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Research program «Policy and Regional Growth»

Determinants of Productivity Growth

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All opinions, interpretations and recommendations developed during the project and presented here are from the authors. In no way do they present an opinion or belief of one of the sponsors, neither as persons nor as institutions, or anybody advising us on the project. All remaining errors are our own.

Executive Summary

This study measures the influence of a set of regional location factors (or attractiveness factors) on the long term economic development of a region. The study selected productivity growth as the dependent variable and chose indicators from the innovation, taxation, regulation and accessibility policy areas plus a number of other indicators such as industrial structure, geography and historical growth rates to explain different growth patterns.

Globalisation and decentralisation are challenging regions' capacities to adapt and improve their economic competitiveness. It is at the regional level that the pressure to maintain economic growth and social development is felt most. Policy makers, especially at the regional level, are challenged to develop strategies to foster regional growth. To support decision makers and to contribute in an empirically sound way to the ongoing discussion about (location) factors influencing regional growth, BAK Basel Economics, in 2003, started an ongoing research program on «Policy and Regional Growth» within the «IBC BAK International Benchmark Club»®. This study summarises the results from the research program in the phase 2004/2005.

The study used data from around 120 European regions with a certain geographical focus on Western Continental Europe, Great Britain and Scandinavia. The data was taken from the IBC database which currently covers up to 400 regions with 64 business sectors per region and annual data from 1980 to 2004 as well as a variety of location factors. The IBC database is regularly updated and extended. The empirical analysis followed a «state-of-the-art» approach in panel data econometrics, which contains a series of test procedures to assure an accurate model specification. The resulting Random Effects model including country dummies was estimated for 1990 to 2003 with Generalized Least Squares. Finally, a sensitivity analysis was performed to guarantee the stability of the results.

The findings can be summarised as follows:

i) Almost all regression coefficients show the signs expected from theory: higher taxes reduce productivity growth, more innovation resources increase productivity growth, and better intercontinental accessibility leads to higher productivity growth. For interregional accessibility, the negative effect prevails over the positive effect although both are theoretically possible. Product market regulation does not show the expected negative signs.

ii) Comparing the individual politically influenced location factors, income taxation of highly qualified employees plays the most important role in explaining productivity growth differentials between the regions in our sample. It is followed by regulation of the labour market, interregional accessibility, company taxation, intercontinental accessibility and innovation indicators such as research and development expenditures and educational attainment.

iii) Productivity growth is also influenced by the global trend in productivity growth, the industrial structure of a region and spatial spillover effects. Large national effects remain as well.

iv) The reported results are statistically significant (at usual levels) and the explanatory power of the econometric model is quite good.

The results, conclusions and policy implications for the four policy areas included are discussed below individually and in more detail:

Innovation:

Regionally available innovation resources positively influence productivity growth. All three available indicators (the research and development expenditures as a share of the GDP, the share of the labour force with a secondary and the share with a tertiary degree) do have positive, significant and stable coefficients. But, somewhat surprisingly, the impact the innovation indicators exhibit on productivity growth is low. One reason for this might be that the available innovation indicators do not reflect the more important kinds of innovation resources, e.g. less formally acquired know-how. The results clearly point out that fostering innovation is not the quick and easy policy solution to solve all growth problems, especially if the policy concentrates on the broader and less focused areas of innovation resources which are covered by the indicators available here. Although innovation does have a positive impact on productivity growth, the road there might be longer than expected. It might thus be necessary to rethink policy with respect to innovation. Quality and efficiency controls should be an integral part of all innovation policies. Rather than drowning in the micromanagement of innovative firms, clusters and R&D expenditures, innovation policy should again put more weight on general framework conditions such as the regulatory burden and its impact on the ability of an economy to innovate.

Taxation:

The two indicators for taxation, the tax burden on investments and the tax burden on highly qualified employees, both influence productivity growth negatively. It is noteworthy that the impact shows a considerable time lag and that the relative position with regard to other regions turns out to be more important than the absolute level of taxation. The indicator «taxation of highly qualified employees» has by far the strongest impact on productivity growth of all the indicators included in the estimations. The impact is much stronger than the impact of company taxation. These findings have two policy implications. First, fiscal policy is indeed an important attractiveness factor. Individuals and the firms that hire them have a strong tendency to choose low-tax locations. Second, the tax burden on individuals has a much stronger impact on productivity growth than the tax burden on firms. Strong theoretical arguments support this empirical result for internationally mobile, highly qualified labour in an increasingly knowledge based economy. After tax reforms that mainly concerned company taxation, regions should now presumably turn their attention to the taxation of individuals, especially of those with high skills.

Regulation:

Labour market regulation has a strong positive impact on productivity growth. Tighter regulation can indeed increase the productivity of the working population, but at the price of reducing the participation of the population in the working process. Many regulations like minimum wages affect only the less qualified labour. Well-educated employees (with high productivity) participate in the labour market regardless of regulation, while low-skilled people (with low productivity) do not get jobs. In the long run, labour market regulations often hurt most those whom they pretend to protect. Of course, one should not conclude that a tightening of labour market regulation is a promising strategy for growth, because its impact on productivity is only half of the story. The overall effect of regulation on GDP growth is expected to be negative. Given that all parts of the population should participate in social well-being, easy access to the labour market is probably the best policy strategy to enable long term growth.

No conclusion can be drawn for product market regulation. Contrary to the hypotheses as well as to empirical studies with country data, product market regulation shows a positive influence on productivity growth. We have reasons to believe that this is a statistical artefact related to the problem that information on regulation is only available on the national level.

Accessibility:

The two indicators for intercontinental and interregional accessibility yield opposite results. While intercontinental accessibility has a positive impact on productivity growth, interregional accessibility (European level) has a negative effect. This might be a statistical effect: accessibility in rural and remote areas increased, with the help of EU Structural Funds, much more than in metropolitan areas although the economic growth of the latter was higher. But there is a “real” economic effect as well. Specialists in transport economics have often pointed out that improving infrastructure between remote and metropolitan areas may benefit the latter more than the former. The reason for this could be a delocalisation effect, i.e. the out migration of highly productive industries toward the economic centres, serving customers in the centre as well as in the periphery from the centre. Better accessibility is a double-edged sword. On the one hand, it enhances business activity and boosts the attractiveness of a region. On the other hand, it allows high value activities to be delivered from a central region. For productivity growth, the latter effect predominates.

The empirical results from evaluating the influence of various location factors on productivity growth in a sample of European regions lead us to a few clear-cut policy conclusions:

i) Fiscal policy should be a key element in a regions’ growth strategy. After tax reforms that mainly concerned company taxation, regions should not forget to turn their attention to the taxation of highly qualified individuals as well.

ii) Innovation policy supports growth, but not just any kind of innovation policy is the quick and easy policy solution to solve growth problems. Quality and efficiency controls are important.

iii) The attractiveness of a region for highly qualified labour is becoming an ever more important part of fostering growth in highly developed knowledge economies. Taxation of individuals is one issue, but there are various other policy areas to increase the regional attractiveness for such individuals.

iv) Policy takes time. The lag structure of the variables suggests that the effect of a specific policy exceeds the election period of politicians. Especially in cases where policy decisions are unpopular, the future positive effects will have to be clearly explained and communicated to stakeholders and to the population.

v) Regions are not self-contained. The economic development of a region might be influenced by political decisions in other regions. “Policy competition” is a realistic setting. It is often the relative position of the region with respect to the rest of the world which is – exclusively or additionally – important for economic development.

vi) It is worth stressing that the attractiveness of a region is a combination of many factors. It is the optimal combination of all policy instruments -- taking geography, history, initial endowment in capital and labour and the initial state of development into account -- which will make a regional policy successful or not.

Although global and structural factors play an important role, long term growth and development are not destiny, but can be influenced by political framework conditions and wise policy decisions. Put in other words: policy matters for regional growth, a regions’ policy as well as the national one.

This study is part of the research program «Policy and Regional Growth» of BAK Basel Economics. We will continue this research program and extend the analysis further in several directions. The most important extensions will be the inclusion of the labour market side in the next research step. Furthermore, the database will be expanded substantially, covering additional regions as well as indictors for location factors. Results can be expected in the summer or autumn of 2006.

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1 Introduction

Globalisation and decentralisation are challenging regions' capacity to adapt and improve their economic competitiveness. It is at the regional level that the pressure to maintain economic growth and social development is felt most. The «IBC BAK International Benchmark Club»®, established in 1998, is a setting to help regions and regional decision makers to cope with this challenge. Its goals are to advise governments, administrations, trade associations, foundations and companies at the national and regional level on matters of business location quality and economic policy.

The most important tool developed and applied by the «IBC BAK International Benchmark Club»® is the Clubs' unique database. The IBC database is unmatched in Europe in terms of both regional and sector-specific differentiation and data actuality. Currently, it covers up to 400 regions with 64 business sectors per region and annual data from 1980 to 2004. It is regularly extended and updated. Apart from indicators of economic performance, the database includes quantitative measures for several location factors and framework conditions.

This database allows the Club's members to assess in detail the strengths and weaknesses of their region, to benefit from the experiences of other regions, and to benchmark themselves against other regions. Benchmarking is a means to compare and assess the multitude of regional location factors and the success of national and regional policy strategies in using a region's potential. Since regions tend to be more specialised than countries, the "right" set of location factors that satisfies the needs of firms and people is particularly difficult to find.

But benchmarking is only one approach to support regional decision makers. The extension of the IBC database development allows another approach as well. The goal is to identify using econometric methods the quality and quantity of the impact location factors have on regional growth. A variety of empirical studies on the subject are available, but they are usually based on country data or focus on regions in a single country.

In 2003, BAK Basel Economics started a research program under the heading «Policy and Regional Growth»[1]. The aim of this continuing project is an empirically sound contribution to the discussion of location factors and economic growth. It focuses on the regional perspective with a multi-country coverage. The project is an integral part of the international benchmarking of regions. The results of the first phase of this project were presented to the public in July 2004. The report presented here documents the results of the research conducted in the period 2004/2005 within the ongoing project.

Since the first phase (2003/2004), the theoretical and empirical background of the research has improved considerably. Unlike for the first phase, the availability of time series for the quality of location factors allowed the use of panel data estimations. Moreover, with the introduction of more regions into the data set, the reliability of the estimations has increased. Regions not only from Continental Europe but also from Great Britain and Scandinavia with different economic and institutional backgrounds were introduced. Given the specific Swiss problem of low productivity growth, the second phase focused on productivity rather than GDP growth.

The report is organised as follows. In Chapter 2, we provide an overview of the research framework. The first section reviews the theoretical growth literature and the second section sums up the empirical research available on the topic. The third section of the chapter develops a stylised model as guideline to the empirical analysis and basis for formulating hypotheses. In Chapters 3 and 4, the data as well as the econometric procedure followed is presented. Chapter 5 illustrates the results of the empirical analysis. In Chapter 6, the results are summed up with respect to their policy implications. Further on, an outlook to forthcoming issues of the research agenda «Policy and Regional Growth» is given.

2 The Research Framework

2.1 Approaches to model economic growth

2.1.1 Classical Growth Theory

The central feature of the growth theory developed by Solow (1956) and Swan (1956) is the neo-classical aggregate production function. The key consequence of this specification is constant returns to scale, diminishing returns to each input (labour and capital) and exogenous saving rate. Cass (1965) and Koopmans (1965) integrate Ramsey's intertemporal household maximisation behaviour to the Solow-Swan model and provide an endogenous determination of the saving rate. Nevertheless, this does not alter the outcome of the Solow-Swan model, namely that the saving rate – and therefore physical capital accumulation – can deviate from the long term growth path only through short term dynamic effects before reaching the long run steady state path again. Therefore, growth rates revert back to their steady state rate as well. As a result, any policy action on the saving rate will affect output growth only in the short run. But the underlying long run steady state growth rate remains determined solely by the growth rate of technological progress, which is an exogenous parameter. In these models, technological progress is essentially not explained, but rather considered exogenous. This is the major drawback to the neo-classical growth model.

The regional version of the neoclassical growth theory (Siebert, 1969, Richardson, 1973) rests on the same framework and assumptions as the Solow-Swan model of decreasing returns to the single accumulated factor, physical capital. A higher capital stock implies lower returns to capital and therefore less output per unit capital than previously, after adding a unit of capital. In addition, neo-classical regional growth models put particular emphasis on factor mobility. Capital and labour move from one region to another until the marginal products are equal among regions. Regarding physical capital, this leads to fewer incentives to invest in regions with a higher per-capita income which is associated with a higher (per-capita) capital stock. By the same token, outflow of labour input from a region hit by an adverse shock into another region decreases the (per-capita) growth rate of the destination region because of diminishing returns. Finally, all regions have access to the same state of technology because there is perfect diffusion of knowledge.

Three consequences based on these key assumptions can be derived. First, convergence among regions must be observed. Poorer regions grow faster than more advanced regions due to diminishing returns to physical capital. Physical capital accumulation is the driving force of growth and it is more attractive to invest in poorer regions. If regional economies are open, migration of labour and free capital flow can even speed up the convergence process. Second, neither spatial structure nor historical events have any implication on the long term growth path of a region. Third, there is no room for policy makers to shape the long run steady state growth rate of a region, and regions convergence mechanically any way[2]. Barro and Sala-i-Martin (1991) and Sala-i-Martin (1996) estimate a convergence speed of about 2% across countries with strong empirical regularity among regions in the world. However, Quah (1993) criticises this convergence measure and evidence of this process of unconditional convergence has weakened in the most recent decades (Bassanini and Scarpetta, 2001).

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[1] Results of the project also appear under the heading „Regional Growth Factors", Regionale Wachstumsfaktoren" and „Politik und Wachstum".

[2] Apart from changing the exiguously given technological progress.

2.1.2 Endogenous Growth Models

A new stance of economic growth thinking emerges with Romer and Lucas in the late 1980s. The assumption of diminishing returns of factor inputs is relaxed and the long run technological growth rate is determined within the model. Therefore, steady state output growth itself is not exogenously defined, but rather endogenously determined within the model giving rise to the designation: endogenous growth model. Knowledge spills over across producers and external benefits from human capital result in increasing returns for factor inputs. As capital accumulates over time, there is no tendency to slower growth in this class of models. Human capital accumulation, characterised to be non rival, makes one single firms' know-how spread over the entire economy (Lucas, 1988), generating a positive externality and allowing increasing returns to scale. The basic ingredients of a Solowian aggregate production function remain, but capital becomes a broader concept including human capital. Another way to introduce increasing returns to scale is through positive intertemporal spillovers within a production unit. Arrow (1962) in his pioneer study observed learning-by-doing effects. As firms produce goods, they improve the production process over time and lower the cost of production. Incorporating this microeconomic observation into a macro growth model framework was the seminal breakthrough in growth theory (Romer, 1986). Finally, in models incorporating research and development theories, monopolistic competitive firms innovate to gain a form of ex-post monopoly power which maximises their profits (Romer, 1990, Grossman and Helpman 1991, Aghion and Howitt, 1992). Due to monopolistic competition the innovation activity tends to be pareto sub-optimum. Hence, in these endogenous growth models, there is room for policy makers to improve the level of innovation activity. In turn, this could increase the steady state growth path. In this type of model, politically defined location factors can positively influence the economic growth path.

2.1.3 New Economic Geography

The growth models discussed above did not include any spatial dimension; the complete economy is concentrated in a single spot. The incorporation of the spatial dimension in economic activity is the core element of the New Economic Geography (NEG) (Krugman, 1991; Venables and Krugman, 1995; Fujita, Krugman and Venables, 1998). The development if NEG started from the stylised facts. In the USA, production activity is concentrated in about 2% of the country's land area (Ciccone and Hall, 1996). While the comparative advantage and the decreasing returns to scale framework of the Ochser-Ohlin-Samuelson type model fails to explain the uneven geographical distribution of economic activity, the NEG rationalises this stylised fact. In the basic NEG model, starting with a symmetric equilibrium between two regions, an uneven shock will lead to forces which make the two regions end up with a core–periphery pattern.

Three basic forces can be identified in the NEG which lead to this pattern. First, there are increasing returns to scale. Most often, transportation cost or fixed costs of production are the rationale behind this. Second, agglomeration effects refer to the advantage of larger markets. While not itself the trigger of spatial diversity, it can drive concentration far beyond what increasing returns to scale alone would be able to do. Third, externalities of different kinds can drive concentration as well. These three forces are discussed in more detail below.

The transport of raw material, intermediate goods and final goods causes transport costs. Typically, depending on the transported good, the costs of transport increase with distance. Hence, the shorter the distance the goods need to be transported from one stage of the production to another during the production process as well as to the final consumer is, the lower the costs of production. As a result, concentration of production in one location and/or close to the final consumer leads to increasing returns to scale. Depending on the goods in question, transport costs could be relatively important. A good illustration is the location of steel mills close to coal mines because the transport over long distances of the large quantities of coal needed in the production of steel would be very costly.

The second cause for increasing returns to scale given in the NEG is fix costs. In industries with fixed costs, the larger the output produced, the more the fixed costs can be spread out decreasing the fixed costs per unit of the goods produced. The average cost curve decreases with increasing production. The growing output of firms leads to economies of scale which is equivalent to increasing returns to scale. Large fixed costs and hence economies of scale are prevalent in highly capital intensive industries such as chemicals, petroleum, steel and automobiles, i.e. in manufactured goods with high value added.

Due to increasing economies of scale, the production of a good tends to concentrate in one region. Even so, there is no ex ante comparative advantage of the region to produce these goods. Any asymmetric shock will lead to a difference in production costs per unit and ultimately to a concentration of the production in one region. As long as there are no linkages through common intermediate products of high transport costs for the final product, there is no reason that different good should locate in the same region. Increasing returns to scale can explain the concentration of an industry in one region, but not necessarily a core-periphery pattern.

Forces driving the regional distribution of economic activity much more in the direction of a core-periphery pattern are agglomeration effects. These effects do need increasing returns, but the force driving the concentration is not directly through cost savings. This phenomenon is highlighted in Krugman (1991) and Venables (1996) stressing the importance of demand linkage as well as forward and backward linkage in a monopolistic competitive framework with increasing returns to scale. Supposing labour mobility is relatively important, a firm which moves to one region will attract the adequate labour force to the region as well. The extra wage yield by the labour input will be spent locally. This new expenditure increases the local demand for goods, again attracting more firms (demand linkage, Krugman, 1991). Supply and demand move positively side by side (circular causation).

Moreover, the size effect of the labour market and the intermediate inputs market leads to a positive effect (cumulative causation). The larger the variety in terms of quality and specialisation of intermediate inputs the more efficient the production of goods could be organised (forward and backward linkage, Krugman and Venables, 1995; Venables, 1996). The same kind of reasoning holds true for quality and specialisation of labour input.

The effect in the paragraph above works through the market size and is therefore considered part of the agglomeration effect. But indeed it is a positive external effect; demand of one firm causes further specialisation of inputs. Other firms profit from this. They experience a positive external effect of the demand decision of the first firm. But it is not the only positive external effect possible. Positive external effects build the third class of driving forces behind the regional concentration of economic activity in NEG.

One such external effect is localised technological spillovers. The new regional growth theory, which combines endogenous growth models (dynamic aspects) with the NEG (spatial aspect), especially sheds light on the effect of these externalities. Intertemporal knowledge spillovers are limited to the local environment. In Martin and Ottaviano (1996) the local externality results from the wide range of service and input differentiation available to labs. The presence of one more firm gives labs access to a wider range of services and inputs without any additional costs. As innovation is cheaper locally labs innovate at a faster rate and some labs relocate from neighbouring regions. Faster innovation and more labs, in turn, increase the local demand for intermediates and, therefore, attract more industrial firms. Thus, labs follow firms and firms follow labs (circular causation). In the same stance, Baldwin and Ottaviano (1997) present a model where R&D activity uses labour to invent patents which are non tradable but infinitely living. As a result, production occurs where invention takes place. The externality comes from the variety of patents concentrated in one place. The large variety of patents has twofold consequences. First, the invention of new patents is cheaper and second, the production of high tech goods is more efficient. Fujita and Thisse (2003) core-periphery pattern end up with all the R&D sector and most manufacturing sector concentrated in one region. To conclude, growth is positively influenced by spatial concentration because of localised spillovers, the so-called «geography of ideas».

Localised human capital spillovers work much in the same way in fostering human capital accumulation locally as localised technological spillovers do for innovation. The diffusion of knowledge is geographically and spatially concentrated. Learning in a local environment creates its own distinct agglomeration force called «learning link circular causality». Because human capital accumulation has been identified as an engine of growth just as physical capital is, agglomeration of skilled labour input reinforces growth. As a result, knowledge agglomeration increases the rate of growth and leads to a geographically uneven distribution of economic activity.

To what extent are technological and human capital spillovers spatially localised rather than global? Lucas's (1988) seminal view of human capital spillovers does not investigate the question whether the spillover effect dies out as distance increases. He supposes human capital know-how spreads over the entire economy without restriction. However, in the regional endogenous growth theory, Martin and Ottaviano (1996) as well as Baldwin and Martin (2003) show that, ceteris paribus, if knowledge capital spreads over to other regions, the agglomeration effect disappears. Global spillovers of technology and human capital make the core-periphery equilibrium unstable and might trigger a sudden industrialisation of the follower region leading to a convergence process.

In opposition to neo-classical regional growth theory, transport costs (costs to overcome space) play an important role in the new regional growth theory. Agglomeration effect stems from transport costs and increasing returns to scale in static models (Krugman, 1991; Krugman and Venables, 1995; Fujita, Krugman and Venables, 1999) as well as in dynamic models (Walz, 1996b; Martin and Ottaviano, 1996; Baldwin and Martin, 2003). It is crucial to distinguish between intraregional and interregional transport and between transport of intermediate goods, final goods and the transport of labour (Walz, 1996a). Improvements in overcoming space (transport) can have the opposite effect on the activity of a region whether the region belongs to the periphery or not. Higher interregional transport costs strengthen the agglomeration effect by making production more costly if productive units are spatially dispersed (intermediate inputs and final goods). It makes sense to concentrate production of intermediate and final goods in the core region with the highest number of customers. But high transport costs make exports from the core region to the periphery costly as well. Consequently, high transport costs have also a centrifugal force; it makes the location of additional producing firms in the periphery worthwhile. High transport costs protect the local industry from competition out of the core region (Krugman 1991). These opposite effects of transport costs lead to non linear relationship between transport costs and specialisation patterns (Krugman and Venables, 1995) and therefore transport costs and growth rates (Walz, 1995b). In almost all models, the first effect (centripetal) outweighs the second (centrifugal) when reducing transportation costs; the core region grows even faster. In the win-lose game framework of the NEG, it is the interest of the periphery region to maintain high interregional transport costs. This outcome is attenuated in the new regional growth theory models (Walz, 1996b; Martin and Ottaviano, 1996; Baldwin and Martin, 2003). Even so, the core-periphery pattern remains. The periphery can benefit from the huge crowding activity of the core region, especially if interregional transport costs are sufficiently low and technological spillovers from the core are sufficiently important (Martin and Ottaviano, 1996). Besides, if core and periphery are close to each other, with lower interregional transport costs, the periphery can be integrated into the core region. As regards the intraregional transport cost, whatever the feature of the region (periphery or core), it is unambiguously in the interest of the region to develop local infrastructure in order to enhance the efficiency of the production structure between production units.

Interregional labour mobility is a key aspect of the NEG and the new endogenous growth theory. Suppose one firm moves to the core region, but the labour mobility is low. Consequently, the labour supply does not follow the firm, and the demand linkage a la Krugman collapses. Furthermore, the relative shortage of labour will increase wages, driving costs up in the region the firm moved to. As emphasised by Ottaviano and Thisse (2002), low interregional labour mobility weakens severely agglomeration effects. This theoretical result seems to be empirically grounded. Indeed, in European regions, production is spatially more dispersed and wage differentials are more pronounced than in the USA. Labour mobility is higher (Blanchard and Katz, 1992) and economic activity is more spatially concentrated in North America. In a NEG spatial framework where regions win at the expense of other regions, regional policy makers of a peripheral region should rather not invest in interregional transport of labour. Restrictions on labour mobility have been considered a policy instrument to prevent undesired agglomeration. During the negotiations on Eastern enlargement, the European Commission negotiated an escape clause to the free mobility of people inside the EU[3]. Although high transport costs and low interregional labour mobility help maintain even economic activity across regions, it is at the expense of overall growth and welfare once both regions are considered together. This key element is absent in a NEG spatial win-lose framework but present in endogenous regional growth theory.

2.1.4 Regional Innovation Systems

Lately, a new approach has developed in the literature. Although far from providing as mathematically formulated models and proofs as the models presented above, the developing Regional Innovation Systems approach provides a variety of interesting thoughts for a study of regional growth factors[4].

An advantage of the approach is that it is based strongly on stylised facts and accepts the variety of processes and influences, including the given the starting point of a region as well as the institutional framework and policy decisions. It is not surprising that the ‘Regional Innovations Approach’ has a strong roots in case studies, and many contributions to the ‘Regional Innovation Systems’ approach are indeed case studies and only first steps toward a consistent and testable framework have been done. Therefore, a ‘disadvantage’ of the ‘Regional Innovation Systems’ approach for an empirical studies lies in the variety covered instead of a general model. No clearly accepted hypotheses have evolved, at least not yet, which would allow empirical testing. Still, the ‘Regional Innovation Systems’ approach is a valuable source when analysing regional growth factors.

Figure 2-1 gives an idea of the framework of thinking of Regional Innovation Systems. It highlights the diversity of (possible) systems and emphasises the importance of institutional settings. Some of the most important issues to be taken into account when analysing a Regional Innovation System are:

- Interactions among enterprises: Joint R&D or other innovation activity of two or more firms, sometimes including a «bridging» institutions (public technology transfer institutions (TTI) or knowledge intensive business services (KIBS))
- Public-private joint research: Interactions between enterprises and public research institutions (universities, research institutes), direct or indirect via bridging institutions
- Market-based technology diffusions: Acquiring of codified knowledge and technology by enterprises incorporated in machines or licenses from other enterprises
- Transfer of knowledge via mobility of employees: Not only the flow of people between jobs and firms, but also back and forth to the educational system, public research institutions and specialised private R&D institutions.

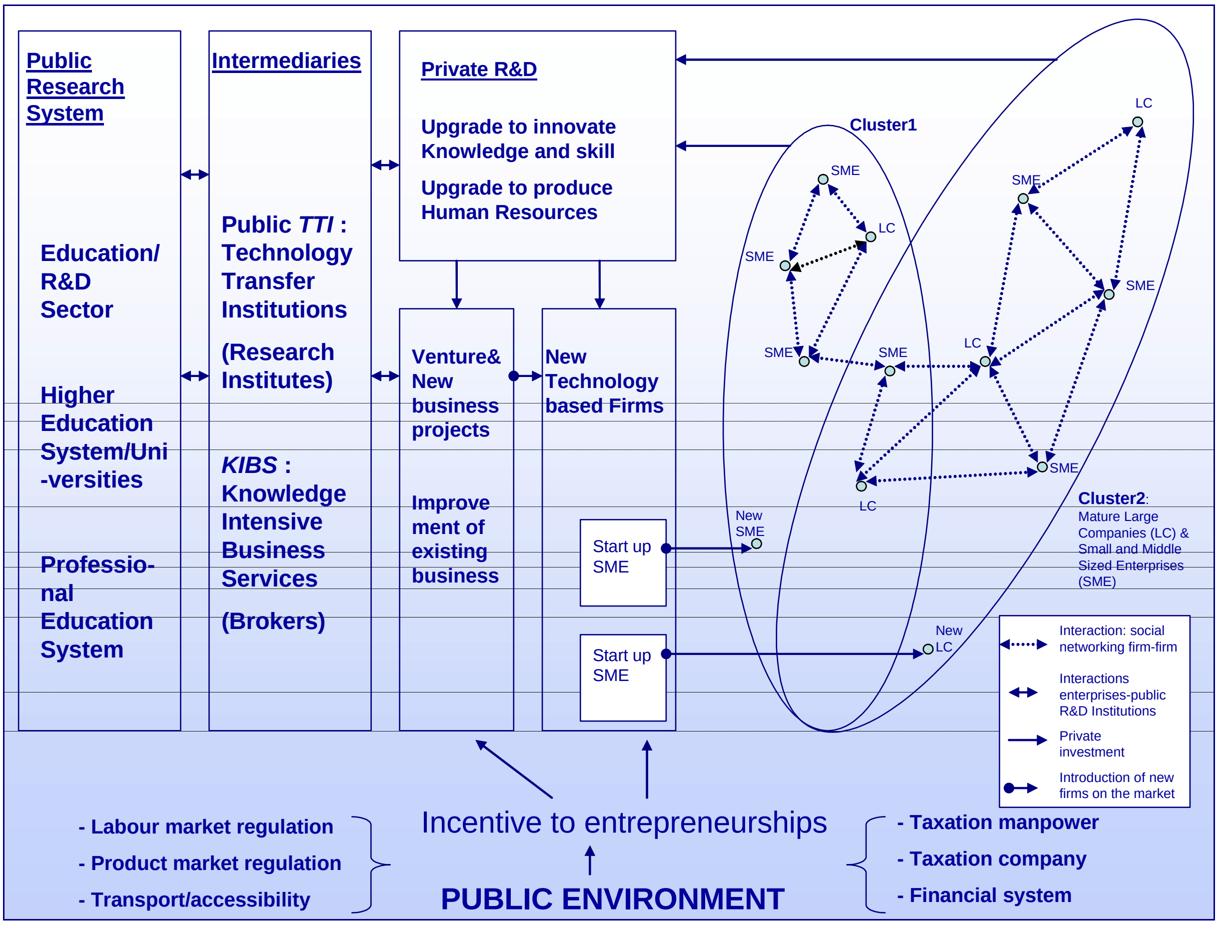
With these (and many other) issues in mind, different types of innovation systems can be identified and described. The most obvious distinction is seen between the more Anglo-American type and the type more prevalent in Germany and Scandinavia. The more traditional Regional Innovation System,

[3] Although, of course, the driving forces behind this escape clause were not the peripheral regions in Europe and the reasoning does not have been descended from the NEG kind of reasoning.

