed that policy makers do not take into account the externality of the wage increase when the competition game is lost. From table 2 it is clear that competing can not be avoided because both competition strategies, ($e_1^{\#}$, $e_2^{\#}$ and $e_1^{\#}$, $e_2^{\#}$) result in Nash equilibriums.

Proposition 3: *Even though competition leads to an overall decrease efficiency, it can not be avoided even when policy makers are aware of this.*

Despite the fact that competition leads to a lower pay-off for the region, the disadvantage of this type of competition there remains the possible opportunistic behavior of the intermediate firm.

5 Asymmetric information and opportunistic behavior of firms

In the previous section we investigated in the contribution of innovative firms. Furthermore we analyzed that regions have an interest in attracting innovative firms, because it generates externalities. As a result regions want to compete in order to attract these kinds of firms. We also showed that this kind of competition does not increase overall welfare but that it cannot be avoided.

In this section we emphasize on regional policy to stimulate innovation by financial support of the innovative firm. Because as it shown by Stauvermann (1997), if positive externalities are accompanied with innovations, government intervention is necessary to reach the economic desirable level.[11] Regional policy is aimed to enhance this kind of investment

In this section we will look more carefully at the consequence of this kind of policy. Especially we analyze the firm behavior, if it is financially supported by the region, and whether this kind of policy is effective. So we ask, if this policy will increase innovative investments and therefore generates more externalities.

The model here follows closely Gertler & Rogoff (1990) who tackle the problem of moral hazard in international lending. Here we analyze the following problem: Is it possible for a region to enhance regional welfare by offering a subsidy to a potential investor, who wants to develop a new patent. In this part of the paper we only take one region into account, the rest of the assumptions of the former sections are the same. Point of departure is that it is for the firm not clear if an investment in the intermediate good industry is successful or not. In so far the investment is risky. The firm however knows the probability if investments will be successful or not. However, the region is not able to observe the amount of the investment. This knowledge is private information of the innovative firm. Regions are only able to observe, if an investment is made and of course the success or failure of the investment. If it is a failure, the region cannot calculate the amount of the investment effort.

Let us first turn to the innovative firm. On beforehand for the firm it is not clear whether the investments in innovation will be successful and possibly can result in patents. We assume that there is a relation between the level of investment and the

[11] See for a proof Stauvermann (1997).

probability of having success. We can describe the probability function of successful innovation as follows:

$$z = z(I),\ z' > 0\ , z'' < 0 \text{ and } z(0) = 0 \tag{44}$$

A higher amount of investment increases the probability of success and as such the expected profit, but at a decreasing rate. Furthermore we assume that under perfect information there is an efficient positive level of investments. Let us assume that the firm could alternatively invest its money on the international capital market, where *r* is the given world risk less interest rate. Obviously, in a world without any risk the following condition must hold; $z'(0)\frac{a}{1-a}\bar{x} > 1 + r$, because otherwise no investment will be made.[12]

As noted in the previous sections there are two types of firms. Firms operating under perfect competition, with zero profit and innovative firms with a positive profit, namely, $\frac{\alpha}{1-\alpha}\bar{x}$. It is now easy to write down the expected profit of the innovative firm:

$$Ep_{m+1} = z(I_{m+1})\frac{a}{1-a}\bar{x} + [1 - z(I_{m+1})]0 = I_{m+1}(1+r) \tag{45}$$

This can be seen as a kind of non arbitrage condition. The expected profits of investing in innovative activities equals the rate of return on risk less investment

The first summand represents the profit is the case of success, the second summand represents the outcome if the innovation fails. The right of the equality sign represents the opportunity costs. Taking the first derivative this we come to the following FOC.

$$z'(I_{m+1})\frac{a}{1-a}\bar{x} = (1+r) \tag{46}$$

The firm will invest up to the point where the expected marginal probability times profits equals the world interest factor. This leads to the optimal level of investment, $I_{m+1} = \bar{I}_{m+1}$. Of course the level is below the social optimal level of investments due to

[12] For a proof see Gertler & Rogoff (1990).

positive externalities which is ignored by the firm in the decision making. Assuming at first full information, it is very easy for the region to determine what the financial contribution should be. It firstly determines the social optimal level of investment $\bar{I}^{*}_{m+1} > \bar{I}_{m+1}$, which exceeds the private level of investments. Next the region offers a subsidy to the firm in order to increase its amount of investment to the social desirable level of investment. The firm is financially supported to invest up to this level ($e_{m+1} = \bar{I}^{*}_{m+1} - \bar{I}_{m+1}$). In the case of perfect information the social efficient amount of investment is achieved. The problem in reality is that the amount of an investment is private information of the firm, and cannot be observed by the regional policy-makers. What can be observed by policy makers is for example the number of patents resulting from successful innovations

Now let us ask the question what will happen in case of asymmetric information where the level of investment can not be observed by the region if the firm is financially supported, because the region offers a subsidy. The big question for the region is of course will the firm use the financial resources for innovations? To analyze that we look at the following new expected profit function, where we assume that the firm will receive a subsidy of $e_{m+1} = I^{*}_{m+1} - I_{m+1}$. In case the investment is successful the firm earns a positive monopolistic competition profit. Otherwise the firm will earn no profit. This means that if the investment is not successful the firm will not be able to refund the received subsidies. This results in the adjusted profit function below:

$$Ep_{m+1} = z\left(I_{m+1} + e_{m+1}\right)\frac{a}{1-a}\bar{x} + \left[1 - z(I_{m+1} + e_{m+1})\right]0 - I_{m+1}(1+r)\,. \qquad (47)$$

The optimal level of investment we get from the following foc:

$$z'(I_{m+1} + e_{m+1})\frac{a}{1-a}\bar{x} = (1+r)\,. \qquad (48)$$

Comparing (48) with (46) gives $z'(I_{m+1} + e_{m+1}) = z'(\bar{I}_{m+1})$ or $I_{m+1} = \bar{I}_{m+1} - e_{m+1}$. This means that the new level of investment is the same as before. Only the private part of the investment is decreased by the amount of the financial support. Implicitly, the firm invests the subsidy on the international capital market and increases in this way its profits, without changing its investment behavior. In the case that investments can not be monitored, it is impossible in case of externalities resulting form innovative investments, to internalize these positive externalities by means of financial support to the innovative firms. So we are able to make the following proposition.

