The technology shift thesis

Understanding long term growth and transformation in a regional system

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2017

Document Version:
Publisher's PDF, also known as Version of record

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Research Reports in Human Geography 2017:1
Department of Human Geography, Lund University

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Research reports in Human Geography 2017:1
Department of Human Geography, Lund University
ISBN: 978-91-7753-381-8 (print)
e-ISBN: 978-91-7753-382-5 (pdf)

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Abstract

In this paper we examines the long run economic growth and productivity performance of regions and how this relates to different phases of structural change and economic adaptability in different part of a national regional system.

Firstly, we suggest a theoretical 'systemic' approach for analyzing long term regional economic growth and transformation. Special emphasis is given to radical technology shifts and their effect in time and space, such as lead-lag relations between industries and regions leading to divergence and convergence in regional growth as consequences of technological change, market integration and economic growth. We hypothesis that technology shifts in combination with industry structure and the existing hierarchy of regions will put strong restriction on what can be achieved in terms of transformation and growth for single regions in specific time periods but also on how interdependency in a regional system evolves over time.

Secondly, in the empirical work, based on detailed analysis of the Swedish regional system 1985-2008, we show that the technology shift have targeted various part of the regional system at different points of time setting the overall average agenda for structural change, productivity development and growth for different levels of the regional system. Further on we have found that regions belonging to different level of the hierarchy tend to follow different "growth corridors" giving the basic precondition for regions to take advantage or not of the impact from the technology shift. Finally we have identified outliers and unexpected idiosyncratic regional growth trajectories calling for further in-depth research.

Introduction

The aim of this paper is to analyze the long term impact of a radical technology shift on growth and transformation in a national regional system. A radical technology shift is the introduction of a new general purpose technology, which is a path-breaking technology that is pervasive and used in a lot of activities and eventually influence the whole economy and society. Microprocessor-based ICT is the latest example of a GPT. Complementarity is an important aspect of a GPT, meaning that its utility increases in combination with certain other activities. Our hypothesis is that a radical technology shift in combination with industry structure, an existing hierarchy of regions and distances between these regions will largely put strong restrictions on what can be achieved by individual regions in terms of growth and transformation in very specific time periods, although they will not fully determine the future growth trajectory of each region. It will also to a large extent determine how interdependencies between regions in a country's regional system will evolve over time.

The theoretical framework that we use is the technology shift thesis and structural cycles generalized for the Swedish economic history (Schön 2006, 2012). This thesis identifies long waves in the rates of economic growth and the mechanisms and characteristics explaining them. In combination with modern basic location theory this thesis will be used in order to trace the main characteristics of the underlying long term regional development. Initially, these characteristics will be traced on regional size-group level. Using an extensive micro-level dataset as well as auxiliary industry price data we investigate this issue for Sweden during the years 1978/1985 to 2008.

After having tested our hypothesis on regional size-group level, we will go deeper into the individual variations between regions within various size-groups. We hypothesize that individual regions to a great extent will grow in specific time-periods as the result of given systemic conditions and in other time-periods more as the result of new unknown conditions and unique capabilities. Among given systemic conditions in regions are industry structure, industry width and productivity. We will try to estimate to what extent such given conditions in regions at the beginning of a time-period will decide the technology shift outcome in terms of growth. Opposed to this we will also estimate to what extent new unknown conditions and unique capabilities in regions will affect the outcome in the same time-period. These unknown conditions cannot be predefined, they are considered residuals.

This systemic/residual approach echoes the classic arguments by Christaller (1966) and Lösch (1954). However, their way of seeing regions as parts of economic hierarchies has left little trace in contemporary economic geography. We find this unfortunate, because it limits our understanding about the prerequisites for growth and transformation. It is very different from the dominant theoretical perspectives on these matters in economic geography and the regional sciences today.

Theories about local clusters, agglomerations and innovation systems have in many cases provided excellent understanding of the prerequisites of growth and transformation in individual regions. However, this has to some extent been at the expense of an understanding of how regions are affected also by technology shifts, their industry structures as well as by their relative positions in a hierarchical regional system, and by developments elsewhere in the economy. Our approach does not at all rule out the existence or importance of clusters, agglomeration externalities or regional institutions promoting growth. But rather than emphasizing the uniqueness of each region and its economic trajectory, we chose with the systemic/residual approach to emphasize the traits that regions on the same level in the hierarchy share, rather than what makes them distinct. Being able to sort out systemic effects from effects coming from unique local growth incentives is considered to be an important research field, opening up for multi-theoretical approaches within the suggested framework.

We proceed by introducing the theoretical underpinning and character of technology shift and growth cycles and identify the roles of different industries in the transformations process. In the next section we provide a brief descriptive analysis of the national economy and how it is related to the technology shift thesis. The rest of the paper is dedicated to the impact on regional level in terms of structural change, productivity development and growth in different part of the regional system. In the last section using regression analysis we identify how “growth corridors”, i.e the precondition for growth and change set by the systemic factors, over time frames the level and character for regional growth in different part of the regional hierarchy. We finalize the paper with concluding remarks and suggestion for some future research venues.