[4] See for example Braczyk, Cooke and Heidenreich (1998); Cooke (1998), Freeman (1995); Holbrook and Wolfe (2000); Keeble and Wilkinson (1999); Niosi (2000); OECD (2001b); Porter (1998a); Porter (1998b); and Porter (1990). The summery presented here is based on this literature as well.

called Institutional Regional Innovation Systems (IRIS), relies on the positive effects of systemic relationships between the production structure and the knowledge infrastructure. These are embedded in a regional networking governance structure and supported by regulatory and institutional frameworks at the national level. In contrast, the so-called Entrepreneurial Regional Innovation System (ERIS), observed more often in the USA and UK, rely on the privately organised and less formal interactions between local venture capital, entrepreneurs, scientists, market demand and incubators to support innovation that draws primarily from an analytical knowledge base.

Figure 2-1 Regional Innovation Systems



Source: BAK Basel Economics

While the 'Regional Innovation System' can not be tested directly, the ideas provided are kept in mind when formulating the hypotheses for the empirical test. At the end, it might be possible to indirectly identify more and less successful Regional Innovation Systems.

2.2 Location factors and growth: overview of empirical results

Apart from theoretical work and case studies, a variety of studies analyse the determinants of economic growth empirically. Most of this research relies on country data, either in cross country level or in a panel data setting. Although different from regional analysis, they often use similar methods and offer benchmarks for the results from the regional analysis. The following chapter provides an overview of this literature and its results.

The studies can be organized along several lines. First of all, as said, most of them use variation across countries. They can be further distinguished by the kind of countries selected: low developed countries, developing countries, high developed countries or a mix of these. There are, as well, studies focusing on (sub-national) regions. Most of them consider regions only from one country, but in a few cases, the regional studies have an international coverage as well. Second, the studies differ in what they attempt to explain. The three most important versions are GDP growth, productivity growth or productivity level. But some studies focusing, for example, on income or average wage level can also be considered as part of this literature. Finally, there are methodological differences. The most important is probably the use of cross-sectional approaches or of panel data.

Table 2-1 Selected empirical studies explaining growth

Study	Method			Explained	Explaining							Note
	econometric	geography	time		Educ	R&D	Tax	Regulation PM	Regulation LM	Acces.	others (selected)	
Ahmed, Miller, 1999	OLS, FE, RE	industrialized countries	panel, 76-84	productivity growth	**+**						investment ==> **0** tech. Progress ==> **+**	study includes different results for low and medium developed countries
Barro, 1991	cross-section	98 countries	60-85	GDP per capita growth	**+**						convergence government consumption ==> **-** public investment ==> **0** political stability => **+** market distortions ==> **-**	
Barro, 1998		100 countries	panel, 68-90	GDP per capita growth	**+**						rule of law ==> **+** government consumption ==> **-** life expectancy ==> **+** fertility ==> **-** democracy ==> **+** inflation ==> **-** conditional convergence is found	
Bassanini, Scarpetta, 2001	Panel VECM	OECD countries	panel, 71-98		**+**	**+** (business only)	**-** (total revenue)				accumulation physical/human capital ==> **+** good macro policy ==> **+** trade openess ==> **+** development of financial markets ==> **+**	
Bleaney, Gemmell, Kneller, 2001	static and dynamic panel with individual intercept, instrument variables	OECD countries	panel 75-95	GDP per capita growth			**-**				consumer tax ==> **0**	testing short and long term effects of fiscal policies
Ciccone, Hall, 1996	OLS, instrument variables	US states	cross sect., 88	productivity level	**+**						density ==> **+**	
De la Fuente, 2002b and 2003		Spanish regions	panel, 90 years	GDP growth	**+**						EU structural fund spending on investment in physical/human capital ==> **+** (but weak)	
De la Fuente, Doménech, 2002	different panel approaches	21 OECD countries	panel, 60-90	various specifications (growth)	**+**							uses different mesures for educational attainment
Dewan, Hussein, 2001	OLS, FE, RE	41 developing countries	panel, 65-97	GDP growth	**+**						good macro policy ==> **+** investment in physical capital ==> **+** open trade policy ==> **+**	
Gust, Marquez, 2002	various	13 industrialized countries	92-99 panel, cross-section	productivity growth		**-**			**-**			via adaptation of IT relatively short-term effects
Gustavsson, Persson, 2003	2SLS	Swedish regions	panel, 11-93	per capita income growth							regional spillovers exist density ==> **+**	
Hall, Jones, 1998	OLS	127 countries	cross-sect.	productivity level	**+**							
Kaldewei, Walz, 2001	pooled OLS	EU NUTS2 regions	panel, 80-96	GDP per capita growth	**+**					**+** (trans-port costs)	agglomeration ==> **+** population density ==> **+** development of financial sector ==> **+** conditional convergence is observed	
Krishna, 2004	FE	Indian states	panel, 60-00								results inconclusive, but divergence observed share of agriculture increases growth in industry/services	
Mankiw, Romer, Weil, 1992	cross-section	98 countries, subsamples: 75 good data, 22 OECD	60-85	GDP per capita 85, change GDP per capita 60==>85	**+**						(conditional) convergence	
Moreno, Artis, Lopez-Bazo, Surinach, 2000	GLS	Spanish regions	panel, 64-91	productivity growth							infrastructure investment ==> **+** (results weak)	
Nicoletti, Scarpetta, 2003	panel (FE) with country and industry dummies	18 OECD countries	84-98	productivity growth	**+**			**-**			behind the technical frontier ==> **+** (≈ convergence)	different regulations have different effects effects differ for industries (production ≠ services)
OECD, 2001	correlation analysis	regions in EU15	cross-section	GDP per capita	**+**	**+**					patents ==> **+**	second education has a stronger effect than tertiary education
Vaja, Lopez-Bazo, Artis, 2000	OLS	108 EU regions	panel, 75-92	labour productivity growth							regional spillovers (from demand and supply side) are important	

Source: BAK Basel Economics

Two different aims of the studies are often found. A substantial part of the studies tries to test hypotheses from the New Economic Geography. The other top topic is the discussion on convergence or divergence. Especially the latter ones often provide useful hints for our research, as convergence in these studies is often conditional convergence – convergence given all other variables influencing growth. Therefore, the estimations regularly include control variables which are often the locations factors we like to test.

Typically for country studies – and for the results from country studies – are the findings of Barro (1998) who uses a panel of roughly 100 countries over the period 1971 to 1998 to determine the drivers of long-run GDP per capita growth. One of the results is that a better educated labour force enhances economic growth. Further, the findings highlight that the better maintenance of the rule of law, smaller government consumption, longer life expectancy, lower fertility rates, and improvements in the terms of trade all increase growth. The estimations also point out that democracy (political freedom) supports growth, while extensive inflation does the opposite. Finally, the hypothesis of conditional convergence is supported. Hall and Jones (1998) show in a cross-section approach with 127 countries that education does also increase the productivity level in a country. A positive influence of education can be presumed for GDP growth in developing countries as well (Dewan and Hussein, 2001). They also show that good macroeconomic policy, investment in physical capital and openness to trade all increase GDP growth. But this does not mean that the factors supporting growth are identical for developing and highly developed countries. Ahmed and Miller (1999) show in a panel setting of 93 countries, that separating the sample into low, medium and high income countries yields different results for the determinants of GDP growth. While in low income countries investment is the driving force, this does not play a significant role in explaining growth in high income countries. Rather, technological change is the driving force. Although this result is challenged, for example, by a study of Bassanini and Scarpetta (2001) who find a significant positive impact of the accumulation of physical capital in a sample of OECD countries, it clearly shows that results derived from a sample of less developed countries – or a mixed sample – must not necessarily correspond to results for highly developed countries. For OECD countries, Bassanini and Scarpetta (2001) report that apart from physical capital human capital accumulation, good macroeconomic policy, trade openness and well-developed financial markets all do help increasing growth in highly developed countries.

Fewer studies put their attention on the regional level, although from a theoretical view, regions are at least as important as countries in analysing growth performance. This lack of empirical studies is probably due to the data limitations. In most cases, research putting its attention on regions is empirically limited to the regions within one country, as data limitations are easier to overcome. Krishna (2004) analyses the patterns and determinants of economic growth in Indian states. Although the results are not stable enough for final convincing conclusions, there is some indication of divergence. Furthermore, a high share of the agricultural sector seems to foster growth of the industrial and service sector. Again, these are results for a developing country which should not be directly transferred to highly industrialised countries. In a series of research papers, De la Fuente (2002, 2003) explores GDP growth in Spanish regions using a panel setting. The main interest is on testing the impact of EU structural fund spending on growth. The funds do support growth, regardless of the money spent on investment in physical or in human capital. This result supports the positive impact of education of the labour force as well. Moreno, Artis, Lopez-Bazo, Surinach (2000) support the finding of significant positive growth contributions of infrastructure investments in Spain.

Examples for studies more concentrated directly in regional interactions are Ciccone and Hall (1996) for the US and Gustavsson and Persson (2003) for Sweden. Both studies identify a positive effect of density on growth. Furthermore, Gustavsson and Persson (2003) identify significant and stable spillover effects between neighbouring regions. In the latter study, the influence of education on growth is not controlled for, while Ciccone and Hall (1996) find a positive effect of the education level of the labour force on the productivity level.

The importance of regional spillover effects can also be confirmed in an international setting using a panel of 108 EU regions for the period 1975 to 1992 (Vaja, Lopez-Bazo, Artis, 2000). They distinguish between supply side spillovers, approximated by the initial level of the neighbours' GDP, and demand side spillovers, measured by the growth of the neighbours. Both kinds of spillovers are significant and contribute positively to growth, although demand-side externality seems to be stronger than supply-side externalities.

With a sample from 1980 to 1996 and using regional data at the NUTS-2-level from EU countries, Kaldewei and Walz (2001) investigate an empirical study very close to the one presented here. The econometric methodology is of the easiest one: pooled OLS to explain GDP per capita growth. The average growth rate of GDP per capita depends positively on the accumulation of human capital, the agglomeration effect, transport costs (or access to market), financial sector development and negatively on migration, population density and population size. However, regional knowledge spillovers (approximated with the number of patents) and regional transfers are not significant. To control for industrial structure, they include the share of employment in agriculture and share of employment in the service sector. Finally, they investigate the beta convergence hypothesis (absolute and conditional) and find evidence for it although lower than 2 percent.

Summing up, methodologically only few studies can be compared to the research presented here. Although panel data approaches are common, few studies have data sets available with enough power for more sophisticated approaches. Much more important are the differences in the sample setting. The vast majority of studies either use country data or are limited to regions within one country, while we are able to use a regional dataset with a multi-country coverage. This is important as most theoretical approaches assume a functional urban area or something more or less equivalent as regional unit, which are not countries. On the other hand, analysing regions within one country limits the variability of the location factors we are interested in substantially; possibly to the degree that no effect can be identified. Furthermore, only few of the locations factors in the centre of interest in our studies are available and/or tested in other studies. Among the locations factors of interest – introduced in detail below in Chapter 3 – in the areas of innovation (education level, R&D expenditures), taxation (companies, manpower), regulation (product market, labour market) and accessibility, it is only the average educational level of the labour force which is regularly included in the studies and usually has a positive impact on growth. For the other locations factors, the evidence available is not yet conclusive. But these are the factors of interest to (regional) policy makers, as these are the factors they can influence, while convergence or regional spillovers are mostly outside their influence and not available to support regional growth.

2.3 Drivers of regional growth: a stylised model

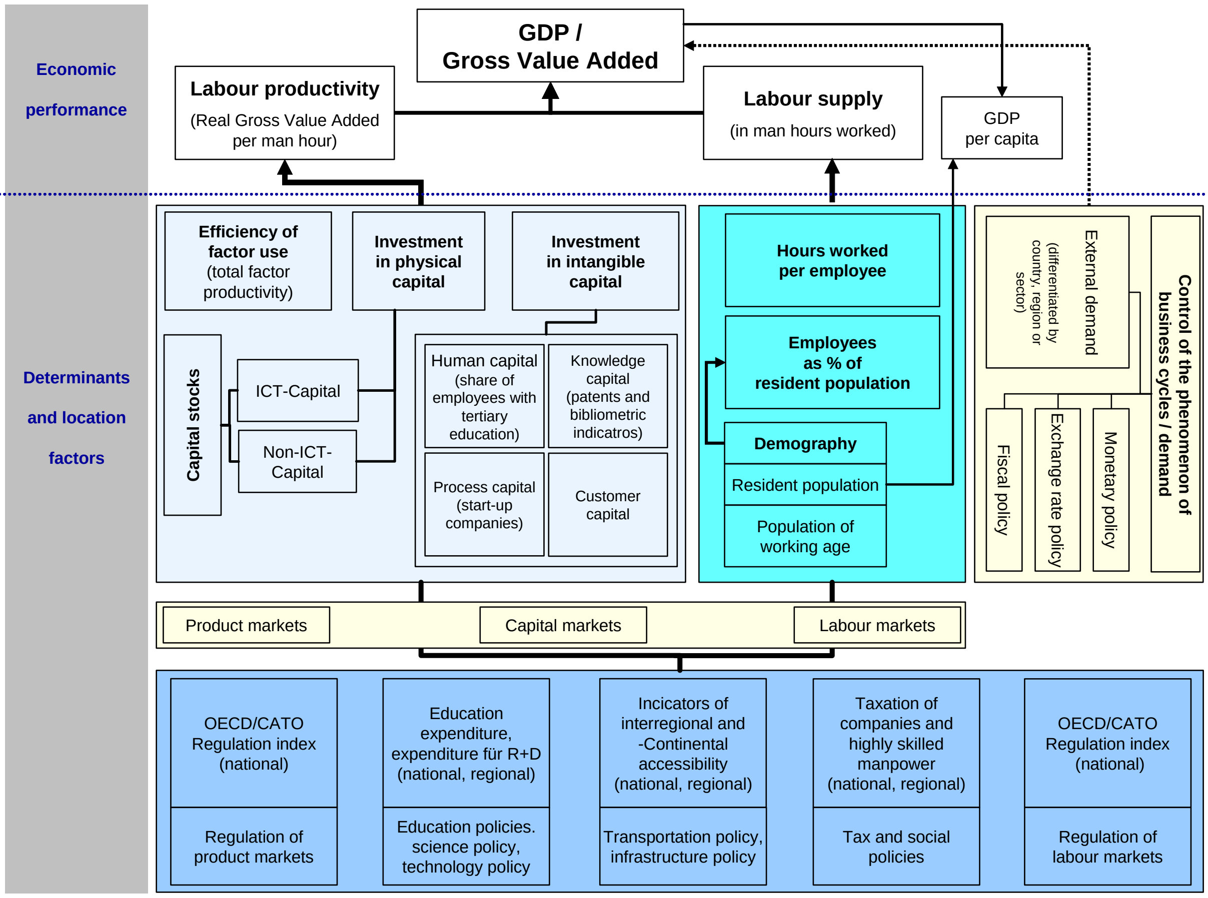
2.3.1 Analytical framework

The research is based on a framework of thinking presented in Figure 2-2[5]. As can be seen, policy variables have several separate transmission paths to influence economic performance. Different markets and a variety of accumulation processes play an important role. Thereby, it is not guaranteed that a policy variable influences growth in the same direction through all transmission mechanisms. For example, consider a regulation forcing employees to a certain amount of continuing education. On the one hand, this lowers the labour input available for production and, therefore, influences economic performance negatively. On the other hand, continuing education increases the human capital available. Therefore, productivity increases and economic performance is positively influenced. Theoretically, the direction of the total effect is unknown. Only an empirical investigation can answer the questions about direction and size of the effect of policy variables on economic performance.

5 We are very grateful to the BAK Scientific Advisory Board and especially Prof. Bart van Ark for their input in developing this framework.

The project uses estimations in reduced forms. Therefore, the different transmission mechanisms of a policy can not be evaluated separately[6]. Only the total effect of a certain policy is at the centre of interest. One step in the direction of separating transmission mechanisms is to use individual estimations for productivity growth and labour input changes instead of one estimation with GDP growth as left hand variable. Besides the special interest in productivity in Switzerland, the separation of transmission mechanisms was a reason for choosing this approach. The results presented in this report focus on the effects for productivity growth[7].

Figure 2-2 Analytical framework



Source: BAK Basel Economics

This framework of thinking is very helpful in understanding policy influences on growth, but a more formalized model would help to formulate hypotheses to be tested empirically. Based on the thinking outlined in Figure 2-2, the remaining of this chapter will start to develop such a model.

2.3.2 Growth model: based on a production function

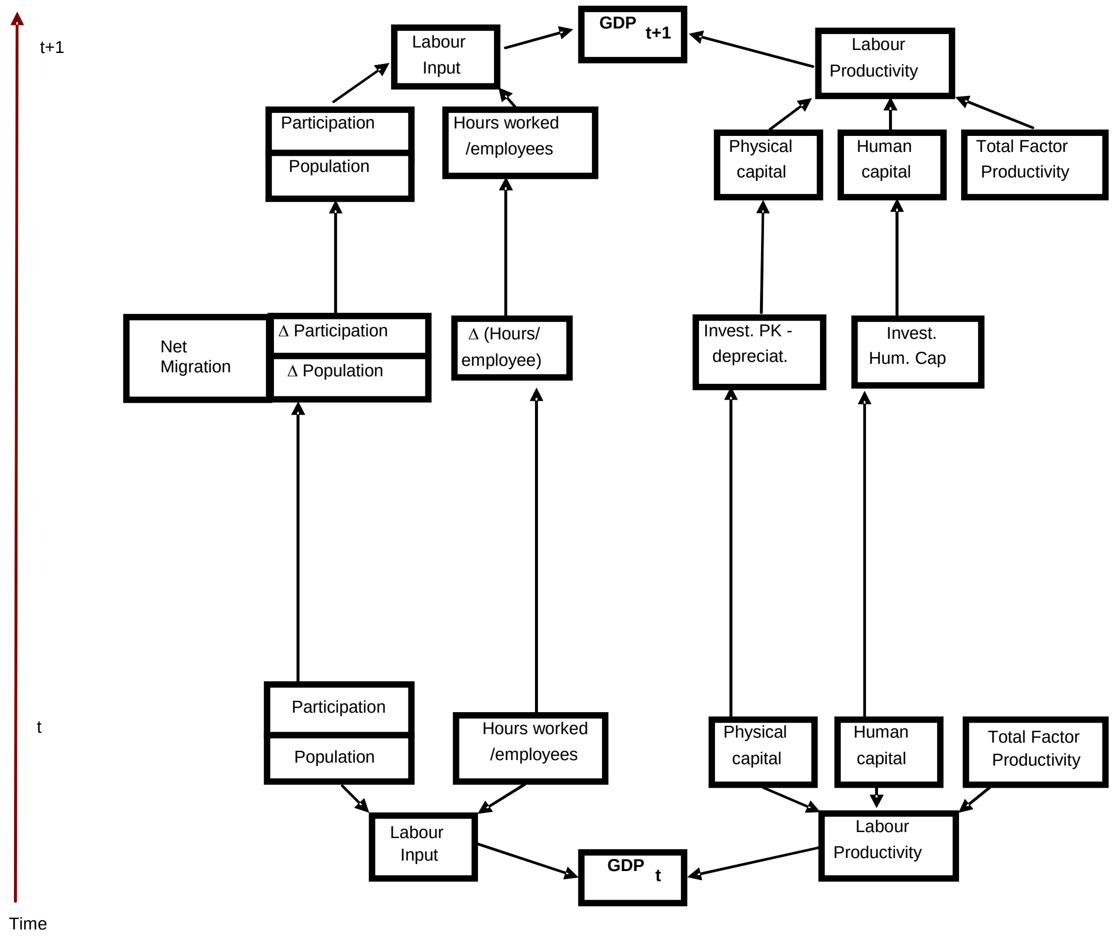
Most growth models are based on an aggregate production function which asserts a stable relationship between aggregate output on the one hand, and labour input, the stock of physical capital, human capital and the state of technology on the other hand. From this perspective, the growth of output depends firstly on the growth rate of labour; secondly, on the accumulation of physical and human capi-

[6] A complete modelling and estimation of a system of equations would be necessary which is beyond the scope of the project as well as the power of the dataset as of today.

[7] The labour market side will be discussed in a separate report, available probably in summer/autumn 2006.

tal, and thirdly, on the speed of technical progress (determining the total factor productivity). Ultimately, the determinants of variation of these variables will determine the output growth rate.

Figure 2-3 Developing the model I



Source: BAK Basel Economics

The model developed here is based on similar relationships. Applying a production function approach, GDP in every period is divided into its elements labour input and labour productivity, and further divided into population, employment rate and hours worked on the one side and physical capital, human capital and total factor productivity on the other side. Between two adjoining periods various accumulation processes (or ‘change processes’ as they are not necessarily monotonistic) define the level of these variables at the following period which, in turn, define the GDP. Therefore, GDP growth is determined by the accumulation processes. Figure 2-3 illustrates this.

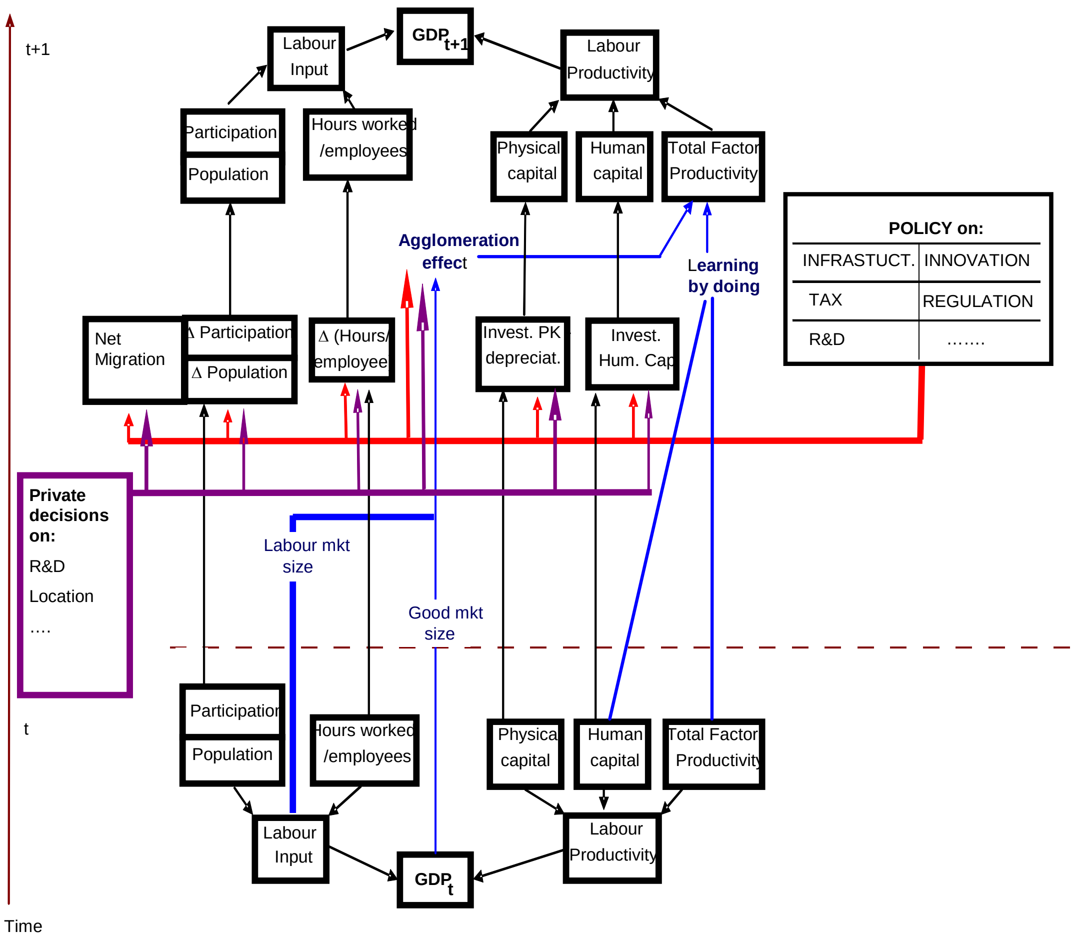
2.3.3 Growth model: policy influence

In a decentralised market-economy, the interaction between the consumers’ choice (maximisation of utility), the firms’ profit maximisation and the policy makers’ actions will determine the accumulation processes and, finally, the growth path of the economy. For example, the underlying utility preferences (parameters), and the consumer consumption path derived from the intertemporal maximisation problem (Euler equation) will determine the savings rate and, therefore, the level of investment (Ramsey, 1928).

The legislator can, however, substantially affect the savings behaviour by setting a favourable legislation: e.g. developing and encouraging pension funds by means of a favourable regulation and tax reduction schemes, etc. In the same way, the legislator can foster investment of physical capital by low corporate taxes or by developing the transport infrastructure.

Policy also influences the accumulation or changes on the labour market side of the model. The government can support children-friendly families to influence the fertility rate. The population development is also affected by migration policies. A more straightforward and quicker measure to increase labour input is to increase the participation rate. Indeed, the regulation framework can be changed to stimulate working incentives on the labour market. This can be implemented by increasing the retirement age and the legal weekly hours worked and by reducing the paid holidays, etc. Taxation policy is another issue to influence the incentives to increase labour input.

Figure 2-4 Developing the model II



Note: *Red arrows mark the influence of policy decisions on the different accumulation processes, pink arrows the influence of private decisions and blue arrows other influences not directly driven by decisions of agents.*

Source: *BAK Basel Economics*

An area heavily influenced by policy is human capital accumulation (see e.g.: Lucas, 1988; Mankiw, Romer and Weil, 1992). In line with the endogenous growth theory, to invest in human capital and innovation is probably the most effective way to foster growth in highly developed economies. The driving force is the accumulation of knowledge. The education policy is central to enhance labour productivity. Furthermore, an innovation policy that promotes R&D programs, research in universities, etc., has a direct effect on the rate of technical progress.

But the effect of education and innovation policy is not limited to their direct contribution in the diverse accumulation processes. In many endogenous growth models (see e.g.: Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992), the rate of technological change is a function depending on capital (human and physical) and labour. Consequently, all productive factors accumulation generates a positive externality which in turn fosters the speed of technological progress. This further increases the growth rate of output.

Figure 2-4 introduces these effects into the production function approach to explain growth. Policy influences as well as private decisions are schematically included. Although we will at this stage of the research program only estimate reduced forms – the influence of policy variables on (productivity) growth – it is clear from the model that we do not expect policy to influence growth directly, but rather indirectly through a detour through the several accumulation processes. An important implication is that there is no unambiguous mathematical relation between policy and growth in one period, but that policy needs time to affect the accumulation processes and finally growth. And there are no clear theoretical answers as to how long this ‘time’ might be. Which time lags are appropriate have to be left to the empirical analysis.