Proposition 4: *In the case of asymmetric information between the firm and the region, a subsidy will never increase the amount of investment.*

We can conclude that there in no guaranty that financial supporting innovative firms will lead to more innovation and as such will support economic development and leads to an increase of overall welfare.

7 Conclusions

In this paper we have shown that a policy to give subsidies to attract high-technology firms is almost always inefficient from the view of the regions. At first we have shown that a competition between regions to attract firms will be inefficient for the region and only the firm will increase its profits. The reason is that both regions are locked-in a kind of prisoner's dilemma. If one region is offering a subsidy, starts competing, it is rational for all other regions also to offer subsidies. As long as the regions are identical, no region is better off at the end of the competition, because the probability to attract the firm remains the same. However, the qualitative result will also hold if the regions would be different and not identical.

In the second part in paper we have investigated into a situation where a region tries to increase the amount of investment with the help of a subsidy. However, because of asymmetric information this is impossible, the amount of investment will remains below the efficient level of investment. Like in the first part only the investor will enhance its profits with the help of the subsidy.

In so far our paper generates the important message, that subsidies are not an efficient mean for regions to compete. The existing EU regional development policy should be reversed, because the idea of competition between regions (with the help of subsidies) seems to be absolute useless. It will not lead to the expected increase in efficiency and welfare. In principle it can be concluded that subsidies are useless from the view of a region.

Also in some sense this result is important regarding judgments about the efficiency of EU structural funds. The idea of the structural funds is to subsidize the attracting of innovative firms in low developed regions within the EU. Additionally, the extent of a possible subsidy is restricted by the EU and depends on the status how much a region is developed. That means that low-developed regions are allowed to give higher subsidies then developed regions. However, if the offered subsidy of a low-developed region exceeds the offered subsidy of the developed regions, the probable winner of a regional contest will be the low-developed region. In so far the mechanism of the EU works very well, but if we take into account our proposition 1, then we come to the conclusion that the low-developed region will probably become poorer and the developed region will probably become richer. In so far the results of the EU policy are contrary to the intention of the EU to equalize the economic differences of regions.

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Table 1: Summary (region 1 is the winning region and region 2 is the losing region)

Equations		Full Liability Competition Game *	Limited Liability Competition Game #	
(18)	$\Delta Y_1 / \Delta Y_2$	$\frac{1}{2} a L^a \bar{k}^{1-a} + \frac{a}{1-a}\bar{k} - fi$	$\frac{1}{2} a L^a \bar{k}^{1-a}$	
(26) & (39)	$e^* / e^\#$	$e^* = \frac{1}{4}\Delta Y$	$e^\# = \frac{1}{3}\Delta Y$	$e^* < e^\#$
(29) & (40)	$p^*_{m+1} / p^\#_{m+1}$	$p^*_{m+1} = \frac{5}{4}\left(\frac{a}{1-a}\bar{k} - fi\right) + \frac{1}{8} a L^a \bar{k}^{1-a}$	$p^\#_{m+1} = \frac{4}{3}\left(\frac{a}{1-a}\bar{k} - fi\right) + \frac{1}{6} a L^a \bar{k}^{1-a}$	$p^* < p^\#$
(30) & (41)	$\Delta Y^*_1 / \Delta Y^\#_1$	$\Delta Y^*_1 = \frac{3}{8} a L^a \bar{k}^{1-a} + \frac{3}{4}\left(\frac{a}{1-a}\bar{k} - fi\right)$	$\Delta Y^\#_1 = \frac{1}{3} a L^a \bar{k}^{1-a} + \frac{2}{3}\left(\frac{a}{1-a}\bar{k} - fi\right)$	$\Delta Y_1^* > \Delta Y_1^\#$
(31) & (42)	$\Delta Y^*_2 / \Delta Y^\#_2$	$\Delta Y^*_2 = \frac{3}{8} a L^a \bar{k}^{1-a} - \frac{1}{4}\left(\frac{a}{1-a}\bar{k} - fi\right)$	$\Delta Y_2^\# = \frac{1}{2} a L^a \bar{k}^{1-a}$	$\Delta Y_2^* < \Delta Y_2^\#$
(32) & (43)	$\Delta Y^* / \Delta Y^\#$	$\Delta Y^*_1 + \Delta Y^*_2 = \frac{3}{4}\left(a L^a \bar{k}^{1-a}\right) + \frac{2}{4}\left(\frac{a}{1-a}\bar{k} - fi\right)$	$\Delta Y^\#_1 + \Delta Y^\#_2 = \frac{5}{6}\left(a L^a \bar{k}^{1-a}\right) + \frac{2}{3}\left(\frac{a}{1-a}\bar{k} - fi\right)$	$\Delta Y^* < \Delta Y^\#$