Technology shifts and growth cycles

Contemporary theorizing of economic growth processes is increasingly based on the idea that long term fluctuations in the rhythm of economic growth are rooted in the discontinuities brought by introduction of new interrelated and pervasive radical technologies, often referred to as general purpose technologies, and subsequent structural adjustment of the economy to newly opening technological opportunities. For quite some time now, the early writings by Schumpeter (for example Schumpeter, 1939, 1951) have inspired the development of an extensive “neo-Schumpeterian“ literature on innovation, economic change and growth, especially within the various stances of evolutionary economic thinking (Nelson and Winter 1982, Fagerberg 2003, Saviotti 2001, Freeman and Louça 2001, Nelson 2006). The evolutionary framework, broadly defined, has also diffused into the core discussion of other disciplines such as economic geography (Boschma 2004, Frenken et al. 2007, Boschma and Frenken 2006, Boschma and Martin 2010). Especially within the non-formalised,

"appreciative" (Nelson and Winter, 1982) stances of evolutionary economics, several scholars have discussed the occurrence of paradigms or structural periods of economic development and change. These eras of economic growth tend to define the main cognitive search area of innovations and innovation implementation in the economy. As these paradigms are often dominated by one or a couple of defining key innovations, some scholars connect this search area to the pervasive impact of general purpose technologies (Bresnahan and Trajtenberg 1995), and emphasize that the eras in this way also are accompanied by new relative price structures (Dosi 1988, Freeman and Perez 1988).

In more encompassing versions of these theories, such as the technology shift thesis and structural cycles, the dominating forces of growth are associated with the co-development of leading technologies and their complementarities, and institutional as well as organisational structures (Schön, 2006, 2012, Ljungberg 2016). By quantitative analysis of aggregated time series (among others investment, capital/labour quotas and productivity) as well as more qualitatively oriented evidence, reoccurring phases of development in the Swedish economy have been identified. These reoccurring phases share similar characteristics in terms of investments, technology diffusion, systematic lag effects between industry and institutional structures, forge-ahead and lagging industries, pre- and post-crises behaviour among actors and distribution of wage/profit quotas. Within each reoccurring period technology shift of about 40-50 years, development is characterised by the stylized sequence of, to put it all too simply, transformation – rationalisation – crisis. By this, Schön provides explanations for the growth and demise of industries over time in a national production system since the initiation of industrial capitalism, as well as to the dynamics of macro-economic crises.

Hence, structural cycles are a generalization describing the Swedish economic history, not necessarily valid for other countries. Of course, the Swedish structural cycles have a crucial relation with the international economy but whether structural cycles exist, or how they look like in other countries, are a matter for further research. An objection to the use of 'structural' as well as 'cycles' is that they imply determinism, the illusion of a perfect model of the future. Remarkably, the same criticism can be directed towards Schumpeter who saw the process of economic development as recurrent phases of cycles of different length. However, Schumpeter was also the instigator of the 'entrepreneur', a concept that highlights the importance of the actors. For Schumpeter, the long waves were driven by the uneven generation of innovations by entrepreneurs. Kuznets (1940), in his classic review of Schumpeter's *Business Cycles* (1939), saw the clustering of innovation as a hypothesis in want of evidence or a rationale. Whereas Schumpeter thought the discontinuous, yet repetitive, behaviour of entrepreneurs/innovators was the cause of the long waves, Schön (2006, 2012) finds the mechanism of the cycles in the dynamics of the structure. A critique demands that endogenously generated

cycles should be of exactly the same length. Basically this critique could be returned as monocausal in only recognizing exogenous factors as occasional disturbances of a perennial equilibrium. If we think of endogenous factors as not only generating return to an equilibrium, but as generating dynamic phases of change, as with Schumpeter's *creative destruction*, then there is still room for exogenous factors that influence the timing and intensity of the cycles. For Schön, the length and actual outcome of the structural cycles are modified by the involved actors. As a model of the future, the structural cycles are hence conditional on actors and furthermore that the economy retains basic traits of the industrial epoch.

Characteristics of the national process

A core argument in the technology shift framework is that new general purpose technologies define main characteristics of economic transformation, renewal and growth during the technology shift process. These technologies spur growth in new industries and revitalise older parts of the economy through productivity increases and lower costs. However, the impact on particular industries and sectors are not only differentiated in terms of scale, but also at different points in time. Table 1 sums the main characteristics of the transformation and the rationalisation periods, based on Schön (2006, 2012) and Lundquist and Olander (2010). These characteristics will be expanded in later sections.

The spread of GPT and macro innovations leads to investments in new production areas during the *transformation* (20–25 years), which is the first period of the technology shift process. Growth increases rapidly in new industries and later spreads to older industries (see also Figure 1). Thus, economic resources are reallocated between businesses. During this period, productivity increases primarily through the transfer of resources from low-productive to high-productive industries.