Two more issues are included in the model which do not directly link policy and the accumulation processes but are important as well, especially with regard to the external effects of human capital building and innovation policy. First, «learning by doing» refers to the observation that as firms produce goods, they improve the production process and get more efficient over time (Arrow, 1962; Romer, 1986). It can be considered a positive intertemporal spillover effect. Second, as the New Economic Geography shows, agglomeration does have the potential to increase growth due to economies of scale and positive externalities. The Agglomeration Effect reflects this: a larger market size leads to increased growth, and market size is determined by the production function in the previous period, but can be influenced by political decisions (e.g. market liberalisation) as well.

2.3.4 Growth model: spatial extension

The spatial concentration of economic activity is at odds with the traditional comparative advantage and decreasing return to scale hypotheses in the Heckscher-Ohlin-Samuelson framework. Marshall was the first to rationalise this reality by developing agglomeration economics. Agglomeration effects occur if the benefits to clustering are higher than costs.

Beginning with the benefits of agglomeration, we quickly refer back to the discussion of NEG (New Economic Geography). Suppose that the transportation of products involves costs that rise with distance. Concentrating the different production stages close to each other and close to the final market will reduce costs. In other words, production in one geographical region will have increasing returns. The higher the transportation costs are (in relation to total costs) the higher the agglomeration effects are (Ciccone and Hall, 1996). Furthermore, other forces increase the tendency to geographical concentration. As proved by Krugman (1991) and Venables (1996), in a monopolistic competition framework, circular and cumulative causation will strengthen the agglomeration effect by attracting workers and firms to larger markets. Demand linkages (Krugman, 1991) and forward and backward linkages (Krugman and Venables, 1995; Venables, 1996) are the driving forces. Finally, technological spillover between firms drives them to cluster if knowledge and technology is not distributed freely and immediately across space. Baldwin and Ottaviano (1997) prove the clustering forces of knowledge in a model with non-tradable patents. All three effects combined and, over time, drive the agglomeration effect in a self-reinforcing process. In a nutshell, as the market size of intermediate input, output and labour rises, the variety of goods and labour supply increases, improving the production process as well as the products themselves because of more specialisation and diversity.

As mentioned above, there are costs as well. We can separate two different kinds of costs. First, the costs which arise in the region in which the concentration takes place due to the fact of higher concentration – the agglomeration costs. Second, there are costs for regions which are not at the centre of the development and lose production, firms, labour and consumers.

Turning to the agglomerating regions first, the costs arising from higher concentration are the limiting factor to the concentration. Otherwise, the whole economy would concentrate in one single spot and geography would not matter in an economic analysis. For example congestion costs (traffic jams, crowded transports) are huge and land prices climb to prohibitive levels, worsening firms' cost. The agglomeration has negative impacts which at a certain level of concentration outweigh the positive spillovers and economies of scale.

As mentioned above, there are costs to other regions as well. The agglomeration effect in region i makes region j worse off especially in a NEG framework. The loss of firms, employment and market size makes production in region j more costly (implied by increasing returns to scale). Even if agglomeration costs prevent a complete concentration in region i, production in j is less productive and region j is worse off than region i, in absolute terms as well as on a per capita basis. Even if the outcome in a regional growth model is more attenuated in terms of growth rate (indeed the periphery can benefit from the huge crowding activity of the core region), the core-rich and periphery-less developed characteristic remains (Baldwin and Martin, 2003). There is clearly an asymmetric outcome in terms of activity location.

The model discussed above[8] does not yet include any 'space'. But as the discussion and the stylised facts show, space plays an important role in the economy and the economic development. We introduce space in a way that we focus our interest in the development of one particular region (i). This region has an individual production function with individual levels of inputs and accumulation processes. The infinite number of other regions is subsumed in another region (j) with its own production function and so on. Of course, the accumulation processes in both regions are not independent from one another. Migration does change the labour available in both regions with opposite signs. Knowledge transfers can drive the total factor productivity in one region depending on the other regions or advantages of specialisation in both regions in parallel. The interaction between the region of interest and the rest of the world has to be taken into account in the model.

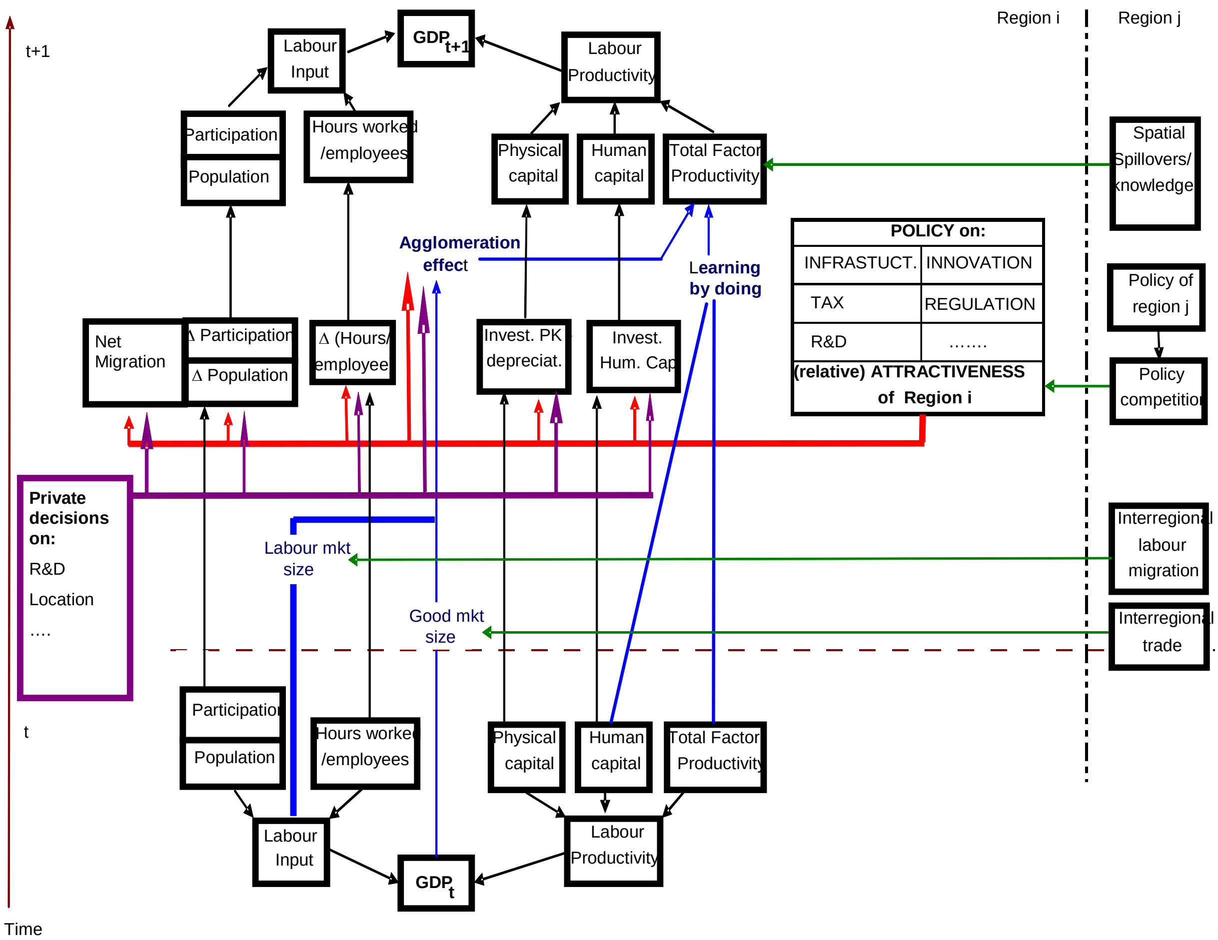
In turn, many of these interactions are politically influenced. For example, consider the case that transport costs are important for a final product and outweigh the advantages of concentrating the production in one region. Firms in both regions will produce the good. For high transport costs, the need to supply markets locally encourages firms to locate to different regions. Suppose that improvements of transportation infrastructure would decrease the costs of transport and the advantages of concentration now outweigh the transportation cost. For the whole economy (region i and j) the development of transport infrastructure is beneficial. However, if we consider the regional units separately, policy advice is more ambiguous. The benefit of developing interregional transport infrastructure for the core region i (where the production would concentrate) is straightforward. For the periphery region j, this is less clear. If both regions are close to each other an improved transport might lead to an integration of region j into the core and therefore foster growth. But if there is no hope to be integrated, the development of transport can be detrimental because it can trigger the departure of the firms from region j without advantages offsetting this.

An important issue is the degree of labour mobility between the regions, as Ottaviano and Thisse (2002) point out. If interregional labour mobility is very low, the lack of interregional mobility severely weakens agglomeration effects and economic activity will remain spatially evenly dispersed. Demand linkages are not at work without labour mobility, and parts of the specialisation gains, namely of spe-

8 See Figure 2-3 and Figure 2-4, Chapter 2.3.2 and Chapter 2.3.3.

cialised labour, are also lost. Besides, low interregional labour mobility leads to a wage differential between regions. As shown by Krugman and Venables (1995), for low transport costs some firms relocate from the industrial agglomeration to regions with lower wages. The agglomeration effects are further reduced with low labour mobility. A lower labour interregional mobility is typically observed in Europe, while in the US, labour mobility is higher. Indeed, the regional concentration of economic activity is much higher in the US compared to Europe.

Figure 2-5 Developing the model III



Note: *Red arrows mark the influence of policy decisions on the different accumulation processes, pink arrows the influence of private decisions, blue arrows other influences not directly driven by decisions of agents and green arrows the influences originated in other regions.*

Source: *BAK Basel Economics*

Agglomeration effects and concentration also depend on the path of knowledge diffusion. In the case of intraregional technological diffusion (as in the neo-classical model), spatial spillovers are global, and ideas and knowledge circulate easily from region i to region j. The best examples are Chinese regions which copy from Japan and other South East Asia regions, but also from Western firms' technology. Baldwin and Martin (2003) introduce intertemporal localised technology spillovers. Endogenous growth is consequently geographically concentrated (New Economic Geography). But as technological spillovers are becoming more global (lower barriers to the spatial diffusion), the cost of innovation in region j decreases and so the region starts to innovate and attracts firms. Global knowledge spillovers can make the core-periphery equilibrium unstable and trigger a sudden industrialisation in the periphery region, leading to convergence with the core region's output level. This industrialisation effect is apparent in Slovenia (especially the regions close to Austria and Italy) but also on a wider extent in China, which copies successfully Western technology. Periphery regions are not condemned to remaining trapped; a voluntary policy to import technology from outside or to innovate itself can trigger an industrialisation and finally lead to convergence.

Now that theory as well as stylised facts provide indications that agglomeration effects are at work but do not lead to final conclusions, the empirical analysis must try to provide such answers. Therefore, we introduce various linkages from the rest of the world to the accumulation processes in the region under investigation in our stylised model. A more detailed modelling would be beyond the scope of the model for the moment, as the empirical analysis is limited as well (reduced forms, data limitations).

2.3.5 Growth model: policy competition

In a very optimistic setting, policy variables (regulation, tax, infrastructure, innovation) are considered exogenous. In reality, many observers challenge this view and suggest that «policy competition» is a more realistic setting. For example «tax competition» on corporate income is a recurrent theme during electoral debates. Many politicians, but also economists, fear a «race to the bottom» and propose a «tax harmonisation» scheme at least between EU members (Wilson, 1999). The argument is based on the non-cooperative game Nash equilibrium (prisoner dilemma) which is pareto sub-optimal in terms of welfare. Baldwin and Krugman (2002) cast doubt on this outcome by proving empirically that there is no race to the bottom. According to them, a tax harmonisation could be harmful because catching-up countries would loose an important instrument of policy and convergence would be much more difficult. However, even if there is no «race to the bottom», attracting firms as well as productive labour («war on talents») with all means including tax levels is a common game between regions.

For our model, that means not only do decisions in other regions influence the accumulation processes in the region of interest. It is the relative position of a region with respect to the rest of the world which is – exclusively or additionally – important. Furthermore, political decisions in other regions might therefore also influence the effect of policy decisions in the regions of interest on the accumulation processes in the region of interest. It is left to the empirical analysis to tackle this problem further. Not only the indicators for political decisions in the region of interest should be considered, but also the relative position of the region regarding these indicators.

It is worth stressing that the attractiveness of a region is a combination of many factors. For example, a regional policy maker can only invest in R&D by tax revenues, and social welfare provided by the public sector, even when costly, enhances a region's attractiveness. It is the optimal combination of all policy instruments and taking into account geography, history, initial endowment in capital and labour and the initial state of development, which will make a regional policy successful or not.

3 Data

The data available for the research are taken from the «IBC BAK International Benchmark Club»® database. This database includes indicators of economic performance (Gross Value Added, employment, working volume, productivity, etc.) as well as quantitative measurement of several location factors and framework conditions on the regional level in topics such as innovation, taxation, accessibility, regulation and population. Additional variables to explain regional productivity growth differentials have been constructed using the available data including variables for spatial and industry spillover effects. The following sections contain a brief description of the most important variables used. For a detailed description of the database, please refer to Annex A.

3.1 Variables

3.1.1 Variable to be explained: real productivity growth per man hour

At least two sub-models can be derived from the theoretical framework presented above: one to explain demography and labour participation, and the other to explain productivity growth. As a first step of the empirical implementation of the theoretical model, the growth of real productivity per man hour was used as the endogenous variable in this study.

3.1.2 Policy relevant explanatory variables

3.1.2.1 Innovation

The IBC database includes a wide range of data on innovation. Unfortunately, as of today, most indicators are available for only a relatively small number of regions, especially in the field of «innovation processes» or «innovation output». The results presented here are based on three indicators which are all related to the input of innovation processes. These are the shares of the regional work-force with a secondary and the share with a tertiary education reflecting human capital resources. The third indicator used is the ratio of research and development expenditures to nominal GDP. All three indicators are expressed in decimal notation.

3.1.2.2 Taxation

Two different kinds of taxation measurement sets are available in the IBC database. The first one is on company taxation. The tax burden on a typical investment is calculated taking all taxes into account. The second set of tax indicators follows a similar concept, but for highly qualified labour. For a given (high) available income, the tax burden is calculated including social security contributions if they do not yield a market equivalent return. Different 'model' investments and 'model' persons can be used for sensitivity checks. The variables are expressed as tax rates in decimal notation.

3.1.2.3 Accessibility

The accessibility of a region is measured by the GDP that can be accessed from the region weighted by travel time. The different travel modes, rail, road and air, are used. The analysis is very detailed; for example, it includes the airport access and check-in times. Two variables are used reflecting intercontinental accessibility to destinations outside Europe and interregional accessibility to other regions in Europe respectively. The variables are indexed with 100 for the average.

3.1.2.4 Regulation

For regulation we only have data on a country level. Two variables are constructed, reflecting the tightness of regulation of the labour market and the product market respectively. The variables are indexed between 0 and 6, i.e. the higher the number the more regulated a market is. For several years, the OECD Regulation Index can be used as original data. To add variation in the time dimension, OECD time series information on the product market regulation in several industries have been used as well as data from the Frasier Institute (the so called CATO-Indices) to built up a time series for labour market regulation.

3.1.3 Other explanatory variables

3.1.3.1 Population

The population in the region is available according to gender and age groups (0-14, 15-64, 65+), measured in 1000 persons. Data is available for the complete observation period and growth rates of population could be used as well. Furthermore, the population density in 1000 persons per square kilometre is calculated.

3.1.3.2 Agglomeration and Spatial Spillover Effects

Large urban areas profit from economies of scale due to larger product markets as well as larger labour markets. This growth effect is usually called an agglomeration effect. For peripheral regions, the proximity to a metropolitan city can have positive as well as negative consequences. In particular, high-productive workers will move from the peripheral regions into the core of the metropolitan area. For less productive work, the effect can be exactly the opposite: if factor costs in the centre rise, less productive work is outsourced to the periphery. The overall growth effect of larger agglomerations on bordering regions, whose sign is ambiguous ex ante, is called spatial spillover effect. Both for the agglomeration and the spatial spillover effect, an indicator was built using population and distance information.

3.1.3.3 Global and Structural (industry spillover) Effect

Regions grow differently due to their unequal industrial composition. The Structural Effect collects the productivity growth impact of different industrial mixes at the beginning of the observation period. It reflects the productivity growth differentials to average western European productivity growth due to the differences in the industrial structure of the economy. The calculation of the structural effect has three stages. In a first step, we calculate a proxy indicator reflecting the productivity which would have been reached if the productivity growth of every industry would have been the western European average growth of the corresponding industry. The regional dimension of this proxy indicator is reached through the use of region specific industry shares in the aggregation process. In a second step, we calculate the difference of step-one-indicator from the actual productivity of the region one year before in percent, so that we get a proxy for a hypothetical productivity growth rate. Finally, this indicator is divided in a structural and a global productivity growth effect by subtraction of the aggregate western European productivity growth (global effect).

3.2 Regional and time period coverage

Productivity was basically available for the time period 1980 to 2003, except for the eastern German regions, for which reliable data is only available since 1990. For the period of 1990-2003, the regional coverage contains 220 regions out of 14 countries in Western Europe and the USA (see Figure 3-1).

Figure 3-1 Regional coverage

Source: BAK Basel Economics

Besides the lack of data for the eastern German regions in the 1980s, some more data limitations showed up with respect to explaining variables. For this reason, unfortunately all US regions, as well as Luxembourg, had to be dropped in the estimation samples. Finally, North-Netherland had to be removed because of large fluctuations in productivity growth. Statistical tests suggested dropping this region for the reason of stability. In the end, the balanced panel sample consisted of 109 regions.

Table 3-1 Regional coverage in estimation sample

Estimation sample			
Germany:	29	Sweden:	5
France:	21	Netherlands	3
Italy:	16	Finland:	4
United Kingdom:	13	Belgium:	3
Austria:	7	Danmark:	3
Switzerland:	7	Spain:	2
Norway:	5	Ireland:	1
			109

Dropped from overall sample	
6 German regions:	Eastern German regions
10 US-regions:	due to missing right hand data
Luxembourg:	due to missing right hand data
1 region from the Netherlands	due to outlier with respect to productivity growth

Source: BAK Basel Economics.

4 Econometric Analysis

In this section we will present the results of the econometric analysis. First we will present the main specification as the key outcome of the empirical research. This specification is the outcome of a «state-of-the-art» framework for the econometric panel-data analysis which contains a series of statistical tests. The whole test procedure is described in section 6-2. Section 6-3 is about sensitivity tests. The main specification presented in 6-1 is the result of a wide range of different specifications and variations checked. Although 6-3 can not deal with all the different specifications checked for, it gives an overview of the stability tests made.

4.1 Estimation results (main specification)

Table 4-1 shows the results of the main specification. The model is specified as a random effects GLS estimation over 109 regions and the period 1990-2003. Besides the value of the coefficients, the table shows the coefficients' standard error, the value of significance-test, the according probability of the significance-test (with null-hypothesis that the parameter coefficient equals zero) as well as the two-side 95%-confidence interval of the coefficients.

Table 4-1 Main specification

Specification		Coefficient	Std. Err.	z	P>|z|	95% Confidence-Interval	
Global Effect	Global Effect	0.673711	0.0311	21.67	0.0000	0.612790	0.734632
Structural Effect	Structural Effect	0.256916	0.0284	9.06	0.0000	0.201325	0.312507
txcoama4l1	Company Taxation	-0.000054	0.0000	-2.52	0.0120	-0.000096	-0.000012
txmpama4l1	Manpower Taxation	-0.000302	0.0000	-12.41	0.0000	-0.000350	-0.000255
rgepama4l1	Product Market Regulation	0.001669	0.0003	6.25	0.0000	0.001146	0.002192
rgpmama4l1	Labour Market Regulation	0.001586	0.0003	5.01	0.0000	0.000965	0.002207
ivsedma4l1	Secondary Education	0.023873	0.0067	3.57	0.0000	0.010764	0.036981
ivtedma4l1	Tertiary Education	0.034214	0.0162	2.12	0.0340	0.002547	0.065882
ivfedma4l1	Research & Development Expenditures	0.002660	0.0012	2.2	0.0280	0.000292	0.005028
acicldma10l1	Intercontinental Accessibility	0.070596	0.0324	2.18	0.0290	0.007185	0.134007
acirldma10l1	Interregional Accessibility	-0.057283	0.0122	-4.7	0.0000	-0.081168	-0.033398
ag21to	Spatial Spillover Effect	-0.000060	0.0000	-2.5	0.0120	-0.000108	-0.000013
co1	Country-Cluster 1 (Dummy)	0.003872	0.0011	3.67	0.0000	0.001802	0.005942
co2	Country-Cluster 2 (Dummy)	-0.007099	0.0010	-6.98	0.0000	-0.009092	-0.005106
co3	Country-Cluster 3 (Dummy)	0.002091	0.0011	1.89	0.0590	-0.000080	0.004262
co4	Country-Cluster 4 (Dummy)	0.016635	0.0040	4.19	0.0000	0.008855	0.024415
_cons		0.007355	0.0010	7.36	0.0000	0.005396	0.009315

Legend	
xar_hpld	Real productivity per man hour, Hodrick-Prescott-filtered, log-difference
Global Effect	Average Wetsern European productivity growth, Hodrick-Prescott-filtered
Structural Effect	Productivity growth due to industry mix in the beginning of each period, Hodrick-Prescott-filtered
txcoama4l1	Taxation of companies, dev. from west. europ. Aver., 4 years-Moving Aver., Lag 1
txmpama4l1	Taxation of highly qual. employees, dev. from west. europ. Aver., 4 years-Moving Aver., Lag 1
rgepama4l1	Labour market regulation, dev. from west. europ. Aver., 4 years-Moving Aver., Lag 1
rgpmama4l1	Product market regulation, dev. from west. europ. Aver., 4 years-Moving Aver., Lag 1
ivsedma4l1	Share of employees with secondary education, annual change, 4 years-Moving Aver., Lag 1
ivtedma4l1	Share of employees with tertiary education, annual change, 4 years-Moving Aver., Lag 1
ivfedma4l1	Ratio R&D expenditures / GDP, annual change, 4 years-Moving Aver., Lag 1
acicldma10l1	Intercontinental accessibility, log difference, 10 years-Moving Aver., Lag 1
acirldma10l1	Interregional accessibility, log difference, 10 years-Moving Aver., Lag 1
ag21to	Spatial spillover effect
co1	Country cluster 1 (BEL, DK, FI, NO), dummy variable
co2	Country cluster 2 (FK, UK, SE, AT), dummy variable
co3	Country cluster 3 (ES, IT, NL, CH), dummy variable
co4	Country cluster 4 (IR), dummy variable
_cons	Constant

Note: *Estimated with STATA*

Source: *BAK Basel Economics*

From a technical point of view, the main results of the regression are:

- All coefficients are significantly different from zero with a confidence-probability of at least 96.8 percent; the vast majority of the coefficients are significant with more than 99 percent.
- Nearly half of the endogenous variables' variance can be explained. The overall R-squared is 44 percent.
- Coefficient signs are in line with theoretical considerations, except that for product market regulation.
- The coefficients of the Global and Structural Effect indicate that a deterministic decomposition within a Shift-Share Analysis overestimates the impact of global developments and industry mix on regional productivity growth[9]. Nevertheless, these two effects are relevant in the context of regional growth. A global acceleration of annual productivity growth of 1 percentage point leads to a 0.67 percentage point autonomous improvement of the productivity growth of a region regardless of all other influences.
- The coefficient of the Structural Effect is somewhat harder to interpret so that the magnitude of the effect is not obvious from the coefficient only. In Chapter 5, a more illustrative graphical analysis will give some insight concerning this matter. It will be shown that for the regions covered in the sample, the Structural Effect played a quite prominent role during the 1990s.
- For taxation and regulation, the actual level of the variable is less relevant than the relative level compared to the Western European average. Therefore, in these fields of policy, the competition between regions plays an important role.
- Taxation of highly qualified employees shows the strongest impact on productivity growth. A 10%-points decrease of the tax rate differential (to the Western European average) has led to an annual 0.3%-increase in productivity growth during the estimation period 1990-2003.
- The impact of company taxation is significantly negative, too. However, the magnitude of the effect is much lower than for manpower taxation. A 10%-points decrease of the tax rate differential has led to an annual 0.05%-increase in productivity growth during the estimation period 1990-2003.
- Both indicators for regulation show a significant positive impact. A deregulation of labour markets (relative to the Western European average) by one index-unit leads to a fall in annual productivity growth by 0.2 percentage-points. The magnitude of the effect of product market is similar.
- Education has a positive influence on productivity growth. However, the identified impact of human capital resources is quite small. For tertiary education, an increase of the share in the labour force of one percentage point leads to an increase in annual productivity growth of 0.03 percentage points. For the share of people with secondary education, the effect is similar (0.02 percentage points).
- R&D-activity shows a positive impact on productivity growth, too. Although the impact is substantial higher than for the other two innovation variables (secondary and tertiary education), we had expected a much stronger influence. If a region expanded its spending on research and development by one percentage point of GDP, its annual productivity growth increased by 0.2 percentage points.
- Intercontinental accessibility increases efficiency and competitiveness. However, again the impact is smaller than expected. A permanent higher increase of intercontinental accessibility of one percentage point led to an increase in annual productivity growth of 0.07%.

[9] Compare the results from phase I of the research program for a discussion of the deterministic Shift-Share Analysis and corresponding results.

- Interregional accessibility shows a significant influence in the opposite direction, with a coefficient of 0.06. That means: a permanent higher increase of interregional accessibility of one percentage point led on average to an annual decrease in annual productivity growth of 0.06%.
- Peripheral regions suffer from spatial spillover effects. As for the Structural Effect, the coefficient alone does not tell much about the magnitude of the effect and has to be regarded in combination with the actual values of this variable. Again, the reader is referred to Chapter 5. At this point it can be stated that Spillover Effects have been quite important for a number of regions in proximity of large urban areas.
- There is still a substantial, unexplained «national» effect left in the residuals. Therefore, country-dummies have been used to catch these effects. Stability tests showed that grouping countries into four groups are superior to adding one dummy for each country separately. Country cluster 1 consists of Belgium, Denmark, Finland and Norway, cluster 2 of France, UK, Sweden and Austria, cluster 3 of Spain, Italy, Netherlands and Switzerland. For Ireland, a separate country-dummy was built (cluster 4). Therefore, the dummies provide information relative to Germany.
- Without country-dummies, the explanatory power of the regression was only about 10 percent. Not yet otherwise explained national effects account for abut 40 percent of regional productivity growth differences.

4.2 Model selection

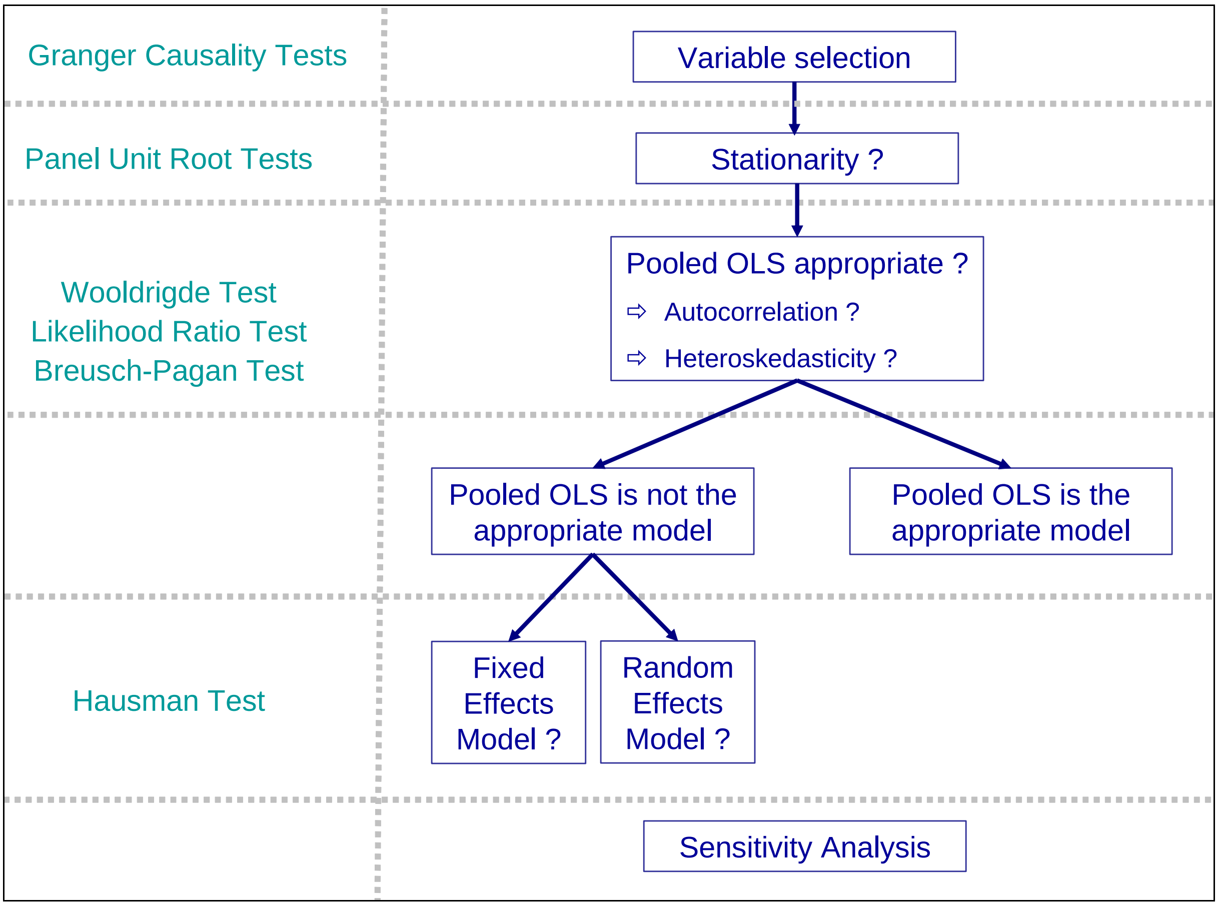
For the selection of the appropriate model, a «state-of-the-art»-framework was used. This framework starts with the problem of variable selection. To account for possible problems with the optimal lag-structure and reciprocal causality, all possible variables are tested on their relationship with productivity growth with a concept known as Granger Causality[10]. Although Granger Causality does not prove causality in the more common use of the term, it gives some indications on the information content of the series available for estimations.

One weakness of the Granger Causality is that it suggests causality between two series with a strong correlation even if there isn't any causal relationship, but only a common underlying trend. This problem is addressed with the Panel Unit Root tests, which analyses each series regarding stationarity. A time series is stationary if the underlying characteristics of the data series remain constant across time.

Once we are sure of the stationarity of the variables, we have to set up the appropriate econometric model. The first decision is whether a pooled OLS estimation leads to unbiased estimators or not. If yes, the Pooled OLS is the most efficient model. If not, a further test has to be executed to decide between the Fixed- and the Random Effects model.

[10] See Granger (1969)

Figure 4-1 Model selection



Source: BAK Basel Economics

4.2.1 Variable selection

Although for all of the variables described in Chapter 3 a relationship with productivity growth can be deduced, only «proxies» for these economic variables are available. Furthermore, for many of our explaining variables, economic theory supplies arguments for a causal relation in both directions. For instance, it is not clear ex ante if regions grow faster because they have a high share of employees with tertiary education or if the share of employees with tertiary education is higher because the region is attractive for highly qualified persons due to high growth rates.

To diminish the problem of variable and lag structure selection, we started our empirical analysis with a concept known as Granger Causality tests. Granger Causality is a technique for determining whether one time series is useful in explaining another one. Ordinarily, regressions reflect «mere» correlations, but Granger argued that there is an interpretation of a set of tests as revealing something about causality. Testing causality, in the Granger sense, involves using F-tests to test whether lagged information on a variable Y provides any statistically significant information about a variable X in the presence of lagged X. If not, then «Y does not Granger-cause X». There are many ways in which to implement a test of Granger Causality. One particularly simple approach uses the autoregressive specification of a bivariate vector autoregression.

The Granger Causality tests gave some indication for the selection of the variables and the lag structure used in the estimations. First, they indicate if a variable has any explanatory power regarding growth at all. Second, Granger Causality tests give some information on the lag structure of the relationship. Third, Granger Causality tests show if there is a bi-causal relationship between location factors and growth. It is important to note that Granger Causality measures precedence and information content but does not by itself indicate causality in the more common use of the term.

Table 4-2 Granger Causality tests I

Granger-Causality between explanatory variables and productivity growth

Number of regions with significant Granger-Causality at 5%-level

	Lag=1	Lag=2	Lag=3	Lag=4	Lag=5	Lag=6	Lag=7
txcoa	41	19	9	11	7	9	9
txmpa	73	30	21	21	19	17	6
rgpma	57	34	26	13	15	16	6
rgepa	64	74	48	34	41	37	12
ivsed	6	15	12	8	13	10	7
ivted	7	13	12	7	13	15	4
ivfed	36	13	20	15	12	16	6
acicld	39	16	16	8	10	15	7
acirld	37	27	17	10	12	15	7

Note: Granger-Causality-test only computable up to 7 lags.

Note: Estimated with STATA

Source: BAK Basel Economics

The first series of Granger Causality tests analyses the explaining factors to be considered as having an impact on productivity growth, i.e. the tests examine, if the location variables have any explanatory power with respect to productivity growth. The Granger Causality tests were accomplished with a lag structure from one to seven lags for each variable to be considered. Table 4-2 shows for each test, how many regions (out of a total sample of 110 regions) show significance at the 5%-level in the according F-test.

Table 4-3 Granger Causality tests II

Granger-Causality between productivity growth and explanatory variables

Number of regions with significant Granger-Causality at 5%-level

	Lag=1	Lag=2	Lag=3	Lag=4	Lag=5	Lag=6	Lag=7
txcoa	11	4	2	1	0	0	0
txmpa	8	3	1	0	0	0	0
rgpma	12	1	2	0	0	0	0
rgepa	4	1	0	1	0	0	0
ivsed	13	9	4	2	1	0	0
ivted	22	6	0	0	0	0	0
ivfed	14	3	0	0	0	0	0
acicld	6	3	3	1	0	0	0
acirld	12	2	2	0	0	0	0

Note: Granger-Causality-test only computable up to 7 lags.

Note: Estimated with STATA

Source: BAK Basel Economics

As can be seen in Table 4-1, for most of the variables the Granger Causality tests indicate a significant impact on productivity growth for more than 10 percent of the regions up to a lag-length of six, except that the tests for the two innovation indicators «secondary education» and «tertiary education» indicate a minimum lag-length of two to six.

The second series of Granger Causality tests analyses the reverse causality, i.e. the tests examine if productivity growth has any explanatory power with respect to the location variables. Table 4-3 shows the results as the number of regions with significant F-test at the 5%-level.

For most of the variables, the tests indicate a significant relationship between productivity growth and the location factors in the subsequent period for more than 10 percent of the regions. This can be interpreted as a sign for reverse causality. As the lag-length increases, the number of significant F-tests diminish and disappear with a lag-length of 4 for most of the variables.

The Granger Causality tests show that there is a strong correlation between the explaining variables and productivity growth, that this relationship holds for a number of lags for the location factors and that reverse causality has to be kept in mind seriously at least up to a lag length of two.

4.2.2 Stationarity

The concept of stationarity plays an important role in the statistical analysis of economic relationships. In order to get an accurate estimate of the coefficients determining the relationship between two or more variables, the underlying characteristics (mean, variance, contemporaneous covariance) of the data series must remain constant across the sample period. Standard inference procedures do not apply to regressions which contain a non-stationary variable or regressor. Therefore, it is important to check whether the variables considered for estimations are stationary or not before using it in a regression.

The formal method to test the stationarity of a series is the Unit Root Test. Recent literature suggests that panel-based Unit Root Tests have higher power than Unit Root Tests based on individual time series. Two different Panel Unit Root tests have been applied in this study, namely the Levin/Lin/Chu-test (LLS) and the Im/Pesaran/Shin-test (IPS)[11]. Whereas the LLS assumes homogenous autocorrelation-coefficients across units, the IPS explicitly allows for heterogeneous autocorrelation-coefficients. For both the LLC and the IPS, we performed the test in three different specifications, with trend and constant, with constant only as well as without both constant and trend. For a detailed description of the concept of stationarity and the corresponding statistical test procedures, please see Annex B.

The Panel Unit Root tests brought up serious problems with respect to the original, non-transformed data. It turned out that most of them are not stationary. For the transformed time series however, non-stationarity turned out not to be a big problem. Table 4-3 shows the result of the Panel Unit Root tests for the transformed variables. For the vast majority of the variables used later on (transformed except the structural effect) stationarity can be stated. This conclusion follows independent of the specification of the test equation. Nearly all of the transformed variables turned out to be stationary at the 1%-significance level within a test specification without trend and intercept. The specification with constant but without trend still showed stationarity for the vast majority of the tested variables in both test procedures. The specification with both trend and intercept indicated some non-stationarity problems within the LLC-procedure, while the IPS comes to the same conclusions as with the specification with constant only. In the end, we preferred the IPS over the LLC because the LLC does not allow for heterogeneity across sections (regions).

[11] See Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003)

Table 4-4 Panel Unit Root tests

	Panel Unit Root Test with constant and trend		Panel Unit Root Test with constant		Panel Unit Root Test
	Im Pesaran Shin	Levin Lin	Im Pesaran Shin	Levin Lin	Levin Lin
xar_hpld	**		**	**	**
txco					**
txmp					**
rgep	*	**	*	**	**
rgpm		**			**
ivse		**	**	**	
ivte	**	**			
ivfe	**	**			
acic	**	*	**	**	
acir					
txcoa			**	**	**
txmpa		**			**
rgepa	**	**		**	**
rgpma			**	*	**
ivsed	**	**	**	**	**
ivted	**	**	**	**	**
ivfed	**	**	**	**	**
acicld	**		**	**	**
acirld	**		**		**
xaser_hpld	*				**
txcoama4l1	**	**	**	**	**
txmpama4l1					**
rgepama4l1	**		*	**	**
rgpmama4l1	**			**	**
ivsedma4l1	**		**	**	**
ivtedma4l1	**		**		**
ivfedma4l1	**		**	**	**
acicldma10l1	**	**	**	**	**
acirldma10l1			**	**	**

Note: ** refers to significance at the 5% level, ** refers to significance at the 1% level.*
Estimated with STATA

Source: *BAK Basel Economics.*

4.2.3 Econometric model

4.2.3.1 Pooled-OLS model

The simplest estimation method with panel data is the pooled-OLS estimator. Although the pooled-OLS estimator is the easiest and relatively most efficient (because of the highest possible degrees of freedom) of all possible panel-data-methods, it essentially ignores the panel structure of the data. Furthermore, it is often not appropriate because it relies on two assumptions which are often not satisfied: first, it assumes that for a given individual, observations are serial uncorrelated (no autocorrelation), and second, that across individuals and time, the errors are homoscedastic. With these assumptions, the model corresponds to the classical linear model and can be estimated with OLS.

To test if the pooled OLS is appropriate, we have to check the model on autocorrelation (Wooldridge-test) and heteroscedasticity (Likelihood-ratio test). If both can be excluded, the pooled-OLS estimator is appropriate; otherwise the estimated parameter values are not valid.

The Table 4-4 and Table 4-5 show that both assumptions – no autocorrelation and homoscedasticity – are invalid (for a more detailed illustration of the test results see Annex B). In a time series framework, autocorrelation and heteroscedasticity do not lead to inconsistent or biased estimator, as long as the errors are orthogonal to the regressors. The only drawback is that making inference is no longer possible (statistical tests are no longer valid). However, in a panel framework, this may indicate the presence of unobserved heterogeneity through individual effects. In that case, the estimated parameters are inconsistent. In conclusion, these results suggest that the OLS estimates suffer from a misspecification due perhaps to unobserved regional heterogeneity (in which case, we have the problem of omitted variable bias). This problem can be addressed by either adding more explanatory variables or by allowing for additional individual effects in the specification.

Table 4-5 Wooldridge-test

Test for Autocorrerlation

Ho: no first order autocorrelation

Test statistics

Wooldridge test for autocorrelation in panel data
F(1,108) = 5317.008
Prob($\chi^2_{critical} > \chi^2$) = 0.0000

Conclusion

⇨ first order autocorrelation

Note: *Estimated with STATA*

Source: *BAK Basel Economics*

Table 4-6 Likelihood-Ratio-test

Test for Heteroskedasticity

Ho: Homoscedasticity

Test statistics

Likelihood-ratio test
LR χ2(108)= 943.98
Prob($\chi^2_{critical} > \chi^2$) = 0.0000

Conclusion

⇨ no homoscedasticity

Table 4-7 Breusch-Pagan-test

Breusch-Pagan LM-test tests for heteroscedasticity

xar_hpld[unit_n,t] = Xb + u[unit_n] + e[unit_n,t]

Estimated results:

	Variance	std. deviation
xar_hpld	0.0000384	0.0061971
e	4.71E-06	0.0021705
u	0.0000182	0.0042677

Null-hypothesis: Var(u) =0

Test statistics

χ^2 =	4076.27
Prob($\chi^2_{critical} > \chi^2$)	0.0000

Conclusion

⇨ individual effects

Note: *Estimated with STATA*

Source: *BAK Basel Economics*

Another check for individual effects can be done by the Breusch and Pagan[12] test that uses a Lagrange multiplier test for heteroscedasticity in the error distribution. Again (see Table 4-6), test results suggest the existence of unobserved individual effects.

In conclusion, these results suggest that the OLS estimates suffer from a misspecification due to unobserved regional heterogeneity, which can be addressed by either adding more explanatory variables or by allowing for additional individual effects in the specification.

4.2.3.2 Fixed- versus Random Effects Model

The two basic extensions to the simple pooled-OLS model are the fixed- and the random effects model. Both allow for individual effects and can be distinguished in the way this individual effect (in our case region specific effect) is implemented. While the fixed-effects model defines an individual intercept, in the random effects model the individual effect it is implemented as a part of the disturbance term. Essentially, the fixed effect model relies on the assumption that the individual effect is correlated with the other exogenous variables, whereas the random-effects model is based on the assumption that the individual effect is uncorrelated with the exogenous variables. For a detailed introduction in these models see Annex B.

Table 4-8 Hausman-test I: model without country-dummies

Hausman Specification Test
Specification without Country-Dummies

Ho: difference in Fixed and Random Effects coefficients not systematic

	Fixed Effects Coefficients	Random Effects Coefficients	Difference
global_effect	0.675195	0.671552	0.003643
structural effect	0.260945	0.274873	-0.013927
txcoama4l1	-0.000042	-0.000057	0.000015
txmpama4l1	-0.000330	-0.000283	-0.000047
rgepama4l1	0.001682	0.001332	0.000350
rgpmama4l1	0.001541	0.001153	0.000388
ivsedma4l1	0.024111	0.021180	0.002931
ivtedma4l1	0.029870	0.040961	-0.011091
ivfedma4l1	0.002639	0.002843	-0.000204
acicldma10l1	0.056210	0.078021	-0.021811
acirldma10l1	-0.055394	-0.056575	0.001181

* Standard error = diag(β_{FE}-β_{RE})^2

Test statistics

$\chi^2(11) = (\beta_F E-\beta_{RE})'[(\sigma^2 b_{FE}-s^2\beta_{RE})^\wedge(-1)](\beta_{FE}-\beta_{RE}) = 164.36$

Prob($\chi^2_{critical}>\chi^2$) = 0.0000

Conclusion

⇨ Fixed Effects specification is appropriate

Note: Estimated with STATA

Source: BAK Basel Economics

Initially, the Hausman-test[13] suggests a Fixed-Effects model for our specification. However, a check of the residuals showed that there is a strong country effect remaining. For this reason, country-dummies

[12] See Breusch and Pagan (1979)

[13] See Hausman (1978)

have been introduced in the estimation. Indeed, most of the coefficients for the country-dummies were highly significant. This led to a duplication of the variance explained and it turned out that with a model including country-dummies, random effects is the optimal model. With a confidence-probability of 5 percent, the null-hypothesis of equal coefficients over both the Fixed- and Random Effects model has to be rejected. In this case random effects model is the preferred specification because of its higher efficiency relative to a fixed effects model.

Table 4-9 Hausman-test II: model with country-dummies included

Hausman Specification Test
Specification with Country-Dummies included

Ho: difference in Fixed and Random Effects coefficients not systematic

	Fixed Effects Coefficients	Random Effects Coefficients	Difference
global_effect	0.673711	0.675195	-0.001484
structural effect	0.256916	0.260945	-0.004029
txcoama4l1	-0.000054	-0.000042	-0.000012
txmpama4l1	-0.000302	-0.000330	0.000028
rgepama4l1	0.001669	0.001682	-0.000014
rgpmama4l1	0.001586	0.001541	0.000045
ivsedma4l1	0.023873	0.024111	-0.000239
ivtedma4l1	0.034214	0.029870	0.004344
ivfedma4l1	0.002660	0.002639	0.000021
acicldma10l1	0.070596	0.056210	0.014386
acirldma10l1	-0.057283	-0.055394	-0.001889

* Standard error = diag(β_{FE}-β_{RE})^2

Test statistics

$\chi^2(11) = (\beta_F E-\beta_{RE})'[(\sigma^2 b_{FE}-s^2\beta_{RE})^\wedge(-1)](\beta_{FE}-\beta_{RE}) = 18.71$

$\text{Prob}(\chi^2_{critical}>\chi^2) = 0.0666$

Conclusion

⇨ Random Effects specification is appropriate

Note: Estimated with STATA

Source: BAK Basel Economics

4.3 Sensitivity tests

The main specification presented in 6-1 is the result of a wide range of different specifications and variations checked. In this section, some of the stability test results are presented. As a complete description of all stability tests goes beyond this paper, it gives only an overview of the various specifications checked. Table 4-10 shows the different structures of Moving Averages used for the stability tests. For each variable, variations from a simple lag up to a Moving Average of ten periods were tested. Table 4-10 shows that for most of the variables, all different lag/Moving Average-structures show significant coefficients at the 99%-confidence-probability, i.e. they have a significance level of at least 1 percent, except the indicator «tertiary education», which shows less significance with Moving-Averages of seven or more lags and the indicator «intercontinental accessibility», which shows only significant coefficients with Moving Averages of a minimum lag-length of seven.

Apart from different forms of Moving Averages, specific different lags of the variables showed significant coefficients, too. These specifications were not documented here because i) these specifications have less explanatory power than Moving Average specifications and ii) the Moving Averages are preferable from a theoretical point of view. Policy measures need time to evolve their impact on real economies performance so the impact of policy measures is expected to be highest when these measures are sustainable (valid over more than one period).

Table 4-10 Parameter stability

	?l1	?ma2l1	?ma3l1	?ma4l1	?ma5l1	?ma6l1	?ma7l1	?ma8l1	?ma9l1	?ma10l1
Taxation of companies	**	**	**	**	**	**	**	**	**	**
Taxation of highly qualified employees	**	**	**	**	**	**	**	**	**	**
Labour market regulation	**	**	**	**	**	**	**	**	**	**
Product market regulation	**	**	**	**	**	**	**	**	**	**
Share of employees with secondary education	**	**	**	**	**	**	**	**	**	**
Share of employees with tertiary education	**	**	**	**	**	**	*	*		
Ratio R&D expenditures / GDP	**	**	**	**	**	**	**	**	*	
Intercontinental accessibility							**	**	**	**
Interregional accessibility	*	**	**	**	**	**	**	**	**	**

** = significant at 1%
* = significant at 5%

Note: Estimated with STATA

Source: BAK Basel Economics

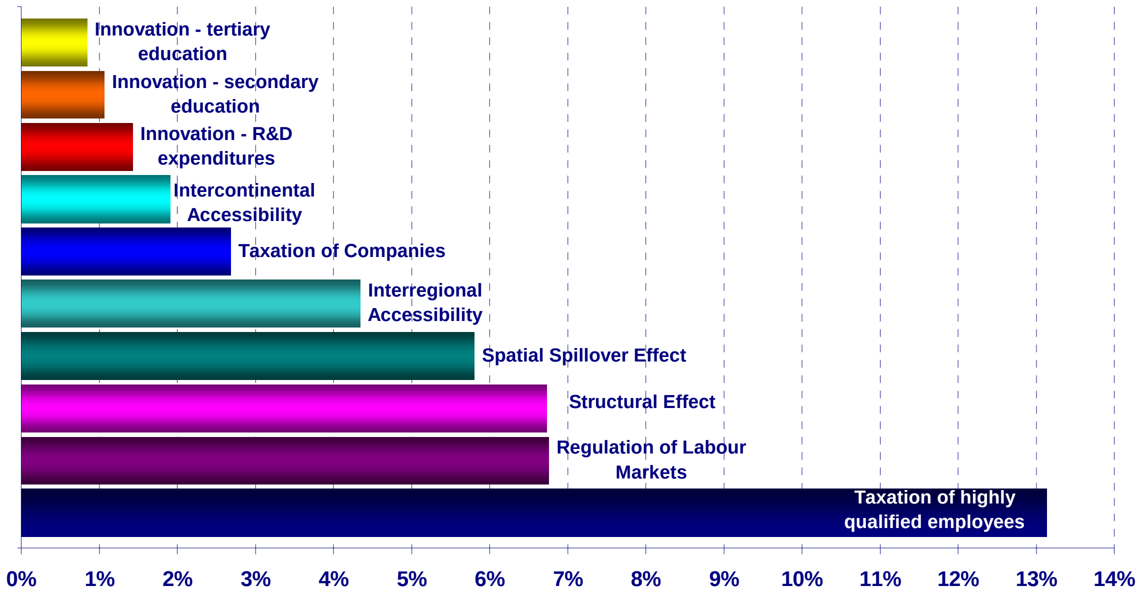
5 Discussion of the Results

5.1 Overview

In this section, we will present the economic relevance of the econometric results with a special focus on the sample of regions used. Summing up the technical results presented in Chapter 4, it can be said that: i) the regression coefficients show the signs expected from theory, except for the regulation of product markets; ii) all central and presented parameters are significant at a significance-level of 5 percent and most of them at the 1%-level; iii) the explanatory power of the econometric model is quite good: nearly half of the endogenous variables' variance could be explained; and finally iv) all results presented here are cross-checked for their stability with numerous variations of the specification.

To gain insight on the relevance of the different factors with respect to productivity growth, this section gives the economic interpretation of the results and illustrates the impact the different factors have within our set of regions. Thereby, we will discuss the individual location factors and their relation to regional productivity growth. The magnitude of the impact of the different factors is represented in Figure 5-1 which shows the difference between the maximum and the minimum cumulative effect in the period 1990-2003 within our estimation sample of 110 regions.

Figure 5-1 Impact of location factors on real productivity growth (cumulative 1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. To show the relevance of the «growth factors» within the sample of regions, for each variable, the difference between the highest and lowest cumulative growth impact is displayed.*
For example: Danish regions with the highest taxation of highly qualified manpower experienced a negative tax effect of about 6 percent over the whole period 1990-2003, while the Swiss region «Zentralschweiz» with the lowest manpower tax rates experienced a positive productivity growth effect of about 7.2 percent through tax induced competitive advantages (note: tax is measured in derivation from the average, which allows positive and negative impacts). Therefore, the growth difference between the best-off and the worst-off regions regarding employee taxation is 13.2 percent (6% + 7.2%) of productivity growth from 1990 to 2003.

Source: *BAK Basel Economics*

By far, the strongest impact on productivity growth is exerted by the relative position of the region with respect to the taxation of highly qualified employees. As Figure 5-1 illustrates, the region with the lowest manpower tax rates experienced a productivity growth advantage (relative to the region with the highest taxes on highly qualified employees) of over 13 percent during the period 1990-2003. The taxation of companies has a significant influence on productivity growth as well, although its magnitude – with an impact of about 2.5 percent between the highest and lowest-tax-region – is much smaller than the impact of manpower taxation. This confirms BAK Basel Economics's earlier research derived by analysing effects on GDP growth. All in all, from the policy indicators available for the research, taxation is the field of policy which exerts the most influence on different regional productivity growth experiences and which seems to be the most important issue in the field of productivity growth oriented policy.

The rather small impact of innovation on productivity growth was unexpected, but it has to be interpreted within the context of data limitations and measurement issues. From another point of view, the results show that innovation is a complex process with many different aspects and that at least not all kinds of innovation policies are quick and easy policy solutions to solve growth problems. Of course, this is by no means proof that innovation orientated policies do not support productivity growth. But it demonstrates that merely focusing on formal secondary or tertiary educational degrees and on pure R&D expenditures without any quality controls might not be an efficient way to foster productivity growth.

In the field of labour market regulation, theory suggests positive as well as negative effects on productivity growth. The empirical analyses reveal a clear dominance of the positive effects. Regions with the tightest labour market system show a growth differential of nearly 7 percent compared to regions with the most liberal system. This result is due to a strong crowding out effect of tight labour market regulation on less productive labour. Labour market regulation has a stronger impact on low-skilled people than on highly educated people. Of course, one should not conclude that a tightening of labour market regulation is a promising growth strategy because its impact on productivity is only half of the story. The overall effect of regulation on GDP growth is expected to be negative by all means, because labour input – the second component of GDP growth – is expected to be clearly negatively affected by labour market regulation.

Ambiguous results are revealed in the field of infrastructure policy and accessibility. While the improvement of intercontinental accessibility is aligned with higher productivity growth, this is not the case (for the regions in our sample) with regard to interregional accessibility. For peripheral regions, better accessibility to agglomerations can lead to an outflow of productive resources. The empirical results show that close proximity to an agglomeration leads to «crowding out» of productivity growth.

Apart from policy relevant growth factors, an important influence can be found in the industrial structure of the region. About seven percent of growth differential is determined by the positioning of a region with respect to its industrial mix. Last but not least, it must be stated that there are still country effects which are not explained by the regional policy indicators applied here. National policies, as well as national framework conditions, play a substantial role for a region's economic performance.

5.2 Innovation

Continuous innovation is probably considered the most important factor for steady economic growth in highly developed industrial countries. Although economic theory as well as public discussion by large agree with this statement, the statement alone does not get us very far, neither in explaining regional growth nor when policy decisions are concerned. «Innovation» itself is not something to be measured, nor is it something to be directly targeted by policy. For example, the discussion on Regional Innovation Systems shows that innovation is a process strongly related to institutional settings, linked to capital accumulation – especially human capital – and to the development and use of knowledge. As the above discussion shows, it is not one system or process, but rather, there are hundreds, if not thousands, of different issues, measures and potential policy actions linked to innovation.

Given the above, it is clear that «innovation» itself can not be tested in an econometric setting. Instead, we tested for the linkage between a variety of variables believed to be related to innovation and economic growth. Of course, the variables to be tested had to fulfil some prerequisites. The variable had to be quantitatively measurable and comparable data had to be available for all regions included in the study. Clearly, there had to be a link between what is thought to be innovation and the variable, proven either by theory and/or by empirical observation. Finally, in a setting aiming at policy decisions, there had to be ways for policy to influence these variables. Given these prerequisites, we ended up with three indicators to be tested in the econometric model.

Two of the variables are linked to human capital. The share of the labour force with secondary education and the share with tertiary education are two measures for the human capital put to use in the economy. The hypotheses state that higher shares lead c.p. to a higher innovation capacity in the regional economy and, therefore, to stronger economic growth. Of course, the causality in this case is far from obvious. An innovative and fast growing economy is attractive for qualified labour. We used lagged values to shed more light on the direction of the relationship. The test presented above indicates the direction flows from human capital toward growth, given the lag structure used in the estimations. Furthermore, the use of changes of the share instead of the levels adds confidence to this conclusion.

The third variable used reflects the resources employed with the explicit goal of innovation. These are the expenditures on research and development. As we have regions of differing sizes in the sample, R&D expenditures are put in relation to the region's GDP. If R&D resources are rationally spent, higher spending should lead to more innovation and, therefore, to growth. We expect a positive relationship between the economic growth rate and the share of GDP spent on research and development.

Because we are only explaining productivity, the hypotheses relating innovation to economic growth have to be rechecked regarding their influence on productivity growth. But in the case of innovation, no changes to the hypotheses are necessary – if any, the connection should be stronger. For all the indicators, theory suggests that the impact of the innovation indicators does not change depending on the value of the indicators in other regions. Therefore, we use the values – actually the change of shares – in the region itself and not a deviation from a European average. Furthermore, due to the expected time lag in the effect of changes in the innovation variables, we use the average of the value for a couple of lagged years for any year in which we explain productivity growth (moving average).

The estimations show the expected results: the relation between the innovation indicators and productivity growth are positive. This result is quite stable even when changes are made in the specification. In general, changing the lag structure and the moving average within reasonable boundaries alters the results only slightly. Dropping or adding other variables in the estimation does not lead to substantially different conclusions. If any, the results get insignificant and no conclusion can be drawn.

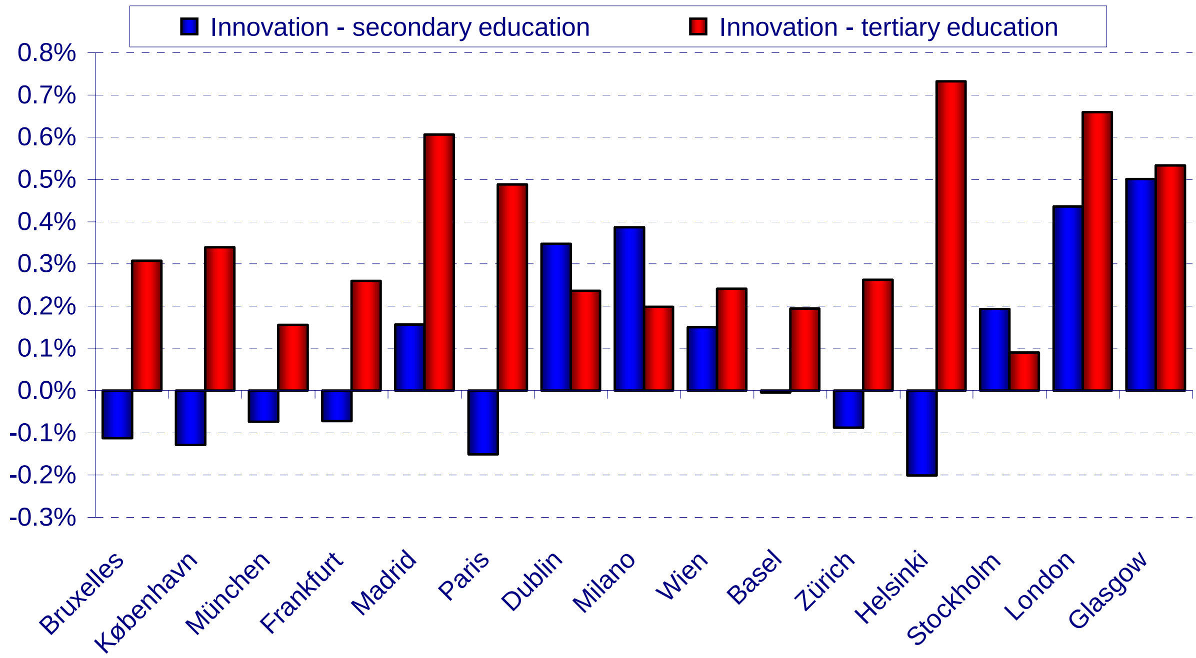
While the direction of the effect is as expected, the amount of the actual influence on productivity growth is surprisingly small for all three variables. For tertiary education, an increase of the share in the labour force of one percentage point leads to an increase in productivity growth of 0.03 percentage points[14]. For people with secondary education, a similar increase in the share results in additional productivity growth of 0.02 percentage points. Finally, if a region expands its spending on research and development by one percentage point of GDP, its productivity growth increases by 0.2 percentage points. Of course, these numbers derived directly from the estimated coefficients are not very informative if the different productivity growth performances of regions are the centre of interest. They have to

[14] Please note that here and in the following, the use of lagged variables and moving averages is ignored. The effects discussed here are in fact equivalent to the aggregated sum of all growth effects in percentage points in later years when all effects of a change in the explanatory variable in one year have been worked through.

be combined with information on value and variety of the corresponding variables in the sample to get an idea about the extent policy decision on the issue could influence productivity growth.

Combining the estimated coefficients with the realised values in a sample of metropolitan regions we observe a contribution to productivity growth 1990 to 2003 between 0.1 and 0.7 percentage points due to an increasing share of the labour force with a tertiary education. For the share with a secondary education, the maximum growth contribution is 0.5 percentage points. But due to the decreasing share in some regions, negative growth contributions appear as well and the variation is about the same as it is for tertiary education. Figure 5-2 provides the details. These surprisingly small effects of the human capital indicators on productivity growth are in line with findings in country studies[15].

Figure 5-2 Impact of innovation on real productivity growth – changes in education of labour force (1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
To given an example, Helsinki had the largest increase in the share of tertiary educated persons in the labour force between 1990 and 2003. Due to this increase, productivity growth increased by just above 0.7 percent compared to a situation where the labour force in Helsinki had not improved the qualification level. At the same time, the share of the labour force with a secondary education decreased in Helsinki, which decreased productivity growth by 0.2 percent. The situation is different in London where the share of secondary and of tertiary educated persons in the labour force increased in the observation period. Productivity growth in London profited from these two developments by about 0.65 percent respectively above 0.4..

Source: *BAK Basel Economics*

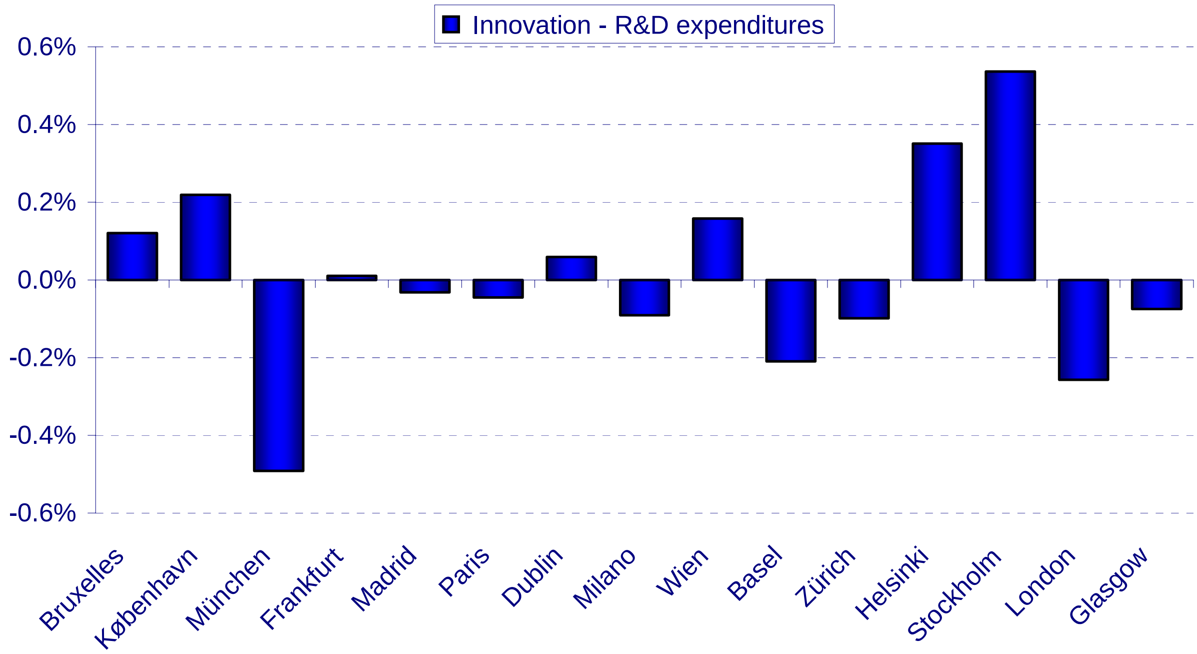
Of course, the influence of the indicators on productivity growth is not equivalent to the influence of human capital accumulation on productivity growth. Measurement difficulties do exist here. First, recall that we can not measure human capital in a region directly. The indicators used alternatively arise from theoretically considerations, but the magnitude of their connection to human capital itself is not empirically confirmed. Second, we use changes in the share instead of the actual share. Theory would just as much justify a link between the actual share and productivity growth, but using actual shares

[15] For instance OECD (2001a)

can lead to possibly biased results. On the one hand, the causality question can be better resolved with changes of shares, and several tests suggest a specification with changes rather than with levels. On the other hand, due to nationally different education systems, differences in the actual shares between regions might not reflect different levels of human capital, but rather, they might only reflect the different national conventions in defining secondary and tertiary degrees. Using the changes of shares, this definition problem might add some noise, but it does not bias the results. Third, a secondary or tertiary degree reflects a formal and often theoretical human capital at the beginning of the working life. But if life-long learning plays the role it is given in public discussion, and if innovation stems more from practical knowledge, the relationship between a formal degree and the actual human capital available for innovation might be rather weak.

Although the coefficient of research and development (R&D) expenditures is larger than that of the education variables, the fraction of growth differentials between regions explained by R&D expenditures is not. In a sample of metropolitan regions, in the worst off region with regard to changes in R&D expenditures productivity growth is c.p. about one percentage point lower than in the best off region. Figure 5-3 has the details. Again, for about half the regions the share of R&D expenditures in GDP fell over the sample period (1990 to 2003). Hence, the impact on growth is negative. This, in itself, is somewhat surprising given the EU's goal to increase R&D expenditures to 3 percent of GDP, a quite substantial step forward.

Figure 5-3 Impact of innovation on real productivity growth – changes in R&D expenditures (1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
For an example how this kind of figure can be interpreted, see Figure 5-2

Source: *BAK Basel Economics*

When discussing the results, the strength of the linkage between R&D expenditures as measured and the actual resources put into innovation has to be scrutinised as one possible source for the weakness of the effects of R&D on productivity growth. The estimations use the change of share in GDP in percentage points for the same reasons as above. But the true causal influence on productivity growth might well be the level of the expenditure, not the growth, which would again show a weaker relationship when changes are used instead of the share itself. Further, R&D expenditures do not differentiate between private and public sources of funding. While private R&D expenditures are considered profitable – at least on average – and hence should increase growth, the opinions on public expenditures differ. If public expenditures are less efficient, focused on basic research or are not put to use regionally – recall the discussion about geographical knowledge spillover which might be less restricted regionally due to publication rules – the use of an average of both figures would weaken the results[16]. Finally, data on R&D expenditures are difficult to measure, especially as time series and on the regional level[17].

In summary, we do find a positive and stable impact of innovation indicators for human capital and resources put into the innovation process, but their actual effect on productivity growth is rather small. Measurement issues and some technical aspects lead us to the conclusion that we may be underestimating their effect. Furthermore, the three indicators used here are not sufficient to reflect all issues related to innovation. More emphasis should be put into this kind of research. In particular, more quantitative, regionally and internationally comparable data is needed on innovation. Still, the results clearly point out that fostering innovation – especially through the broader and less focused areas the indicators used here cover – is not the quick and easy policy solution to solve all growth problems. But innovation and the indicators used here do have a positive impact on productivity growth. Although the road to travel might be longer than expected, policy supporting innovation is growth policy. The question could be posed if more focused measures would improve the results as some theoretical considerations suggest. But empirical proof that these measures are better suited to supporting growth is still lacking.

5.3 Taxation

Taxation is a key topic for businesses when evaluating the attractiveness of a location. In view of intensive international competition for capital – and hence for workplaces – the tax burden on companies is one of the most important location factors driven completely by policy. A lower tax burden not only attracts new companies to a location and provides an incentive for existing companies to stay. Given the necessity of a market return on capital, it is also a factor influencing the competitiveness of a firm. A lower tax burden allows ceteris paribus lower prices and, therefore, a potentially higher market share for the firm. This again is good for local growth. Of course, regions do need taxes to be able to provide infrastructure and public services. But ceteris paribus, if the level of infrastructure and public services is given, lower taxes should increase growth. This is precisely what is tested in the multivariate setting used here.

Not only does economic theory suggest such a relationship, but it is also widely accepted in the public discussion. Company taxation, in particular, is thought to be one of the key policy issues to enhance regional attractiveness. Recently, the new EU member countries aggressively followed a low company taxation strategy. But, as the data reveals, they were not the only ones to follow such a strategy. In nearly all the regions in Europe in the sample, the current direct tax burden on companies is lower than it has been on average over the last two decades. Further, it can be observed that the variation of the tax burden between regions has decreased. But direct taxation is not the only tax burden a company has to bear.

Companies have to bear part of the income tax burden of their employees as well. Employees focus on net available income, while firms competing for these employees have to bear the internationally different tax and social security burdens. With the increasing international mobility of labour, especially

[16] Unfortunately, no separate figures are available on the regional level at the moment. It is one issue we hope to tackle in the next phase of this ongoing research project.

[17] Quite a bit of the regional data had to be estimated itself. See BAK (2003b).

of highly educated employees, and the growing importance of human capital owners in a knowledge based economy, income taxation becomes an ever more important issue in international competition between regions for capital and companies. This suggests that a lower tax burden on highly educated manpower makes a region more attractive for companies and gives companies in the region a competitive advantage, just as lower company taxation does. Furthermore, while direct company taxation can, to some extent, be shifted around different locations of a multinational firm together with the profits, the tax on manpower is closely tied to the location decision of the company and the workplaces created.

In theory, the relationship between economic growth and taxation is rather obvious, but things are less clear regarding productivity growth. In the case of taxation of highly qualified manpower, a positive connection should be expected as well. Companies employing a large share of highly qualified people are, on average, expected to be more productive. Because international – and even interregional – competition for labour takes place for highly qualified rather than for low skilled labour, the companies whose location decision is influenced by the income tax burden should be the more productive companies or company parts. Hence, lower taxation of highly qualified employees should c.p. lead to higher productivity growth. For direct company taxation, this is less straight forward. Still, we would expect a positive connection between company taxation and productivity growth since more productive firms on average have higher profits and, therefore, are more affected by their tax burden.

As for innovation, taxation influences growth through companies' long term decisions. Therefore, we again use lags and a moving average for the two tax indicators included in the estimation, the average tax burden on a profitable investment of a company and the average tax level on the income of a highly qualified employee. Furthermore, we use derivations of the Western European average instead of the tax level directly. Although the absolute tax level might play some role as well, in the end, it is the tax level compared to competing regions – the "relative tax burden" – which drives development. Control estimations with the tax level directly as well as including changes of the level in the estimation supported this selection and did not lead to any substantially different conclusions.

The estimations show the expected negative influence of the tax levels on productivity growth. Also as expected, the impact of the tax burden on highly qualified manpower is stronger than the impact of direct company taxation. A 10 percentage point higher taxation of highly qualified labour reduces productivity growth by 3 percent. If direct company taxation is 10 percentage points higher, productivity growth is only reduced by 0.5 percent. These results match quite well the results from the first phase of the «Policy and Regional Growth» project in 2003[18] which used a far smaller sample and less sophisticated methods, but had economic growth as its focus. The impact of both kinds of taxes is negative, but income taxation has a stronger effect on growth than company taxation[19]. As most other studies are not able to discriminate between different kinds of taxes, they can neither support nor contradict the finding that manpower taxation is more important for the regional economic development than direct company taxation. But the general negative impact of taxation on economic development is supported by other studies[20].

Figure 5-4 gives an even better insight into the importance of taxes for productivity growth than the estimation results alone. For the same set of metropolitan regions as above, the estimation results are combined with the values of the explanatory variables in these regions. We observe that especially the Swiss regions gained from low taxation. About 5 percentage points of productivity growth in Zürich and Basel from 1990 to 2003 are due to their below European average taxation of highly qualified employ-

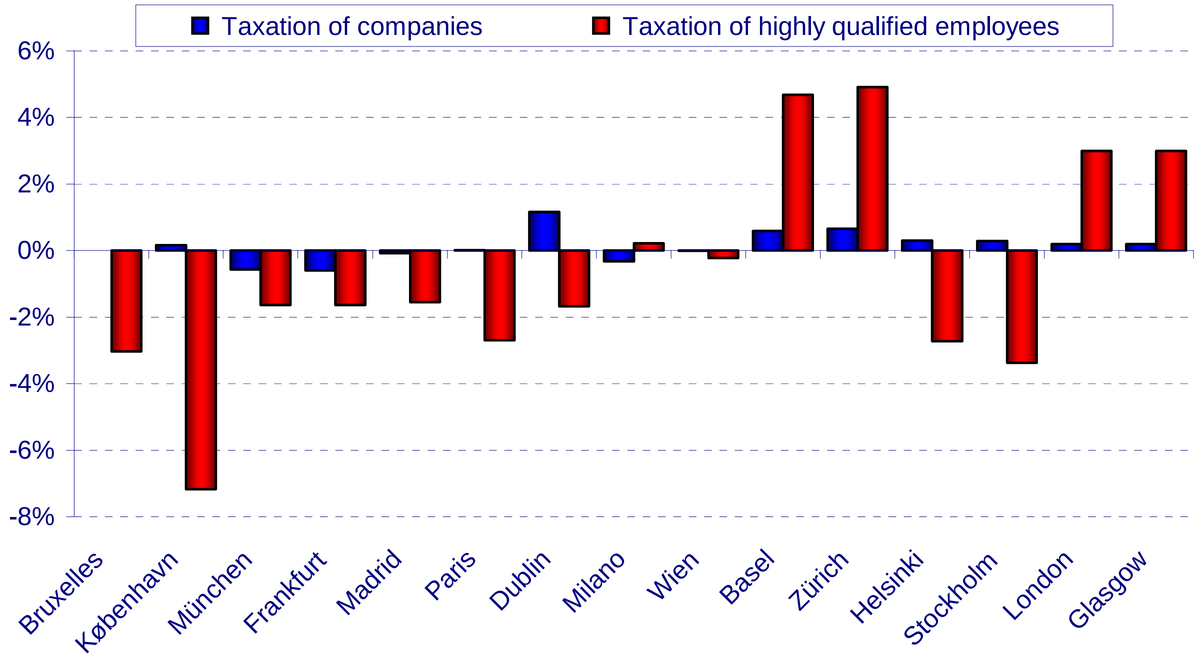
[18] Notice that the research program was called «Regional Growth Factors» at that time. See BAK (2004) and Eichler and Grass (2004).

[19] Due to the limited power of the sample, the estimations in Phase One were inconclusive for company taxation when both kinds of taxes were included. This fits perfectly with the results presented here based on a more powerful sample even though productivity instead of economic growth is used as the left hand variable and advanced methods are used.

[20] Amongst others, Bassanini and Scarpetta (2001), Bleaney, Gemmell and Kneller (2001).

ees, another 1 percentage point to lower company taxation. On the other hand, we see Kopenhaven, with a 7 percent growth disadvantage due to high tax levels. We also notice that the importance of income taxation over company taxation is even more pronounced when the sample variation of the explanatory variables is taken into account as well.

Figure 5-4 Impact of taxation on real productivity growth (1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
For an example how this kind of figure can be interpreted, see Figure 5-2

Source: *BAK Basel Economics*

The relevance of the income tax level is an important observation and quite policy relevant. Policy tends to concentrate on company taxation as the means to foster economic growth. But the empirical observation suggests that it might be worthwhile to look more closely at income taxation of highly qualified manpower. A variety of arguments support this observation. Taxation of highly qualified manpower is less of an issue in the public discussion – and therefore in politics – than company taxation. Consequently, employees' income taxation varies more than direct company taxation and the changes observed in the last 25 years have no unique direction. Both, lowering and increasing the tax burdens are observed. For company taxation, the picture is much more homogeneous. Therefore, company taxation might have been more important, but continuous competition played its role and today, the differences between regions are rather small (given the particular public service level in the region). Furthermore, as argued above, multinational companies are, to a certain extent, able to separate the location of a facility or plant from the location where the company tax duties occur[21]. Such interregional shifts to lower tax regions are hardly possibly for employees. Finally, the increasing international mo-

[21] Notice that only productivity growth is the variable of interest in this argumentation. From the reasoning, it is clear that just the opposite policy conclusion has to be drawn when tax revenues are the variable of interest. Furthermore, revenues might influence the public service level, which is assumed to be given in the estimation. Therefore, a policy decision regarding taxation has to take the consequences on the revenues into account, as well as consequences of changing public service levels due to changes in revenues. This could mean an overall lower impact on productivity than would be expected from the change in taxation directly, which is discussed here.

bility of labour as well as the growing importance of knowledge in the economy increases the significance of income taxation levels as location factors.

It should be noted that the special IBC Taxation Module allow a variety of sensitivity tests for the taxation results. For company taxation, we use the effective average tax rate (EATR). The average is relevant, for example, in the case of location decision for a company site. We also have information on the effective marginal tax rate (EMTR) available. This indicator is of central interest when deciding the amount to be invested in an existing plant, e.g. to buy another machine[22]. Using EMTR instead of EATR in the estimations does not lead to substantially different conclusions. For manpower taxation, there are several different indicators available as well. The estimation presented here uses the tax rate on a disposable income of €100'000 for a single person. The IBC Taxation Module also provides information for different income levels, different family status and different incentive packages[23]. Again, using other indicators does not lead to substantially different conclusions.

In summary, taxation does indeed play an important role in explaining regional growth differentials. In fact, of all the location factors available for research, taxation contributes the most to explain different productivity growth experiences in regions. Interestingly, taxation of manpower has an even greater effect on productivity growth than company taxation does. This econometric result is supported by theoretical considerations and stylised facts. Therefore, it might be time to replace the "old" thinking of company taxation as the trigger to growth and add taxation of highly qualified manpower to the political growth agenda.

5.4 Regulation

Regulation corrects market failures and compensates for externalities. On the other hand, regulation is costly. There are direct costs like administration and controlling, but there are indirect costs as well, e.g. government failure or incompatible incentives with negative consequences for economic growth. From the economic growth perspective, the most important forms of state-run regulation are in the areas of product and labour markets. Since there are costs as well as benefits of regulation, there must be an optimal level of regulation with respect to economic growth which can not be determined theoretically; empirical studies have to be used to answer this question, at least in part.

Although the optimal level is unknown, it is widely believed that in Continental Europe the level of regulation is too high with respect to maximising economic (productivity) growth. Studies based on country data found such an influence. But regulation can differ regionally as well and could explain regional growth differentials. Unfortunately, the data available for this study is on the country level only. Although we are aware of the limitations, we include regulation in the empirical analysis, not least because we are interested in its interaction terms with other variables.

Regulations work through many channels of an economic system, and the relationship between regulation and productivity (growth) is very complex. A policy change toward a more liberal system of product markets and higher competition can lead, first of all, to higher efficiency from better resource allocation and more economic use of inputs. While this effect will result in a one-time shift in productivity, higher competition can also lead to higher productivity growth through enhanced efforts to innovate and faster diffusion of innovations.

Liberal labour markets allow the optimal use of the labour force potential. Furthermore, a transition to more flexible labour markets can also lead to faster innovation processes and therefore to dynamic efficiency gains. The implementation of innovations requires the ability to quickly adjust employment to

[22] For a more detailed discussion of the different figures and their relevance, see Eichler, Elschner and Overesch (2005) and Lammersen and Schwager (2005).

[23] See Eichler, Elschner and Overesch (2005) and Elschner and Schwager (2005) for more details.

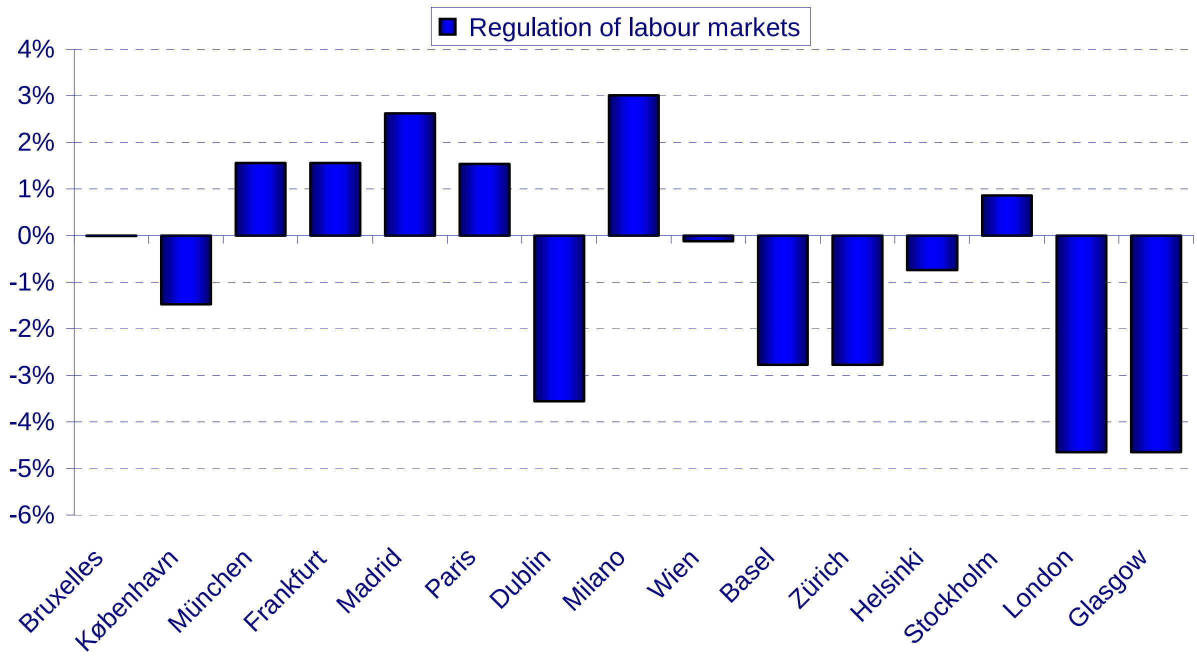
meet the needed mix of qualifications. The more flexible the labour markets are, the cheaper and faster companies can react to new requirements on the qualification structure of their workforces.

But a more restrictive labour market regulation also has a positive effect on productivity. Through minimum wages and employment protection legislation, less productive labour becomes unattractive for firms because the price of low qualified labour is higher than their marginal productivity. In other words: low skilled labour is too expensive and is «crowded out» from the legal labour market. This is a phenomenon widely observable in continental Europe. For example, Germany shows one of the highest productivity levels within Europe, but that is, to a large extent, due to the «crowding out» of low skilled labour.

Since the transmission process of regulatory changes to economic growth is very complex, the transmission process is expected to show a certain time lag. As is true for taxation (which is indeed a special form of regulation), regulation influences growth through companies' long term decisions. Therefore, we again use lags and a moving average for the two regulation indicators included in the estimation, the index of product and labour market regulation.

Furthermore, we use the absolute level as well as derivations of the Western European average. Although the absolute regulation level certainly plays a role with respect to productivity growth, it is believed that the effect of policy competition is even stronger in the context of international competition.

Figure 5-5 Impact of labour market regulation on real productivity growth (1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
For an example how this kind of figure can be interpreted, see Figure 5-2

Source: *BAK Basel Economics*

As mentioned above, theory suggests positive and negative effects of labour market regulation on productivity growth. The empirical analyses reveal a clear dominance of the positive effects. A deregulation of labour markets by one index-unit (relative to the Western European average) leads to a fall in productivity by 0.2 percent. Control estimations with the regulation level directly instead of the relative level did not lead to any substantially different conclusions. However, including changes in the estimation led to insignificant parameter coefficients for the level.

According to these results, labour market regulation has a stronger impact on low-skilled people than on the highly educated. First of all, some regulations like minimum wages only affect the less qualified sector of the labour market. Second, the relative burden of regulation in relation to productivity is higher for low-skilled persons. Well-educated employees (with high productivity) participate in the labour market regardless of regulation, while low-skilled people (with low productivity) do not get jobs.

Although the empirical results for labour market regulation were stable over various different specifications, they have to be interpreted against the background of the underlying estimation sample. The majority of the regions in the estimation sample (60 out of 110) are from Germany, France and Italy, all countries well known for their high level of employment protection combined with relatively high productivity levels. These three countries are prime examples of the crowding out effect mentioned above.

Of course, one should not conclude that a tightening of labour market regulation is a promising strategy for growth because the impact on productivity is only half of the story. The overall effect of regulation on GDP growth is expected to be negative by all means because labour input – the second component of GDP growth – is expected to be clearly affected negatively by labour market regulation. Unfortunately, due to limited resources, the modelling of the labour market could not take place in this project phase. The results for labour market regulation show why the integration of the labour market into the model framework is one of the most important issues on the future research agenda of «Policy and Regional Growth».

Unexpectedly from theoretical considerations and contradictory to various empirical studies with country data[24], for product market regulation, the empirical analyses for our set of regions showed a significant positive influence on productivity growth. Again, this result is mainly driven by our sample. With more than half of the regions from Germany, France and Italy, our sample has a clear focus on countries which experienced a slowdown in productivity growth during the 1990s, while, at the same time, the process of deregulation of product markets was promoted more forcefully in these countries than in many other Western European countries. Consequently, regions from these countries show a significant improvement in the relative position regarding product market regulation. Due to the fact that other regression variables could not sufficiently explain the slowdown in the productivity growth, the indicator for product market regulation catches this effect through the overweighting of the countries mentioned above. To a large extent, this problem is driven by the fact that we have information on regulation on the country level only. Interregional regulation differences – which certainly do exist – could not be used in the estimation. Having regional data on regulation available would have eased the problem. Further, we suspect that the indicator for product market regulation, which is a variable on the national level only, catches, to some extent, unobserved country effects as well. Due to this line of argumentation, we are not convinced by the empirical results that higher product market regulation has a positive effect on productivity growth. This by no means is proof for the opposite: that lower product market regulation leads to higher productivity growth. Although there are valid theoretical arguments for a productivity growth decreasing effect of tighter labour market regulation, its opposite could also be argued for. Again a kind of “crowding out” could be at work, if regulation tends draw “old-styled”, less productive goods and technologies out of the market or forces competitors for companies active in monopolistic markets into new technologies because this is the only way of market access. Although such cases are possible, without much harder empirical evidence, it is hard to believe that this could be the case in the current Western European setting. More research will shed more light on this issue.

[24] See for example Nicoletti and Scarpetta (2003), Aghion et al. (2001) and Gust and Marquez (2002).

5.5 Accessibility and Agglomeration Effects

Accessibility for the workforce of a company to suppliers, customers, or other sources like scientific institutions or even competitors is getting more important. Although well established in theory, it is difficult to evaluate the precise kind of accessibility important for growth. Furthermore, due to a lack of data, only few empirical tests for this hypothesis were possible on the appropriate regional level apart from case studies. For the econometric analysis, we could use two indicators of the accessibility of regions. One is reflecting accessibility on a global scale, using intercontinental travel times. The other reflects accessibility in a European context, based on the travel times between European regions.

In general, good accessibility is thought to be a positive location factor. But as the theoretical discussions in the chapters above revealed, that is not necessarily the case. Depending on the characteristics of the region and geographical issues, better accessibility can also lead to delocalisation. The following hypotheses are derived:

- Better intercontinental accessibility increases efficiency and competitiveness. Therefore, it should enhance productivity growth.
- For interregional accessibility different effects can lead to either positive (increased efficiency and competitiveness as well as increasing agglomeration gains for central regions) or negative (crowding out, losing high productive employment to more central regions) effects on productivity growth.
- Theory does not show clearly if it is the level of accessibility which influences productivity growth or if changes in accessibility are more important.
- Agglomerations have a productivity advantage (level) due to density and efficiency. Nothing could be said ex ante about the influence of agglomeration on growth of productivity.
- Close proximity to an agglomeration leads to a delocalisation of productivity growth (high productive work is centrally done in the agglomeration; less productive production moves to the periphery).

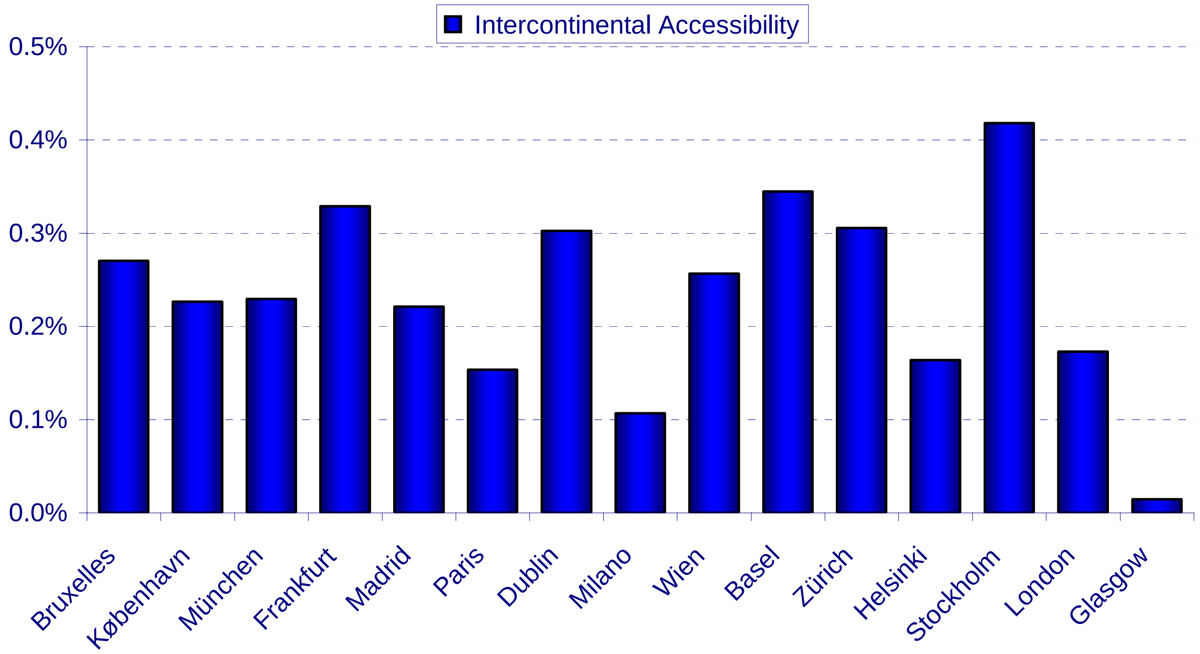
Unfortunately, apart from the more basic problem of how to measure the characteristics of a region, the sample size does not allow us to split the regions up into sub samples with similar characteristics. . Hence, we are not able to clearly discriminate between some of the above hypotheses in the results. But we include two control variables: one reflecting the fact that a region is a central agglomeration, the other one reflecting the proximity to such agglomerations.

Improving accessibility (infrastructure) not only often needs a lot of time, but also quite some time must pass before the effect can be seen in economic variables. Hence, we used a long moving average in the estimation. Apart from levels, we also tried to work with changes. Although some regressions showed a significant relationship between the level of accessibility and productivity growth, stability tests proved that it is the change in accessibility in the first place that led to a higher productivity growth in the sample period. Finally, it is important to recognise that all spatial variables are closely related – except possibly intercontinental accessibility. The estimation results for the individual variables can not be interpreted separately, but need to be taken together.

Intercontinental accessibility does have the expected positive effect on productivity growth. Improvement in global accessibility in a region leads to higher productivity growth in later years. For example, the Swiss cities, already well connected in 1990, were able to achieve about 0.3 percentage points of productivity growth due to an improvement in global accessibility.

For interregional accessibility, we find a negative – and quite substantial – impact on productivity growth. The delocalisation of highly productive activities in regions when access to more central areas is improved seems to outweigh the positive effects. This might partly be due to an unbalanced effect related to the measurement of accessibility. If a peripheral region and a metropolitan area are connected better, the improvement for the first is substantial: not only does it normally have a lower level to start from, but, because accessibility uses GDP-weights, the improvement toward a metropolitan area is also heavily weighted. For the metropolitan area which gains from the delocalisation, the change in accessibility is rather small. This is even more pronounced if connections from the peripheral region to other destinations in Europe run through the metropolitan region. For the metropolitan region, connections to third destinations will seldom run through the peripheral region. Therefore, the estimation weights the latter effects less. Furthermore, we look at productivity growth and not output growth. While highly productive activity moves to the (few) metropolitan centres, peripheral regions can gain from improved accessibility as well if less productive activities move out of the metropolitan regions due to the high costs there. This hypothesis will be tested within the future research agenda when the influence of location factors on the labour market is empirically analysed as well.

Figure 5-6 Impact of intercontinental accessibility on real productivity growth – changes in intercontinental accessibility (1990-2003)



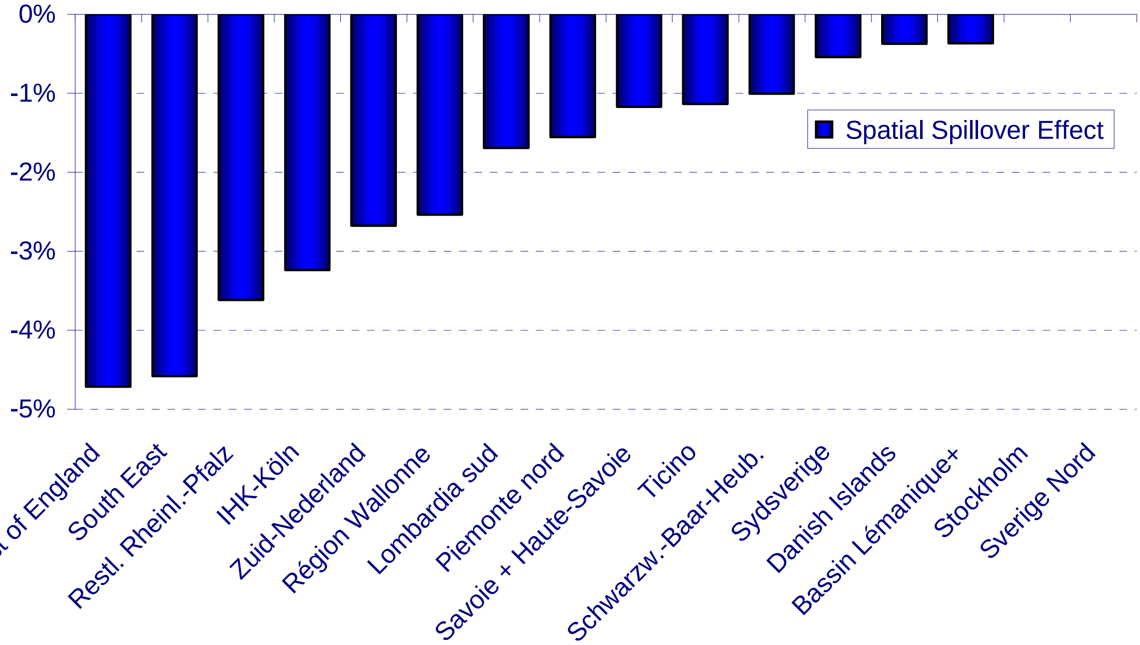
Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
For an example how this kind of figure can be interpreted, see Figure 5-2

Source: *BAK Basel Economics*

The issue of agglomeration forces and their different impacts on the agglomeration itself and on the peripheral regions around was addressed specifically with two additional variables based on population and distance data only. Whereas theory implies a positive effect for the agglomeration itself, positive as well as negative effects are conceivable for the surrounding regions from a theoretical view. In our estimations, the latter effect turned out to be negative (and very stable over various different specifications). In other words, there are strong regional spillover effects toward agglomerations.

The second variable which, in fact, reflects the agglomeration size of the metropolitan regions showed no significant impact on productivity growth. This indicates that there are no additional agglomeration effects apart from regional spillover effects which work in the direction of large agglomerations. However, it has to be said that more research and a more sophisticated modelling of agglomeration effects have to be done to draw final conclusions on this issue.

Figure 5-7 Impact of Spatial Spillover Effects on real productivity growth (1990-2003)



Note: *The bars display the effect of the particular variable according to our estimation results, i.e. the impact of the variable on a region is calculated as the product of the regression coefficient and the actual value of the variable in the particular region. The impact is displayed as the cumulative productivity growth effect during the period 1990-2003.*
For an example how this kind of figure can be interpreted, see Figure 5-2

Source: *BAK Basel Economics*

In summary, the results on spatial and accessibility variables do not yet allow a clear distinction between the different theoretical concepts. The results point to the fact that better accessibility is a double-edged sword. On the one hand, it enhances business activity and boosts the attractiveness of a region. On the other hand, it allows high value activities to be delivered from a central point. Clearly, more research is necessary before clear-cut policy advice can be given, especially taking different characteristics of regions into account. Also, taking the effects on the labour market side into account is clearly necessary here before policy advice can be formulated.

5.6 Global and Structural (industry spillover) Effect

Instead of removing Global and Structural Effects deterministically by a Shift-Share Analysis as in Phase I of the research project, these effects have been taken into account stochastically, i.e. they were introduced into the estimation model as regression variables. The estimation result shows that a deterministic Shift-Share Analysis overestimates the impact of both the global and the structural effect on productivity growth. The coefficients of 0.67 (global effect) and 0.26 (structural effect) are evidence of this (Shift-Share Analysis is basically assuming coefficients of 1). But they also prove that global (here: Western European average) developments as well as global structural trends play a significant role for regional productivity growth.

Although the direct effect of the industrial mix on the regional productivity growth has been implemented by the Structural Effect, we did check for the influence more detailed with regressions including additional industry share variables. There are reasons that there are still significant relationships between the share of an industry in the region and the regional productivity growth. A possible explanation is a clustering effect. The industries grow faster in clusters than on average in Western Europe, and an existing cluster leads to a higher share in the region. Other possible explanations include spill-over effects between industries («use of ICT stronger in regions with ICT industries») and unobserved characteristics of the region. However, the regression results did not show clear evidence for these considerations. We found quite significant influence for several industries, but the regressions were not stable over different specifications. Again, more specific research is necessary before clear-cut policy advice is possible.

5.7 Further results

As pointed out in Chapter 4, country dummies showed a significant influence on regional productivity growth. These effects can be assigned to national variables not integrated in the estimation. Without country-dummies, the explanatory power of the regression was only about 10 percent, so that national effects not included explicitly in the regression account for abut 40 percent of regional productivity growth differences. Or stated the other way around: about 60 percent of regional productivity growth differences are not determined by national characteristics.

6 Summary and Conclusions

Globalisation and decentralisation are challenging the regions' capacity to adapt and improve their economic competitiveness. It is at the regional level that the pressure to maintain economic growth and social development is felt most. For policy makers, especially for policy makers at the regional level, this leads to the challenge to develop strategies to foster regional growth and therefore economic well-being in the region. To support decision makers in this challenge and to contribute in an empirically sound way to the ongoing discussion about (location) factors influencing regional growth, BAK Basel Economics, in 2003, started an ongoing research program on «Policy and Regional Growth» within the «IBC BAK International Benchmark Club»®. The second phase of the research program concludes with this study, presenting the results for the influence of a set of regional location factors (or attractiveness factors) on the long term growth of a region. The study selected productivity growth as the dependent variable and as the variables to explain different growth patterns chose indicators from the innovation, taxation, regulation and accessibility policy areas plus a number of other indicators such as industrial structure, geography and historical growth rates.

The empirical work relies on the «IBC BAK International Benchmark Club»® and the Club's unique database. The IBC database is unmatched in Europe in terms of both regional and sector-specific differentiation and data actuality. Currently, it covers up to 400 regions with 64 business sectors per region and annual data from 1980 to 2004. The IBC database is regularly updated and extended. Besides indicators of economic performance, the database includes quantitative measures for several location factors and framework conditions as time series, which are, to our knowledge, not available elsewhere in such a rich combination. This dataset allows applying panel methods to a set of regions in an international dimension. Around 120 European regions, with a certain geographical focus on Western Continental Europe, Great Britain and Scandinavia, build the estimation sample. The empirical analysis followed a «state-of-the-art» approach in panel data econometrics which contains a series of test procedures to assure an accurate model specification. The resulting Random Effects model was estimated with Generalized Least Squares for 1990 to 2003. Finally, a sensitivity analysis was performed to guarantee the stability of the results. The econometric results can be summarised as follows:

- i) Almost all regression coefficients show the signs expected from theory, i.e. higher taxes reduce productivity growth, more innovation resources increase productivity growth, and better intercontinental accessibility leads to higher productivity growth. For interregional accessibility, the negative effect prevails over the positive effect although both are theoretically possible. For productivity growth, central regions crowd out the development of peripheral regions (negative spillover effect), an effect which is increased by better interregional accessibility. Product market regulation does not show the expected sign.
- ii) Comparing the individual policy location factors, income taxation of highly qualified employees plays the most important role in explaining productivity growth differentials between the regions in our sample. It is followed by regulation of the labour market, interregional accessibility, company taxation, intercontinental accessibility and innovation indicators such as research and development expenditures and education of the workforce.
- iii) Other factors influencing productivity growth in regions are global trends, the industrial structure of a region and spatial spillover effects. Large national effects remain as well (captured with country dummies).
- iv) All important parameters reported here are significant at a significance-level of at least 5 percent and most of them are at the 1%-level.

v) The explanatory power of the econometric model is quite good; nearly half of the endogenous variables' variance could be explained (although much of this is due to the inclusion of country dummies).

vi) All results presented here are cross-checked for their stability with numerous variations of the specification.

The results, conclusions and the policy implications for the four policy areas included in empirical tests, namely innovation, taxation, regulation and accessibility, are discussed below individually and in some more detail.

Innovation:

Regionally available innovation resources positively influence productivity growth in the region. All three available indicators (research and development expenditures as share of GDP, the share of the labour force with a secondary and the share with a tertiary degree) do have positive, significant and stable coefficients. But, somewhat surprisingly, the impact the innovation indicators exhibit on productivity growth is low. Different reasons could lead to such a finding in our setting, even if innovation itself is more important for productivity growth. This includes, first of all, the available choice of indicators which were mainly based on the qualification of the workforce. Formal qualification, for instance, need not necessarily reflect actual capacity to do complex jobs or the ability to react quickly to market demand. However, the results confirm the finding of other studies (OECD, 2001a) that secondary education is at least as important as tertiary education and that «learning by doing» and «learning on the job» are as important as academic titles and diplomas. The strongest influence is exerted by research and development which confirms the policy implications of the new regional growth theory and the alleged effects of a strong localised knowledge base. The three indicators used here are not sufficient to reflect all issues related to innovation. More emphasis should be put into this kind of research. In particular, more quantitative, regional and international comparable data is needed on innovation.

Policy with respect to innovation might thus take different directions: the results clearly point out that fostering innovation is not the quick and easy policy solution to solve all growth problems, especially if the policy concentrates on the broader and less focused areas of innovation resources which are covered by the indicators available here. Although innovation does have a positive impact on productivity growth, the road there might be longer than expected. It has been shown that while highly qualified labour is important, education at the secondary level («Berufsbildung») should not be neglected. Research and development to increase innovative capacity is a crucial means to increase regional competitiveness, but especially for public spending on R&D, quality and efficiency controls are necessary. Rather than drowning in the micromanagement of innovative firms, clusters and R&D expenditures, innovation policy should again put more weight on the general framework conditions such as the regulatory burden and its impact on the ability of an economy to innovate. Also, knowledge and technology transfer to firms from universities and other research and education institutions are as important as the creation of knowledge itself. While public money might be a crucial factor for having a better qualified workforce and more knowledge transfer, introducing more market incentives into the innovation process could also improve its effectiveness with respect to economic growth.

Taxation:

The two indicators for taxation, the tax burden on investments and the tax burden on highly qualified employees, both influence productivity growth negatively. It is noteworthy that the impact shows a considerable time lag and that the relative position with regard to other regions turns out to be more important than the absolute level of taxation. The indicator «taxation of highly qualified employees» has by far the strongest impact on long term productivity growth of all the indicators included in the estimations. The impact is much stronger than the impact of company taxation.

These findings have two policy implications. First, fiscal policy is indeed an important attractiveness factor. Individuals and the firms that hire them have a strong tendency to choose low-tax locations. Regions may thus, within the scope of national tax law, use their local fiscal policy as a tool for long term development. Second, the tax burden on individuals has a much stronger impact on productivity growth than the tax burden on firms. This is compatible with the hypothesis that competition for capital assets (firms) has been so fierce in the past and has reduced tax rates on firms so much that the latter no longer have a distinctive role for a firms' location choice (given the individual level of public services). Corporate tax rates all over Europe appear to have reached a rather uniform and low level. Indeed, fiscal competition appears to have shifted away from capital toward labour which, in the last one or two decades, has become ever more mobile. Whereas 20 years ago regions and countries competed for mobile firms, they now compete for their highly qualified mobile staff. Taxation of individuals finally affects the number and the size of firms willing to settle in a region, especially if they need a large share of highly qualified labour. Typically, these are the firms driving productivity growth – for the labour market input in GDP growth, the results can differ or at least be less pronounced. After tax reforms that mainly concerned company taxation, regions should now presumably turn their attention to the taxation of individuals, especially of those with high skills, if they want to increase their well-being (and tax income) and to withstand increasing international tax competition.

Regulation:

Labour market regulation has a strong positive impact on productivity growth. Tighter regulation can indeed increase the productivity of the working population, but at the price of reducing the participation of the population in the working process. Many regulations like minimum wages affect only less qualified labour. Furthermore, regulation has a higher weight in the labour costs of less productive workers than for more productive workers. Well-educated employees (with high productivity) participate in the labour market regardless of regulation, while low-skilled people (with low productivity) do not get jobs. In the long run, labour market regulations often hurt most those whom they pretend to protect.

Of course, one should not conclude that a tightening of labour market regulation is a promising strategy for growth because its impact on productivity is only half of the story. The overall effect of regulation on GDP growth is expected to be negative by all means, because labour input – the second component of GDP growth – is expected to be clearly affected negatively from labour market regulation. Furthermore, tight labour market regulation may exclude a part of the population form the labour market and may thus counteract the general objective of social integration. Moreover, low participation may threaten the financial balance of social security systems. Policy measures that focus uniquely on productivity growth without taking into account their impact on other GDP components could in the end lead to lower GDP growth rates. Given that all parts of the population should participate in social well-being, easy access to the labour market is probably the best policy strategy to enable long term growth and social inclusion.

No conclusion can be drawn for product market regulation. Contrary to the hypotheses as well as to empirical studies with country data, product market regulation shows a positive influence on productivity growth. This result is less stable than the ones presented above – in different specifications the coefficient is insignificant – and we have reason to believe that this is a statistical artefact related to the problem that information on regulation is not available at the regional level and we had to rely on national data. These, in turn, are highly affected by EU driven liberalisation in a common way. Still, the results shed some doubt on the importance of deregulation of product markets for productivity growth. Again, the story can be different for GDP growth, which will be analysed in the next step of the research program.

Accessibility:

Interestingly, the two indicators for intercontinental and interregional accessibility yield opposite results. While intercontinental accessibility has a positive impact on productivity growth, interregional accessibility – which includes not only air but also land transport – has a surprising negative effect. This might be a statistical effect: accessibility in rural and remote areas increased, with the help of EU Structural Funds, much more than in metropolitan areas, although the economic growth of the latter was higher. But there is also a «real» economic effect behind this. Specialists in transport economics have often pointed out that improving infrastructure between remote and metropolitan areas may benefit the latter more than the former. Transport policies with the objective of bettering the connection between urban and remote areas could thus have the unexpected result of actually reducing the growth potential of remote regions. The reason for this could be a delocalisation effect, i.e. the out migration of highly productive industries toward the economic centres of a country, from where the rural population can then be better served. Growth-inspired transport and infrastructure policy probably benefits mostly urban areas, while for the more rural areas, it may end in disappointment. Better accessibility is a double-edged sword. On the one hand, it enhances business activity and boosts the attractiveness of a region. On the other hand, it allows high value activities to be delivered from a central region. For productivity growth, the latter effect predominates. Again, for GDP growth the conclusions could be different as low value added activities move to the periphery with better transportation to serve the metropolitan area cheaper.

The empirical results presented in this study – the evaluation of the influence of various location factors and other variables on productivity growth in a sample of European regions – lead us to a few clear-cut policy conclusions:

i) Fiscal policy should be a key element in a regions' growth strategy. After tax reforms that mainly concerned company taxation, regions should not forget to turn their attention to the taxation of highly qualified individuals as well.

ii) Innovation policy supports growth, but not just any kind of innovation policy is the quick and easy policy solution to growth problems. Quality and efficiency controls are important.

iii) The attractiveness of a region for highly qualified labour is becoming an ever more important part of fostering growth in highly developed knowledge economies. Taxation of individuals is one issue, but there are various other policy areas to increase the regional attractiveness for such individuals.

iv) Policy takes time. The lag structure of the variables suggests that the effect of a specific policy exceeds the election period of politicians. Especially in cases where policy decisions are unpopular, the future positive effects will have to be clearly explained and communicated to stakeholders and to the population.

v) Regions are not self-contained and the economic development of a region might be influenced by political decisions in other regions. «Policy competition» is a realistic setting. It is often the relative position of a region with respect to the rest of the world which is – exclusively or additionally – important for economic development.

vi) It is worth stressing that the attractiveness of a region is a combination of many factors. It is the optimal combination of all policy instruments taking into account geography, history, initial endowment in capital and labour and the initial state of development, which will make a regional policy successful or not.

Although global and structural factors beyond the reach of policy play an important role, long term growth and development are not destiny, but can be influenced by political framework conditions and wise policy decisions. Put in other words: policy matters for regional growth, a region's policy matters as well as the national one.

This study has focused on productivity growth of a set of European regions, trying to link growth rates to a number of attractiveness factors – or location factors – such as innovative capacity, tax rates, accessibility and the regulatory environment. The study is part of an ongoing research project of BAK Basel Economics to contribute to the discussion on drivers of economic growth. This leaves various options to continue the research. In the next project phase, the major extensions planned are:

i) Model extension: Integration of the labour market as a complement «module» to productivity particularly in order to gauge the effect of different policy measures on productivity and participation of the workforce. Combining both results will also allow conclusions for the drivers of GDP growth, which is indeed the most interesting variable. But a separation in labour and productivity allows a more in-depth understanding of the underlying mechanisms.

ii) Geographical extension: Inclusion of additional regions, particularly US-American regions with different institutional backgrounds. This should increase the reliability of the results and make comparisons between Europe and the United States – or between their different underlying economic systems – possible. Furthermore, more variety in the dataset and degrees of freedom allow more complex model specifications.

iii) Data extension: More explaining variables (especially indicators on innovation processes and outcomes) to enhance the specification of the model.

iv) Industry specific analysis, i.e. analysis of the impact of location factors on specific industries and business sectors.

7 Reference

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8 Annex A: Data

The «IBC BAK International Benchmark Club»®, established in 1998, advises governments, administrations, trade associations, foundations and companies at the national and regional level on matters of business location quality and economic policy. The Clubs' unique database currently covers about 400 regions and up to 64 business sectors and is regularly extended and updated. This database allows the Club's members to assess in detail strengths and weaknesses of their region and to benefit from the experiences of other regions.

Globalisation and decentralisation are challenging the regions' capacity to adapt and improve their competitiveness. It is at the regional level that the pressure to maintain economic growth and social development is felt most. This is why the «IBC BAK International Benchmark Club»® focuses increasingly on the regional level. Benchmarking is a means to compare and assess the multitude of regional location factors and the success of national and regional policy strategies to use their potential. Since regions tend to be more specialised than countries, the «right» set of location factors that satisfies the needs of firms and people is particularly difficult to find. Benchmarking can therefore contribute to developing policy strategies that lead to sustainable economic growth.

The IBC Club's database is unmatched in Europe in terms of both regional and sector-specific differentiation and data actuality. The database includes indicators of economic performance as well as quantitative measurement of several location factors and framework conditions. In the remainder of this Chapter, we will provide a rather quick overview on the data available and used in this research and its definitions. For a more comprehensive explanation, the reader is referred to the publications of the IBC, especially the IBC report 2005, Part III: Sources and Methodology, from which most of the following is taken.

8.1 Performance indicators of the IBC-database

8.1.1 Gross Domestic Product and Value Added

Gross domestic product at market prices is the final result of the production activity of resident producer units. It can be defined in three ways:

- GDP is the sum of gross value added of the various institutional sectors or the various industries plus taxes but minus subsidies toward products (which are not allocated according to sectors and industries). It is also the balancing item in the total economy production account.
- GDP is the sum of final uses of goods and services by resident institutional units (actual final consumption and gross capital formation), plus exports but minus imports of goods and services.
- GDP is the sum of uses in the total economy generation of income account (compensation of employees, taxes on production and imports minus subsidies, gross operating surplus and mixed income of the total economy).

Value added is defined as the difference between the value of output (= sales plus net increase in stocks of finished goods and work in progress) and the value of intermediate consumption (= the goods and services consumed in the production process). Value added may be calculated in gross or net terms. The data in the IBC database are gross, meaning before deduction of consumption of fixed capital.

Value added may be calculated at basic prices, factor costs, producers' prices or market prices. The 1995 European system of accounts (ESA 1995) recommends valuing output at basic prices or producers' prices. In the IBC database valuation is at basic prices, whenever possible. The only exceptions are data referring to the USA and the American regions. They are valued at market prices.

Basic Prices

The basic price is the price producers can obtain from the purchaser for a unit of a goods or services produced as output minus any tax payable on that unit as a consequence of its production or sale (i.e. taxes on products) plus any subsidy receivable on that unit as a consequence of production or sale (i.e. subsidies of products). It excludes any transport charges invoiced separately by the producer. It includes any transport margins charged by the producer on the same invoice, even when they are itemized on the invoice.

Factor Costs

Factor costs may be derived from basic prices by subtracting any other taxes on and adding any other subsidies toward production that are not related to the number of units produced.

Market Prices

Market prices are those paid by purchasers for the goods and services they acquire, excluding deductible value added tax (VAT).

Constant Prices

Valuation at constant prices means valuation of flows and stocks in an accounting period at the prices of a previous period. The purpose of valuation at constant prices is to break down changes over time in values of flows and stocks into changes in price and changes in volumes. Flows and stocks at constant prices are said to be in volume terms. In the IBC Database, the basic year is 1995.

8.1.2 Purchasing Power Parities for industry comparisons

Purchasing power parities represent the amount of currency units for a country needed to buy a basket of goods that costs one unit of the currency of the 'base' country. For example, if the purchasing power parity for food products in Switzer-land equals 2.1 relative to the United States, then a basket of food products purchased in Switzerland for CHF 2.1 costs $1 in the United States. When the exchange rate is 1.4 francs to the dollar, this means that the relative price level of food products in Switzerland is 50 per cent above the level of the USA.

The IBC Database considers purchasing power parities (PPPs) for 29 sectors and 10 countries for the year 1997. The PPPs can be used to compare relative price levels across countries, and to convert value added and GDP from national currencies to a common currency in order to compare levels of output and productivity by sector. Industry-specific PPPs are constructed for each sector and each country vis-à-vis the United States. The countries include Austria, France, Germany, Ireland, Italy, the Netherlands, Spain, Switzerland, and the United Kingdom. All PPPs are expressed in terms of national currencies to the US dollar. For international comparisons of output and productivity, PPPs are preferable over exchange rates. One of the major drawbacks of exchange rates is that differences in price levels between countries are not reflected. More-over exchange rates only deal with prices of tradable goods, and are subject to the impact of capital mobility and speculative movements.

Expenditure versus Industry of Origin PPPs

There are two methods to obtain PPPs. The first method is the expenditure approach, which is developed under the auspices of the International Comparisons Project (ICP), and which has been most widely used and applied by the international statistical agencies, including Eurostat, OECD, the World Bank and the United Nations (see, for example, OECD (2002b)). These expenditure PPPs have important drawbacks for comparisons of sectoral output. They do not include prices on goods which are used as intermediate inputs only. Furthermore, they do not reflect producer prices but market prices (include trade margins and transportation costs, include indirect taxes and subsidies, include prices of imports and exclude prices of exports). An alternative method is the industry-of-origin approach, which develops PPPs by industry and sector. Since 1983, the International Comparisons of Output and Productivity (ICOP) project at the University of Groningen, has developed studies based on sectoral and industry PPPs for a wide range of countries. The most commonly used PPPs in industry-of-origin comparisons are unit value ratios (UVRs). Unit values are obtained as the ratio of values and quantities of items, which are matched across countries. This information is derived from production statistics, including censuses and surveys of individual sectors of the economy (See for example Van Ark (1993a), Van Ark (1993b)).

8.1.3 Labour / Employment

The European System of Accounts (ESA 1995) introduced a number of measurements of employment in particular:

- employment (= employees and self-employed)
- the number of jobs
- the full-time equivalence
- the total hours worked

The rationale is to find measurements of employment which match output data and hence allow analysis of productivity. The recommended measurement is the total number of hours worked. The IBC-Database contains two measurements of employment:

- total hours worked in order to analyse productivity
- employment for analysing labour participation

The concept of employment is generally used by OECD countries. One exception is the USA: employment data by industry are not available. Therefore the concept of jobs has to be used.

Employment

Employment covers all persons, both employees and self-employed, engaged in some productive activity that falls within the production boundary of the system.

Employees (in paid employment)

Employees are all persons who work under contract for another resident institutional unit and receive a renumeration. They fall into the following categories:

- persons (manual and non-manual workers, management personnel, domestic staff, people carrying out remunerated productive activity under employment programs) engaged by an employer under an employment contract
- civil servants and other government employees whose terms and conditions of employment are laid down by public law
- armed forces, consisting of those who have enlisted for both long and short engagements and also conscripts (including conscripts working for civil de-fence)
- ministers of religion, if they are paid directly by a general government or a non-profit institution
- owners of corporations and quasi-corporations if they work there
- students formally committed to contributing some of their own labour to an enterprise's production process in return for remuneration and (or) education services
- outworkers if there is an explicit agreement that the outworker should be paid on the basis of work done. That is to say, the amount of labour contributed to some production process

- persons employed by temporary employment agencies, who are to be included in the industry of the agency which employs them, and not in the industry of the enterprise they actually work for

Self-employed Persons

Self-employed persons are defined as persons who are the sole or joint owners of the unincorporated enterprises in which they work, excluding unincorporated enterprises classified as quasi-corporations.

- Self-employed persons include:
- unpaid family members, including those working in unincorporated enterprises engaged wholly or partly in market production
- outworkers whose income is a function of the value of the output of some production process for which they are responsible, however much or little work they put in
- Workers engaged in production undertaken entirely for their own final consumption or own capital formation, either individually or collectively

Jobs

A job is defined as an explicit or implicit contractual relationship between a person and a resident institutional unit to perform work in return for compensation for a specified period or until further notice. That definition covers both employed and self-employed persons.

Full-time Equivalence

Full-time equivalent employment, which equals the number of full-time equivalent jobs, is defined as total hours worked divided by the average annual number of hours worked in full-time jobs within the economic territory.

Total Hours Worked (= Work Volume)

Total hours worked represent the aggregate number of hours actually worked by an employed or self-employed person during the accounting period, when their output is within the production boundary.

Total hours actually worked include:

- hours actually worked during normal working times
- hours worked in addition to those worked during normal working times, and generally paid at higher than normal rates (overtime)
- time spent at the place of work on tasks such as site preparation, repair and maintenance work, preparation and cleaning of tools, and making-out receipts and invoices, keeping time sheets and writing-up other reports
- time corresponding to short rest periods at the work place, including refreshment breaks

Hours actually worked do not include:

- hours which are paid but not worked, such as paid annual leave, public holidays, or sick-leave
- meal breaks
- time spent travelling between home and the work place when paid for (construction workers)

Hours Worked per person in employment

Average annual hours actually worked per person in employment is defined as:

Total number of hours worked over the year divided by the average number of people in employment.

8.1.4 Productivity

Hourly Productivity (Output per Hour Worked or Man-hour Productivity). In the IBC Report hourly productivity is calculated as real value added divided by the total number of hours worked over the year. Hourly productivity therefore is a measurement of labour productivity.

8.1.5 Labour Costs

Labour Costs

For most sectors of the economy labour costs contribute substantially to the over-all costs. Firms' decisions about the location for their production are influenced to a great extent by regional differences in the expenses for labour. Therefore, the latter are an important factor when measuring international competitiveness.

Labour costs consist of wages and ancillary costs. Direct wages and direct ancillary costs sum up to gross wages. Adding indirect additional costs again yields the total cost of labour. The IBC Database uses data on labour costs that have been raised by the national statistical offices. Unfortunately, surveys on labour costs are not conducted very frequently. In fact, in most countries labour costs have been collected only twice within the last decade. For this reason, data on gross wages, which are available on an annual basis, are used to extrapolate the labour costs. For recent years, when wages are not available due to a considerable time lag in reporting, we use wage indices developed by Oxford Economic Forecasting (OEF) for their international industrial model. In this way, continuous time series are constructed.

Unit Labour Costs

Unit labour costs are defined as labour costs per output unit. They are calculated as hourly labour costs divided by hourly productivity (which is calculated as annual real value added divided by the total number of hours worked p.a.).

8.2 Location indicators of the IBC-database

The IBC database does not only include data covering the economic performance of regions. Also it provides an overview on the position of the regions regarding several location factors. These are organised in separate so-called Modules. The following introduces the modules and provides an overview on the information available for the econometric analysis. In some cases, the data was collected especially for the project and have not been available before. They are described here as well, as they will be part of the IBC data in future.

8.2.1 Innovation

The ability to innovate (i.e. access to knowledge) is a central element of a business location's attractiveness. Textbooks on economic theory stress the close relationship between the development of the knowledge base and the creation of wealth. The results of the company surveys carried out repeatedly by BAK Basel Economics Ltd within the framework of the International Benchmark Report since 1995 have also underscored the importance attached to innovativeness by representatives of enterprises [e.g. BAK (2003a)].

For these reasons, BAK conceived and implemented the initial stage of the «Innovation Module». The studies conducted during the first phase (2000-2001) confirmed the advisability of following the example set by the Massachusetts Technology Collaborative Massachusetts Technology Collaborative (2002) in trying to describe and analyse the innovative capabilities of individual regions. This approach addresses the complex phenomenon of the innovative capacities of regional economies by investigating the specific subjects of innovation results, innovation resources and the innovation process itself. Studies for Europe carried out in the past failed to venture below the national level [e.g. OECD (2000, 2002a, 2003) and EU Commission (2002)]. The IBC module on innovations started to fill this gap for Europe on a regional level.

The module provides data on a wide range of innovation indicators. These include among others innovation resources like human capital, quality and quantity of the production of human capital, R & D expenditure (public and private), venture capital and communication infrastructure. Furthermore, there are indicators for the innovation processes like patents, bibliometric indicators and company founding. Unfortunately, most indicators are only available for a subsample of regions, and these subsamples are often small and differ from each other. Therefore, only two variables out of the innovation module could be used in the empirical analysis. They are defined below.

- Variable Human Capital
- Definition Share of labour force with secondary education
- Coverage (Regions) Full sample of 127 IBC-Regions
- Coverage (Time) 1980-2003

- Variable Human Capital
- Definition Share of labour force with tertiary education
- Coverage (Regions) Full sample of 127 IBC-Regions
- Coverage (Time) 1980-2003

- Variable Research and Development expenditures
- Definition Research and Development expenditures as ratio of nominal GDP
- Coverage (Regions) Full sample of 127 IBC-Regions
- Coverage (Time) 1980-2003

8.2.2 Taxation

Taxation of companies and highly qualified manpower plays a very important role in the competition between regions as business locations and is now even being intensified by globalization. In order to underscore subjective estimates of the tax burdens of different business locations with objective data, BAK Basel Economics is conducting a study carried out by the ZEW (Zentrum für Europäische Wirtschaftsforschung, Mannheim).

The objective of this IBC module consists in compiling and comparing indicators for the regions and countries. The module is divided into two parts: Company taxation and tax burdens on highly qualified manpower.

Company taxation:

The method applied in this module is the Devereux-Griffith Approach (DG Approach). It calculates «effective average tax burdens» in addition to «effective marginal tax burdens» (i.e., the tax burdens borne by capital projects whose return on investment is just high enough to be deemed worthwhile to the investors). The effective average tax burdens are defined as the tax burdens on projects that yield returns greater than the minimum return. They take a set of different kinds of investment goods (e.g. machines, industrial buildings, financial assets) as well as different ways to finance the investment (e.g. profits, shares, credits) into account. National, regional and local taxes are included in the calculation.

Tax burdens on highly qualified manpower:

A traditional way of comparing the fiscal attractiveness of regions competing with one another internationally is to concentrate on the tax burdens borne by mobile capital and mobile companies. Lately this approach has been broadened by paying increasing attention to the mobility of employees, especially those with high and highest qualifications. Of course local governments like to see such highly qualified people moving in, for one thing because of their lack of need for social support services. Several surveys have shown that companies competing for the best-qualified job applicants are also very interested in the level of taxation and other charges these potential employees would be faced with at the location in question. In the module the average tax burden on atypical highly qualified employee is calculated, taking into account not only all direct taxes on wage and other benefits, but also social security contributions in as far as there is no market identical return. This can be calculated for different level of available net income (50’000, 100’000, 200’000 EURO), different family settings (single, married with 2 kids), or different pay-packets (normal, old age oriented, incentive oriented). Further, the assumption can be varied (pensions are completely market equivalent; all social security contributions are market equivalent).

- Variable Taxation of Companies
- Definition Average tax rate on an investment
- Coverage (Regions) 117 of 127 Regions
- Coverage (Time) 1980- 2003

- Variable Taxation of Companies
- Definition Average tax rate on an investment
- Coverage (Regions) 117 of 127 Regions
- Coverage (Time) 1990- 2003

8.2.3 Accessibility

Transport infrastructure plays an important role in the development of regions. According to economic theory, regions with a well established access to markets are more productive, more competitive, and hence basically more successful than regions with less developed access possibilities. Economical reasons for this are lower transport and time costs enterprises and individuals have to bear in easily accessible regions. Such lower costs allow a division of labour between regions and thus regional specialisation, which entails economies of scale and benefits of specialisation. In an increasingly globalised world the part a region can take in economic growth depends mainly on its Accessibility. This is why the improvement of regional Accessibility has a high priority in the European Regional Development Fund (ERDF), one of the four structural funds of the EU.

Accessibility is a complex term. Before specifying indicators it has to be clear what kind of Accessibility is going to be measured. Accessibility analysis works on a combination of travel costs with structural data of locations. Two components of measures are necessary:

- Activity of regions (population, places of work, GDP etc.)
- Impedance (geographical distance, travel cost, travel time etc.)

Accessibility values are calculated from activities and impedances according to special functions.

Specifications Focus on Accessibility requirements of companies and institutions

- Access to input and goods markets (activity)
- Only Accessibility of persons
- Travel time as impedance measure
- Modes: road, rail and air

Separate view on intraregional, interregional and intercontinental Accessibility is necessary. An indicator for intraregional Accessibility could be the highly qualified manpower within 60 minutes commuting distance. Furthermore, infrastructure measures like bus stops or measuring actual average travel times can be used. Up to date data could only be calculated for a few model regions and these indicators can not be used in the econometric part of the project.

The interregional indicator focuses on the access to the European market, to clients, suppliers, partners, and advanced business services. Activity values are economic potential, level of advanced producer services, level of research, prominence as conference cities, etc. Impedance values are calculated on the basis of the fastest daily connection using all modes.

The focus in intercontinental Accessibility is on the worldwide contacts within the corporate group, the cooperation with partners, the Accessibility of trade fairs and conferences, but also the access to worldwide clients and suppliers. Activity values of destination world cities are based on economic activity, density of headquarters, density of multinational companies and organisations, prominence as conference cities etc. The calculation of total travel time takes into account access time to the intercontinental hub and the time spent on the hub.

- Variable: Intercontinental Accessibility
- Definition: Sum of GDP to be reached weighted by travel time, indexed to average = 100
- Coverage (Regions): Full sample of 127 Regions
- Coverage (Time): 1980-2003
linear interpolation between 1980, 1991, 1996, 2000, 2002, 2003

- Variable: Interregional Accessibility
- Definition: Sum of GDP to be reached weighted by travel time, indexed to average = 100
- Coverage (Regions): Full sample of 127 Regions
- Coverage (Time): 1980-2003
linear interpolation between 1980, 1991, 1996, 2000, 2002, 2003

8.2.4 Regulation

What is the optimal level of public regulation? Regulation corrects market failures and compensates for externalities. On the other hand regulation is costly. There are direct costs like administration and controlling. There are indirect costs as well, e.g. not market-conform incentives or government failure. The optimal level of regulation can not be determined theoretically; empirical studies have to be used to answer this question at least pertly.

Regulations work through many channels of an economic system, and the relationship between regulation and growth is very complex. Due to data availability and the wider focus of the complete study the indicators used in this project had to be limited to two, one for product market regulation and one for employment protection.

The indicators are based on the OECD regulation database. The two indicators used are themselves a summary of a wide range of regulation indicators collected by the OECD, weighted according to the results of a factor analysis. The individual indicators include among others economic regulation concerning market access, the use of inputs, output choices, pricing and international trade and investment; administrative regulation (i.e. the interface between government agencies and economic agents) including means for communicating regulatory requirements to the public as well as compliance procedures; and employment protection legislation (EPL) for regular as well as temporary employment contracts.

The OECD-regulation database contains indicators for the years 1990 (Labour Market Regulation), 1998 (Product and Labour Market Regulation) and2003 (Product Market Regulation). To add variation in the time dimension, OECD time series information on the product market regulation in several industries have been used as well as data from the Frasier Institute (the so called CATO-Indices) to built up a time series for labour market regulation. The CATO regulation index follows an approach similar to the OECD, and a cross section comparison yields similar country ratings.

- Variable: Regulation of Product Markets
- Definition: Indexed, 0 (best) to 6 (worst, most regulated)
- Coverage (Regions): 126 of 127 Regions
regions within a country have identical values
- Coverage (Time): 1980-2003

- Variable: Regulation of Labour Markets
- Definition: Indexed, 0 (best) to 6 (worst, most regulated)
- Coverage (Regions): 126 of 127 Regions
regions within a country have identical values
- Coverage (Time): 1980-2003

8.2.5 Population

Population and population growth is often related to economic development. Although the causality of the relation is not clear, it is useful to take population into account when analysing economic performance. In the IBC a variety of population data are available. Separate information is included on gender and age. Age is split in groups according to possible labour market participation: From birth to age 15, from 16 to 64, 65 and older. As the geographical size of the regions is included in the database as well, population density can be calculated, for the complete population as well as for population parts according to gender and age group.

- Variable Population
- Definition Number of Persons
- Coverage (Regions) Full sample of 127 Regions
- Coverage (Time) 1980-2003

- Variable Population Density
- Definition Persons per square kilometre
- Coverage (Regions) Full sample of 127 Regions
- Coverage (Time) 1980-2003

8.2.6 Global and Structural Effect (productivity growth)

The underlying concept of the Global and Structural Effect is the well-known Shift-Share Analysis, where regional growth is decomposed into several effects. The Shift-Share Analysis has achieved from its origin a great popularity within regional science. This technique was first developed by E.S. Dunn (Dunn (1960)) as a method for the determination of the components explaining the cross-country or cross-regional variations of growth of economic variables. The variables so decomposed may be gross value added, employment, income, population or a variety of other economic magnitudes.

In its traditional form, the Shift-Share Analysis allows to decompose the growth rate of let's say gross value added in a certain period of time as the sum of three components: a Global Effect, a Structural Effect as well as a Regional Effect.

The Global Effect reflects economic growth of a superior geographic area which is in context of regions the economic growth of the country to which the region belongs. The Global Effect is identical for all regions and measures therefore the regional growth that could have been reached if the region had grown at the same rate as the superior area (which is in most cases the nation). It is expected that if the nation as a whole is experiencing growth, it would have a positive influence on the local area. In another way the Global Effect is reflecting a kind of business cycle element which is equal for all the regions belonging to a relative homogenous economic area.

The Structural Effect refers to differences in growth rates between regions which are related to growth differences between the industries on the national level. Differences in the Structural Effect of regions only occur due to differences in the local industry mix (at the beginning of the period investigated), so that the Structural Effect reflects the degree to which the region is specialised in industries that are fast or slow growing nationally. Positive Structural Effects indicate that the industrial composition of the region was tilted toward faster growing sectors in the beginning of the period; negative outcomes for the Structural Effect would indicate just the opposite.

As a residual of the decomposition of the regions economic growth remains – after the deduction of the Global and the Structural Effect – the Regional Effect. The Regional Effect measures the growth component which is related to differences between the local industry's growth rate and the national industry growth rates. It is attributed to all the factors which have a regional dimension.

The Shift-Share Analysis has been subject to widespread criticism because Shift-Share decomposes regional growth deterministically; there is no means of statistically testing its results. For this reason, a conversion of the Shift-Share Analysis into an estimable stochastic formulation was proposed. Following this proposal, we included the Global and the Structural Effect in our econometric regression.

The only distinction to similar approaches is that we applied the Shift-Share Analysis on productivity growth and not on GDP or Value Added growth. The definition of the Global Effect just replaces GDP growth with productivity growth, so that the Global Effect is given from the average Western European productivity growth. The calculation of the Structural Effect is somewhat different as productivity can not be aggregated through unweighted addition as GDP. In fact, the hours worked provide the appropriate weights to aggregate. For every industry a hypothetical productivity growth was calculated with the assumption that its productivity has grown according to the Western European average growth of this industry. This hypothetical productivity was set into relation with the actual regional productivity to obtain a hypothetical productivity growth rate relying on regional weights and global industry growth rates. The Structural Effect is then defined as the difference between this number and the Global Effect. Both the Global and the Structural Effect rely on Hodrick-Prescott- filtered data.

8.2.7 Agglomeration and Spatial Spillover Effect

Large urban areas profit from economies of scale due to larger product as well as larger labour markets. This growth effect is usually called agglomeration effect. For peripheral regions, the proximity to a metropolitan city can have positive as well as negative consequences. The overall growth effect of larger agglomerations on bordering regions, whose sign is ambiguous ex ante, is called spatial spillover effect. Both for the agglomeration and the spatial spillover effect, an indicator was built using population and distance information.

As for the analysis of agglomeration effects metropolitan data rather than data on administrative delimited city is necessary, we had to make use of external data sources, namely the population data of the internet-supplier www.citypopulation.com, which contains city population data as well as population data for metropolitan areas. The definition of metropolitan areas follows the concept of functional regions, which defines regions economically. The delimitation of a metropolitan area is made on basis of commuter-data. Up to a certain thresholds of net-commuting administrative units around large cities are defined as a part of the metropolitan area.

From this database, 101 metropolitan areas (with a minimum population of 200’000 within the metropolitan area and 100’000 within the core city) were chosen for the analysis (see Table 8-1). Every of these 101 metropolitan areas was checked, which IBC regions are included within a radius of 75 or 150 kilometres (for the Mega-Metros Paris and London, the threshold radius is 75 and 205 kilometres respectively). Thereby, for every of the two radius it was differentiated between regions, which are

- totally covered
- not totally covered, but the economic centre of the region lies within the radius
- solely a marginal part of the region is within the circle, i.e. it is not totally covered nor isn’t even the economic centre of the region covered

Consequently six categories arise from this analysis, in which a region around a metropolitan area (within a radius of 150 kilometres) can be classified with. Each category was encoded then so that a conversion into a metrical measure could be made. For each category the region matches, one point is attributed to the regions’ score. Finally, the resulting value was weighted with the population of the metropolitan area to take account for the fact that centrifugal forces of n agglomeration increase with their size.

The procedure described above was executed for every of the chosen 101 metropolitan areas. The indicator «Spatial Spillover Effect» is then calculated as the sum of the regions' scores over these 101 cases. If a region is itself a metropolitan area, the value of the variable reached for the analysis of the own metropolitan area (as none of the 101 analysed metropolitan areas exceeds a surface of 75 square kilometre, the score is 8 in each case) were subtracted to obtain the spillover effect and attributed instead to the second variable, the «Agglomeration Effect».

Table 8-1 Metropolitan Areas

		Population in Metropolitan Area	Population in Core City			Population in Metropolitan Area	Population in Core City
1	Paris	9'644'507	2'125'246	51	Venezia	658'771	271'073
2	London	8'278'251	7'172'091	52	Utrecht	644'272	265'107
3	Ruhrgebiet	5'788'460	589'499	53	Sheffield	640'720	439'866
			(Essen)	54	Bergen	629'377	237'430
4	Madrid	5'603'285	3'092'759	55	Gent (Gand)	607'943	229'344
5	Barcelona	4'667'136	1'582'738	56	Aachen	597'516	256'605
6	Berlin	4'170'487	3'388'477	57	Karlsruhe	595'941	282'595
7	Stuttgart	2'615'702	589'161	58	Espoo	587'407	221'597
8	Hamburg	2'532'565	1'734'083	59	Bielefeld	585'318	328'452
9	Milano	2'514'206	1'256'211	60	Leipzig	572'531	497'531
10	Birmingham	2'284'093	970'892	61	Trieste	559'804	211'184
11	Manchester	2'244'931	394'269	62	Bristol	551'066	420'556
12	München	1'920'063	1'247'873	63	Eindhoven	546'428	206'138
13	Frankfurt am Main	1'902'815	643'432	64	Nantes	544'932	270'251
14	Köln	1'827'526	965'954	65	Malmö	532'674	265'481
15	Wien	1'825'287	1'550'123	66	Charleroi	531'770	200'608
16	Amsterdam	1'786'417	735'080	67	Tampere	529'689	199'823
17	Torino	1'731'755	865'263	68	Toulon	519'640	160'639
18	Stockholm	1'684'420	758'148	69	Liège (Luik)	491'690	185'488
19	Mannheim	1'575'427	308'353	70	Odense	488'562	184'308
20	Leeds	1'499'465	443'247	71	Vantaa	482'152	181'890
21	Genova	1'483'190	610'307	72	Basel	479'308	165'051
22	Rotterdam	1'456'858	599'472	73	Genève	471'314	177'535
23	Helsinki	1'360'242	559'716	74	Groningen	469'574	177'145
24	Marseille	1'349'772	798'430	75	Turku	462'876	174'618
25	Lyon	1'348'832	445'452	76	Brighton	461'181	134'293
26	Düsseldorf	1'318'356	572'511	77	Edinburgh	452'194	430'082
27	Oslo	1'268'306	521'886	78	Portsmouth	442'252	187'056
28	København	1'218'240	501'285	79	Leicester	441'213	330'574
29	Glasgow	1'168'270	629'501	80	Aalborg	430'809	162'521
30	's-Gravenhage	1'127'243	463'841	81	Strasbourg	427'245	264'115
31	Antwerpen (Anvers) [Antw	1'106'117	455'148	82	Chemnitz	423'464	249'922
32	Zürich	1'080'728	342'518	83	Grenoble	419'334	153'317
33	Nürnberg	1'023'196	493'553	84	Trondheim	409'152	154'351
34	Dublin	1'004'614	495'781	85	Bournemouth	383'713	167'527
35	Lille	1'000'900	184'493	86	Freiburg im Breis	380'031	212'495
36	Hannover	1'000'193	516'160	87	Bruxelles (Brusse	374'588	141'312
37	Saarbrücken	953'870	181'860	88	Middlesbrough	365'323	142'691
38	Bologna	902'145	371'217	89	Belfast	350'000	277'391
39	Nice	888'784	342'738	90	Bern	349'096	122'707
40	Newcastle upon Tyne	879'996	189'863	91	Braunschweig	346'943	245'076
41	Firenze	865'450	356'118	92	Cardiff	327'706	292'150
42	Bremen	855'764	544'853	93	Metz	322'526	123'776
43	Wuppertal	840'648	362'137	94	Lausanne	311'441	116'332
44	Liverpool	816'216	469'017	95	Brugge (Bruges)	310'209	117'025
45	Göteborg	810'372	474'921	96	Kingston upon Hu	301'416	301'416
46	Toulouse	761'090	390'350	97	Graz	290'629	226'244
47	Bordeaux	753'931	215'363	98	Montpellier	287'981	225'392
48	Århus	707'825	291'258	99	Rennes	272'263	206'229
49	Dresden	685'764	483'632	100	Linz	270'770	183'504
50	Nottingham	666'358	249'584	101	Dijon	236'953	149'867

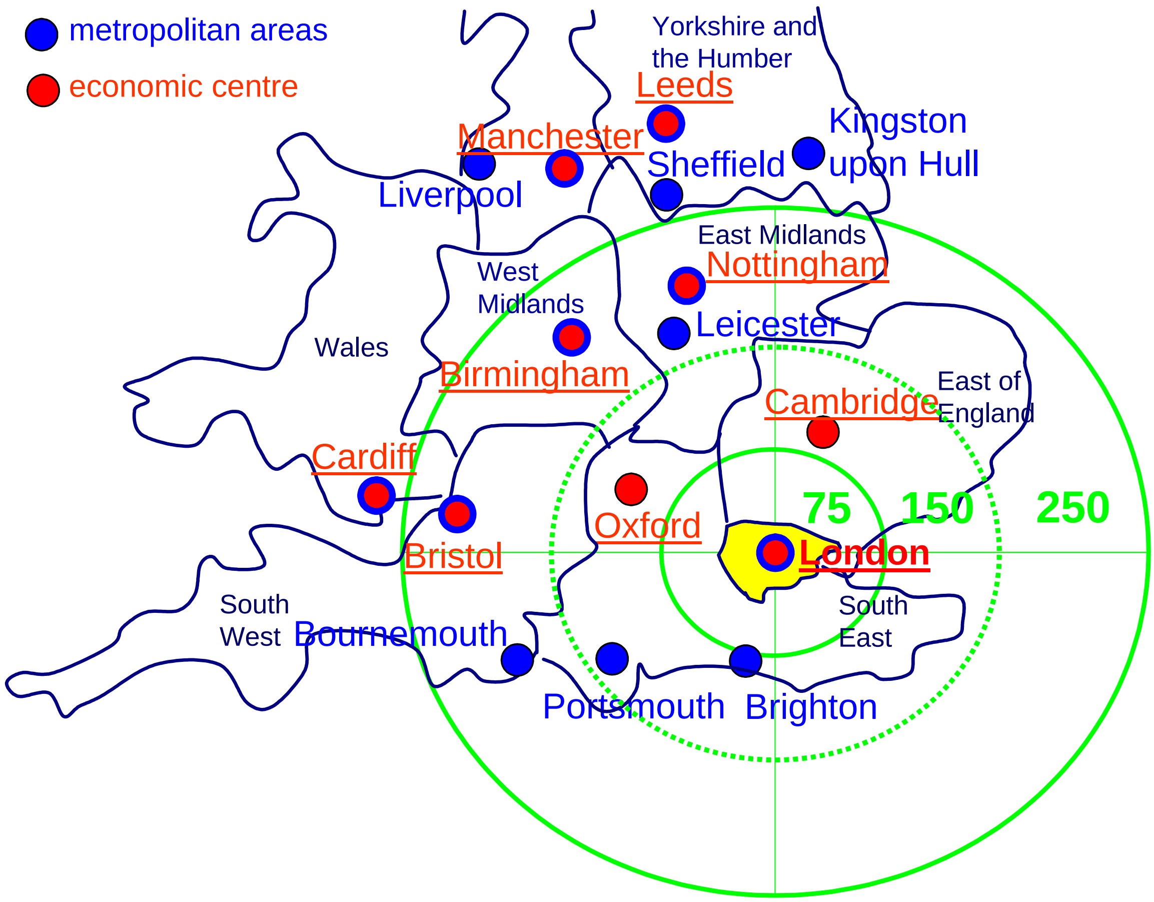
Note: *For 26 cities[25], only population of the core city was available. For the population of the according metropolitan area, the numbers reflect calculations based on estimations.*

Source: *www.citypopulation.com, Estimations BAK Basel Economics*

[25] Milano, Torino, Genova, Bologna, Firenze, Venezia, Trieste, Amsterdam, Rotterdam, 's-Gravenhage, Utrecht, Eindhoven, Groningen, København, Århus, Odense, Aalborg, Oslo, Bergen, Trondheim, Helsinki, Espoo, Tampere, Vantaa, Turku

To illustrate the calculation of the two indicators, the example of the metropolitan area Greater London is described. Figure 8-1 shows the geographical units relevant for this example, Table 8-2 the classification of the regions into the six categories, and in table 10-3 the according indicator values for the regions involved.

Figure 8-1 Agglomeration and Spillover Effect: the example of Greater London



Source: BAK Basel Economics

Table 8-2 Agglomeration and Spillover Effect: the example of Greater London I

75 KM circle	region completely covered	1	**Greater London**
	region only partly covered, centre of region covered	1	Greater London
	region only partly covered, centre of region not covered	1	Greater London, **East of England, South East**
250 KM circle	region completely covered	1	Greater London, East of England, South East
	region only partly covered, centre of region covered	1	Greater London, East of England, South East, **East Midlands, West Midlands, South West**
	region only partly covered, centre of region not covered	1	Greater London, East of England, South East, East Midlands, West Midlands, South West, **Wales**

Source: BAK Basel Economics

Table 8-3 Agglomeration and Spillover Effect: the example of Greater London II

	Points	*Population of Metro [Mio.]*	*Indicator value*
Agglomeration Effect			
London	6	8.3	**49.67**
Spatial Spillover Effect			
East of England	4	8.3	**33.11**
South East	4	8.3	**33.11**
East Midlands	2	8.3	**16.56**
West Midlands	2	8.3	**16.56**
South West	2	8.3	**16.56**
Wales	1	8.3	**8.28**

Source: BAK Basel Economics

9 Annex B: Econometric Methods

9.1 Granger Causality

The issue of causality is at the foundation of any study that examines an economic relationship. General understanding of how a change in one variable affects another is paramount in comprehending economic behaviour and in formulating policy. Fortunately, economic theory is often available to help guide the building of models that are used to empirically examine the causal relationships among variables. However, this is not always the case.

A methodology that has been used extensively in recent years to gain further insight into such situations is Granger Causality (see Granger (1969)). To briefly explain how this methodology works, assume there are two time series, X and Y, where evidence is sought of a potential causal relationship. The following fundamental procedure is used to test for Granger Causality running from X to Y. If, while controlling for the information contained in past (lagged) values of Y, past (lagged) values of X add significantly to the explanation of current Y, then X is said to ‘‘Granger-cause’’ Y.

A symmetric test can also be performed to test for Granger Causality running from Y to X. If, while controlling for the information contained in lagged values of X, lagged values of Y add significantly to the explanation of current X, then ‘‘Y Granger-causes X.’’ A finding that only one of these relationships is true provides support for a unilateral line of causation. However, if both are found to be true, support for a bilateral (or jointly determined) relationship is provided. If neither relationship is found to exist, the assumption is made that the two variables are unrelated.

A more formal test for Granger Causality running from X to Y is shown as:

$$Y_t = a_t + \sum_{j=1}^{J} b_j * Y_{t-j} + \sum_{k=1}^{K} c_k * X_{t-k} + v_t \ ,$$

where v_t is assumed to be a white noise error term and Y_{t-j} and X_{t-k} represent the information contained in lagged values of Y and X. The number of lagged values (J and K) for the independent variables is chosen by the investigator to adequately capture the integrity of the relationship.

To conduct the Granger Causality test, the above regression equation is estimated with and without the regressor matrix X followed by an F-test to test the null hypothesis that $c_k = 0$ for k = 1,..,K. A rejection of the null hypothesis implies that X Granger-causes Y. The formal test for Granger Causality running from Y to X is performed analogously. If the null hypothesis for each of the above Granger Causality tests is rejected, the evidence would indicate that the relationship between X and Y is bilateral, which implies they are jointly determined.

It should be noted that this methodology does not provide ‘‘proof ’’ of causation. The results from such tests should only be interpreted as showing that prior changes in one variable add (or do not add) significantly to the explanation of the future value of another variable. However, these Granger results do provide valuable information that existing ones.

9.2 Stationarity

A common assumption in many time series techniques is that the data are stationary. A stationary process has the property that the mean, variance and autocorrelation structure do not change over time. If the time series is not stationary, we can often transform it to stationarity by building differences. The order of integration is the number of unit roots contained in the series, or the number of differencing operations it takes to make the series stationary.

Testing variables on stationarity before running regressions is necessary because standard inference procedures do not apply to regressions which contain an integrated dependent variable or integrated regressors. As a result, estimation results probably indicate a causal relationship between two variables even if the result is just due to the fact that both variables underlie the same trend. Such results are known as «spurious regressions«.

The formal method to test the stationarity of a series is the Unit Root Test. The standard Dickey-Fuller test is carried out by estimating Equation

$$y_t = \alpha_1 \cdot y_{t-1} + u_t \qquad \text{or} \qquad \Delta y_t = \delta \cdot y_{t-1} + u_t \text{ respectively}$$

The null hypothesis assumes that δ =0, tested with a conventional significance test.

Dickey and Fuller (1979) show that under the null hypothesis of a unit root, this statistic does not follow the conventional Student's t-distribution, and they derive asymptotic results and simulate critical values for various test and sample sizes. MacKinnon (1991) implements a much larger set of simulations than those tabulated by Dickey and Fuller.

The simple Dickey-Fuller Unit Root Test described above is valid only if the series is an AR(1) process. If the series is correlated at higher order lags, the assumption of white noise disturbances is violated. The Augmented Dickey-Fuller (ADF) test constructs a parametric correction for higher-order correlation by assuming that the series follows an AR(p) process and adding lagged difference terms of the dependent variable to the right-hand side of the regression:

$$y_t = \alpha_1 \cdot y_{t-1} + \alpha_2 \cdot y_{t-2} + .. + \alpha_p \cdot y_{t-p} + u_t$$

After transformation the underlying equation of the test is

$$\Delta y_t = \delta \cdot y_{t-1} + \sum_{j=2}^{p} \beta_j \cdot \Delta y_{t-j+1} + u_t \text{ , with } \delta = -(1 - \sum_{i=1}^{p} \alpha_i) \text{ und } \beta_i = \sum_{j=i}^{p} \alpha_i$$

or if a constant and time trend is included

$$\Delta y_t = \beta_1 + \beta_2 t + \delta \cdot y_{t-1} + \sum_{j=2}^{p} \alpha_j \cdot \Delta y_{t-j+1} + u_t$$

The number of lagged difference terms is determined with the Akaike- or Schwartz-criterion, the Ljung-Box-Q-Statistics and significance-tests on the correspondent coefficients.

For panel data however, the classical time series AD-test, applied individually for each section (region) is not suited because of the lack of power. Indeed, the time dimension T=24 in our sample is too short to estimate the parameters in the ADF test. Recent literature suggests that panel-based Unit Root Tests have higher power than Unit Root Tests based on individual time series.

Panel Unit Root Tests are similar, but not identical, to Unit Root Tests carried out on a single series. Consider a following first-order Autoregressive process for panel data:

$$y_t = \rho_1 \cdot y_{t-1} + \delta_i \cdot X_{it} + u_{it}$$

where i=1,..,N cross-section units or series, that are observed over periods t=1,..,T.

The X_{it} represent the exogenous variables in the model, including any fixed effects or individual trends, δ_i are the autoregressive coefficients, and the errors u_{it} are assumed to be mutually independent idiosyncratic disturbance. If $|\rho_i|<1$, y_i is said to be weakly (trend-) stationary. On the other hand, if $|\rho_i|=1$, then y_i contains a unit root. For purposes of testing, there are two natural assumptions that we can make about the ρ_i.

First, one can assume that the persistence parameters are common across cross-sections so that $\rho_{i=}$ ρ for all cross-sectional units. Alternatively, one can allow ρ_i to vary freely across cross-sections.

Two different Panel Unit Root tests have been applied in this study, namely the Levin/Lin/Chu-test (LLC) and the Im/Pesaran/Shin-test (IPS)[26]. The two principal drawbacks of the LLC are i) it does not allow for heterogeneity across sections (regions) as the autocorrelation coefficient is assumed to be the same for all regions, and ii) it does not take into account cross-sectional correlation. In contrast, IPS established by Im, Pesaran and Sin (1997) allows each region to have its own autocorrelation coefficient and is therefore preferable in our case. Nevertheless, both tests have been executed.

9.3 Autocorrelation and heteroscedasticity

In a time series framework, autocorrelation and heteroscedasticity do not lead to inconsistent or biased estimator, as long as the errors are orthogonal to the regressors. The only drawback is that making inference is no longer possible (statistical tests are no longer valid). However, in a panel framework, this may indicate the presence of unobserved heterogeneity through individual effects. In that case, the estimated parameters are inconsistent.

To test the pooled OLS residuals on autocorrelation, the Wooldridge test for autocorrelation in panel data was performed. Under the null of no serial correlation the residuals from the regression of the first-differenced variables should have an autocorrelation of -.5. This implies that the coefficient on the lagged residuals in a regression of the lagged residuals on the current residuals should be -.5. The Wooldridge test performs a Wald-test of this hypothesis.

To test for heteroscedasticity, the Likelihood ratio (LR) test was applied. The LR test is based on the comparison of two Cross-sectional time-series FGLS regressions, one with the underlying assumption of heteroscedasticity (and no autocorrelation) and one with the proposition of homoscedasticity. The LR test statistics is approximately chi-square distributed with degrees of freedom equal to the difference of the dimensions of the unrestricted and restricted model). In our case, the first FGLS regressions involves the estimation of 109 covariances, while the restricted model only estimates one (homoscedasticity, so that the test statistics was chi_2-distributedegree with 108 degrees of freedom.

9.4 Unobserved heterogeneity

In a panel dataset, the pooled OLS estimator is the most efficient estimator among all others, it is said to be BLUE (Best Linear Unbiased Estimator). The problem is that it only holds under very restrictive assumptions (classical OLS assumptions). The key condition needed for pooled OLS to consistently estimate the parameters is that the disturbance term has mean zero and is uncorrelated with each of the repressors.

Pooled OLS does not allow any heterogeneity among sections (regions). Consequently, we ignore the heterogeneity among sections (regions), and so assume that all explanatory variables are exogenous. An explanatory variable is said to be endogenous if it is correlated with the error term. The endogeneity leads to inconsistent and biased estimations in an OLS framework. Many causes can be responsible for the endogeneity. The most current is the omitted variables. Indeed, in a panel dataset, it is very usual to have heterogeneity across section (in our case regions) without having a variable explaining it. Fixed effect and random effect allows taking into account to a certain extent unobserved effects and so avoiding the correlation between repressors and the error term.

Following the literature, we compare the OLS with RE (or FE) to determine whether heterogeneity across sections (regions) is present. The Breush-Pagan test is perfectly suited to test the presence of an unobserved effect. The Breusch-Pagan (1979) Lagrange multiplier test tests for heteroscedasticity

[26] See Levin, Lin and Chu (2002) and Im, Pesaran and Shin (2003)

in the error distribution, conditional on a set of variables which are presumed to influence the error variance. The test statistic, a Lagrange multiplier measure, is distributed Chi-squared(p) under the null hypothesis of homoscedasticity. The test is asymptotically equivalent to White's (1980) general test for heteroscedasticity if the same auxiliary variables are specified (for White's test, all distinct regressors, cross-products and squares of regressors). See Greene (2000), pp. 507-511.

9.5 Panel data methods

The basic methods used in a in a panel data setting are the Fixed Effects Model and the Random Effects Model. They mainly differ in the way they take individual heterogeneity into account. The starting point is the simple model

$$y_t = X'_{it} \cdot \beta + \varepsilon_{it}$$

In extension to the standard regression model, the structure for the error term is of the form

$$\varepsilon_{it} = \alpha_i + \eta_{it} \,,$$

where η_{it} follows the standard assumptions of the classical linear regression model. One of these assumptions is that η_{it} is uncorrelated with X_{it}.

It is the assumption about the first part of the error structure, namely the time-invariant term α_i, whether one speaks of a fixed effects or a random effects model. Within the random effects framework, one assumes that α_i is uncorrelated with X_{it}, while this restriction is not necessary within the fixed effects framework.

9.5.1 Fixed Effects Model

As been said, within the fixed effects framework, α_I is not assumed to be uncorrelated with X_{it}. The fixed effects model is simply a linear regression model in which the intercepts vary for the individual units i. Therefore the fixed effects approach implies that the individual heterogeneity is represented through a shift in the intercepts:

$$y_t = \alpha_i + X'_{it} \cdot \beta + \varepsilon_{it}$$

Mention that α_I is just treated as an unknown parameter, which has to be estimated. Because the number of individuals in typical panel settings is large and the number of periods is small, often problems with the degrees of freedom arise.

To come along with this difficulty, one usually transforms the equation above in a way that the individual effects are cancelled out (a common fixed effects estimator is the so called within estimator). The parameters of the individual effects are then determined indirectly through retransformation, although one can not obtain consistent estimates for these parameters in the typical panel case.

9.5.2 Random Effects Model

Within the random effects model the individual heterogeneity is introduced through an additional error component. The error term $\varepsilon_{it} = \alpha_i + \eta_{it}$ consists of two components: an individual specific component α_I, which does not vary over time and a remainder component which is assumed to be uncorrelated over time.

As said, α_I is assumed to be uncorrelated with X_{it} so that, along with the assumptions for η_{it}, the coefficients of X_{it}, can be estimated unbiased with ordinary least squares (OLS). Two problems arise with using OLS however: First, OLS will produce consistent estimates of β but the standard errors will be understated. Second, OLS is not efficient compared to a feasible generalised least-squares (GLS) procedure by exploiting the structure of the error covariance matrix.[27] The GLS procedure is a regression technique that is usually attended when the error terms from an ordinary least squares regression display non-random patterns such as autocorrelation or heteroscedasticity.

The GLS estimator is sometimes referred to as a weighted least squares estimator, because it is a least squares estimator in which each observation is weighted by a factor proportional to the inverse of the error variance. The use of weights implies that observations with a higher variance get a smaller weight in the estimation. In other words, the greatest weights are given to observations of the highest quality and the smallest weights to those of the lowest quality.[28]

9.5.3 Hausman-test

A widely used class of tests in econometrics is the Hausman test (Hausman (1978)). The underlying idea of the Hausman test is to compare two sets of estimates, one of which is consistent under both the null and the alternative (the fixed effects model) and another which is consistent only under the null hypothesis (the random effects model). A large difference between the two sets of estimates is taken as evidence in favour of the alternative hypothesis.

In other words: The Hausman test tests the null hypothesis that the coefficients estimated by the efficient random effects estimator are not systematically different from the ones estimated by the consistent fixed effects estimator. In fact, the Hausman test is based on estimating the variance var($\beta_{\text{Random Effects}}$-$\beta_{\text{Fixed Effects}}$)of the difference of the estimators by the difference var($\beta_{\text{Random Effects}}$)-var($\beta_{\text{Fixed Effects}}$) of the variances. The test statistic is chi^2 distributed with a degree of freedom according to the dimension of the variance matrix (number of regressors).

If the Hausman test suggests that the coefficients are not systematically different, it's safe to use random effects. A Fixed effects model is also consistent in that case, but the random effects model leads to a more efficient estimator. Otherwise, if the Hausman test suggests systematic differences between the two estimators, a fixed effects model has to be applied.

[27] See Johnston and DiNardo (1997), p.391, Verbeek (2000), p. 315.

[28] See Verbeek (2000), p.78.

10 Annex C: Summaries of Selected Studies

In the following selected empirical studies of determinants of growth are summarised.

Ahmed, H. and S. Miller, (1999),

«The level of development and the determinants of productivity growth»

Pooled OLS, RE and FE estimations for three different country samples (low-income countries, middle-income countries, high-income countries) in a sample of 93 countries from 1976 to 1984. The productivity growth rate is regressed on investment to GDP, population growth and parameters of the production function to find out the specificity in each group of country. The main result is that investment is the most important determinant of productivity growth for low-income countries (mostly African countries), while for middle-income countries, additional effects like technological change are important. However, for high-income countries, investment is not significant any more, but solely technological change. The results of this paper can be used to justify why in the project BAK regional growth rate investment has not been investigated. The population growth rate affects productivity growth negatively both in low- and high-income countries, but does not significantly affect productivity growth in middle-income countries. The analysis also gives an explanation for the slow down of productivity growth in high-income countries. Expansion of the low-productivity service sector and the decrease in the share of the high-productivity industrial (manufacturing) sector pulls down real productivity growth. Thus, in high-income countries, productivity growth can increase if the industrial sector share expands, or the level of technology in the expanding service sector is raised.

Barro, R. (1998),

«Determinants of economic growth: a cross-country empirical study»

The regression framework is applied to a panel of data covering roughly a hundred countries over the years 1968-1990 in an effort to determine what factors are important in explaining long-run growth. The findings highlights that the growth rate of real per capita GDP is enhanced by better maintenance of the rule of law, smaller government consumption, longer life expectancy, more male secondary and higher levels of schooling, lower fertility rates, and improvements in the terms of trade. The data also support the notion of conditional convergence; that is, for given values of these variables, countries with a lower initial level of real per capita GDP grow faster. The analysis also looks at democracy and inflation as potential factors determining growth rates. In chapter II, he looks at the role of political freedom in determining growth rates. The positive relation between democracy and prior measures of prosperity is well established as an empirical regularity. The third chapter considers the effects of inflation on long-run economic performance. The clear evidence for adverse effects of inflation from the experiences of high inflation (annual rates in excess of 20%).

Bassanini, A. and S. Scarpetta, (2001),

«The driving forces of economic growth: panel data evidence for the OECD countries»

Panel VECM to estimate cross-country (OECD countries) differences in GDP growth performance as well as the evolution of performance over time in each country. Bassanini and Scarpetta choose a pool mean group estimator that allows intercepts, the convergence parameter, short run coefficients and error variances to differ across countries, but imposes homogeneity on long-run coefficients. Accumulation of physical capital as well as human capital (main drivers of economic growth) turned out to be essential. In addition, R&D activity (expenditures on

R&D), sound macroeconomic environment (low inflation, small government deficit, large government sector), trade openness and well-developed financial markets contribute to raise GDP in OECD countries.

Brakman, S., H. Garrestsen and M. Schramm, (2002),

«New economic geography in Germany: testing the Helpman-Hanson model»

According to the paper, the spatial characteristics of the German economy can be explained by the New Economic Geography by means of a WLS (Weighting Least Square) they find that all parameters of the wage equation are significant and have the right sign.

Brakman, S., H. Garretsen and M. Schramm, (2004),

«Putting new economic geography to the test: free-ness of trade and agglomeration in the EU regions»

Based on an estimation of the equilibrium wage equation from the NEG, Brakman et al. find evidence that economic integration leads only to agglomeration for regions that are relatively close to each other. In Europe, agglomeration seems to be most relevant at lower geographical scales because of the lack of labour mobility.

Ciccone, A. and R. Hall, (1996),

«Productivity and the density of economic activity»

Two hypothesis of the NEG were tested: the local geographical externalities and the diversity of local intermediates services. Both theoretically lead to Increasing Return to Scale. Ciccone and Hall show that, first the density of economic activity at the county level is crucial for explaining the variation of productivity at the state level. The doubling of employment density explains a 6% increase of average labour productivity. The econometrical methodology is a cross-sectional OLS regression.

Davis, D. and D. Weinstein, (1998),

«Market access, economic geography and comparative advantage: an empirical assessment»

Existence of «home market effects» (theoretical concept by Krugman) if the importance of market access in implementing models of economic geography is taken into account.

De la Fuente, A, (2002b),

«The effect of structural fund spending on the spanish regions: an assessment of the 1994-99 objective1 CSF»

The EU structural policy impinged positively on the regional GDP of about 1% and 0.4% of employment creation per year. Besides, the convergence reduced the gap between regions at 20% over the period considered. The results are based on a supply side model. The coefficients of physical capital accumulation, infrastructure and human capital are all three positive and statistically significant in a fixed effect model.

De la Fuente, A, (2003),

«Does cohesion policy work? Some general considerations and evidence from Spain»

Empirical investigation with the following results: EU regional structural policy has a positive impact on regional GDP particularly when funding investment in human capital (education) and to a fewer extent in infrastructure. Investing in infrastructure has a positive impact for low GDP regions with weak infrastructure, but once reached a high infrastructure standard (saturation effect), investment is no longer effective.

De la Fuente, A, R. Doménech and J. Jimeno, (2003)

«Human capital as a factor of growth and employment at the regional level. The case of Spain»

First, the effects of school attainment on individual wages, participation rates and employment probabilities in Spain are quantified; second, the contribution of education to labour productivity at the regional level is measured. These results are used to estimate the private and social returns to schooling. First, using Weighted Least Squares and allowing wage correlation within firms, they find that schooling has a strong positive impact on wages. Second, with a probit two-stage procedure they show that schooling has a positive impact on labour force participation and employment probabilities.

De la Fuente, A. (2002),

«Convergence across countries and regions: theory and empirics»

Discussion about the relevance of beta and sigma convergence (among regions within a country). The author argues that panel econometrics is not always relevant for convergence analysis.

Dewan, E. and S. Hussein, (2001),

«Determinants of economic growth»

Panel econometrics methodology with fixed effects and random effects estimators are used to explain the GDP growth rate in developing countries (41 middle-income countries). The dependent variables are first differenced and are: labour force, gross domestic investment, inflation, import goods, public spending on education, good imports. The results show that countries with strong macroeconomic fundamentals (change in inflation ->low inflation,) tend to grow faster, but also change in investment in both physical and human capital (public spending on education), open trade policies (less trade barriers), are necessary for economic growth. The change in technology (capacity to adopt technological changes) is essential too.

Feenstra, R. J. Markusen and A. Rose, (1998),

«Understanding the home market effect and the gravity equation: the role of differentiating goods»

Quantification of the home market effect using cross-sectional gravity equations. Domestic income export elasticities are indeed substantially higher for differentiated goods than for homogeneous goods

Gustavson, P. and J. Persson, (2003),

«Geography, cost-of-living, and determinants to economic growth: a study of the swedish regions, 1911-1993»

This paper analyses determinants to economic growth with a spatial perspective using data on the Swedish counties for the period 1911-1993. First the authors analyse spatial interdependency in regional income per capita growth rates, and find robust and significant evidence for spatially autocorrelated growth rates, that is, growth rate in one county are found to be dependent on growth rates in contiguous counties. Additional channels of geographical growth spillover were found, i.e., the income per capita, and market size spillover. Agglomeration, measured by population density, has a positive effect on the growth rate of income per capita. Among the control variables, only the net migration is found to have a negative robust impact on per capita income growth independently whether income is PPP adjusted or not. The econometric tools are 2 Stage Least Square estimators.

Hall, R. and C. Jones, (1998),

«Why do some countries produce so much more output per worker than others?»

In a cross-sectional OLS estimates, including 127 countries, they prove that high level of output per worker is achieved in the long run because of high investment rates in physical capital, human capital and high level of productivity (production function). These variables are driven positively in countries where social infrastructure is well developed. This social infrastructure means institutions and government policies that make up the economic environment within which individuals and firms make investments, create and transfer ideas, and produce goods and services.

Kaldewei, C. and U. Walz, (2001),

«The determinants of regional growth in Europe: an empirical investigation of regional growth models»

With a sample from 1980 to 1996 and using regional data at the NUTS-2-level, Kaldewei and Walz investigate an empirical study of determinants of GDP per capita growth. The econometric methodology is of the easiest one: pooled OLS. They combine elements of the New Economy Geography and Endogenous Growth theory and find evidence that the average growth rate of GDP per capita depends positively on, the accumulation of human capital, the agglomeration effect, transport costs (or access to market), financial sector and negatively on migration, population density and population size. However, regional knowledge spillovers, regional transfers and transport costs are not significant. Regional knowledge spillovers are approximated with the number of patents. Transfers and transport costs on the other hand have opposite effects on GDP growth. At first sight transfers have a positive effect, but they also hinder structural adjustment. Transport costs have theoretically non linear effects on GDP and so this result (the fact that transport costs are not significant) is also justified. To control for industrial structure, they include the share of employment in agriculture and share of employment in the service sector. Finally they investigate the beta convergence hypothesis (absolute and conditional), and find evidence for it but lower than 2% (2% are the estimate of Barro and Sala-i-Martin).

K L Krishna, (2004),

«Patterns and determinants of economic growth in Indian States»

The paper studies economic performance of Indian States during the period 1960-2000. Using panel fixed effect estimator, he finds evidence. In developing countries, the size of the agricultural sector has a positive impact on industrial and service sector growth. Besides, social infrastructure is an important determinant of the investment decisions.

Moreno, R., M. Artis, E. López-Bazo and J. Suriñach, (2000),

«Evidence on the complex link between infrastructure and regional growth»

Analysis of the link between public infrastructure and productivity in Spanish regions. Infrastructure has a positive but modest effect on productivity. The existence of spatial autocorrelation with other regions (spatial spillover) makes the link between productivity and regional productivity very complex. Taking into account this autocorrelation effect, there is little evidence of a positive-link infrastructure-growth. But public infrastructure is a prerequisite to economic activity and so essential.

Overman, H., S. Redding and A. Venables, (2001),
«The economic geography of trade, production, and income: a survey of empirics»

Geography is a major determinant of factor prices, and the degree of access to foreign market (transport costs, time costs, fixed costs, barrier to enter new foreign markets) is shown to explain some 35% of the cross-country variation in per capital income. The paper documents empirical findings of home market effects, suggesting that imperfectly competitive industries are drawn more than proportionally to locations with good market access.

Vayà, E., E. López-Bazo and M. Artis, (2000)
«Growth convergence and (why-not?) regional externalities»

Investigation of the question how important regional spillover in regional convergence is. The distinguish demand driven externalities (approximated by the weighted growth rate in the region’s neighbours) while the supply-side would be by the initial level of the neighbours. Both effects are robust to different specifications. Demand-side externality seems to be stronger than supply-side externalities.