Table 1. Characteristics of transformation and rationalisation

Transformation	Rationalization
GPT initiation	Diffusion of competence
New industries	Technological standardisation
GPT diffusion	Decomposition
Supply-driven industries	Demand-driven industries
Development blocks	Consumption growth
Productivity from structural change	Productivity from within industries
Bottlenecks	Credit market expansion
Building investments	Machinery investments

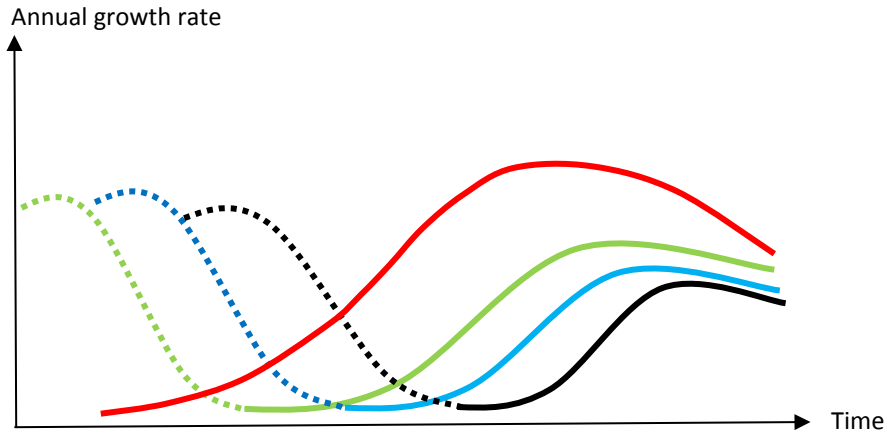

Figure 1. New and old industries in hypothetical sequence during the technology shift process.

Production increases faster than productivity in the beginning of the transformation, because of extended learning periods and limited availability of skills in the new technology. This relationship only changes later in the transformation. The renewal and growth during the period are primarily visible in the increased activity on the supply side of the economy. New technologies leads to falling relative prices and rising relative volumes in new and updated technology-intensive production.

In the beginning of the *rationalization* (15–20 years), which is the second period of the technology shift process, demand-driven industry expand while the previous supply-driven industries slow down (see also Figure 1). The new technology that emerged in the preceding period is standardized, expands into other fields of application and spreads efficiently to older parts of the economy. The productivity increase in the economy does no longer come so much from transfer of resources from low-productive to high-productive industries, but rather from increased productivity from within all industries. Investments are primarily focused on cutting costs in production and distribution. At the end of this period, slow growth, over-capacity, recurring recessions and falling profits will eventually lead to a structural crisis in which communities and economies prepare for opportunities for new paths of growth.

It should be pointed out here that we are first and foremost talking about economic growth in a relative sense, as a cyclic phenomenon in time and space, not necessarily in absolute terms. Absolute and final economic growth is a complicated outcome of technology shift in combination with short business cycles, industry mix, specific industry technologies, specific local capabilities and many other prerequisites for economic growth. We will deal further with this issue in the final parts of the paper.

Characteristics of the regional process

The main idea behind the technology shift thesis and structural cycles is to understand national economic change over long time, not to develop a theory about regional economic change. That is, however, the main idea behind *the geographical reference cycle* (Lundquist and Olander 2001, Lundquist and Olander 2010, Henning et al 2016), being in the centre of interest in this article. When introducing the notion of this reference cycle we will use the technology shift thesis and structural cycles as a platform and building on that an understanding about regional economic change by adding theoretical concepts and findings from economic geography.

To start with, the economy's adjustment to the new technological paradigm are not equally distributed across space. Regions are differentially equipped with the ability to absorb, develop, implement, and commercially translate the growth forces of the technology shift. In previous research this ability has been coined *the regional receiver and development competence* (Lundquist and Olander 2001). Following initial contributions of the New Economic Geography, contemporary view of regional economic growth builds upon the principle of increasing returns derived from internal and external scale effects, size of a local market, transaction costs and comparative advantages from production factors (Krugman 1991, Fuijta et al. 1999). The principle of increasing returns might be further connected to an endogenous capacity of regions to generate innovation as well as to receive and exploit ideas, innovations, technology and market changes from the outside world (Jaffe et al. 1993; Boschma and Lambooy 1999). This capacity is dynamic in its nature and defines the ability of a region to translate growth forces of the technology shift into competitive performance. As receiver capacities, roles and relations between regions are changing over time, it has been claimed that technology shifts are inherently geographical in character (Lundquist and Olander 2010; Henning, Lundquist and Olander 2016).

Spatial and sectorial outcomes of adjustment to newly emerging technological opportunities are then dependent on a range of interlinked mechanisms and channels connected to internal organisational structures of firms and industries, pure imitation by new and existing competitors, emerging complementarities between new and old parts of the economy, possibilities for decomposition and fragmentation of value chains as well as opportunities grown from processes of standardisation, price competition and falling transaction costs.

In particular, in the beginning of the adjustment process, industries making an early use of new technological opportunities are mainly supposed to be located in markets at the top of a regional hierarchy as these provide sufficient economies of scale when transaction costs are high. Beginning gently and experimentally in these sites, new activities take time to become visible. Mature businesses initially dominating the scene gradually decrease in size and importance offering space

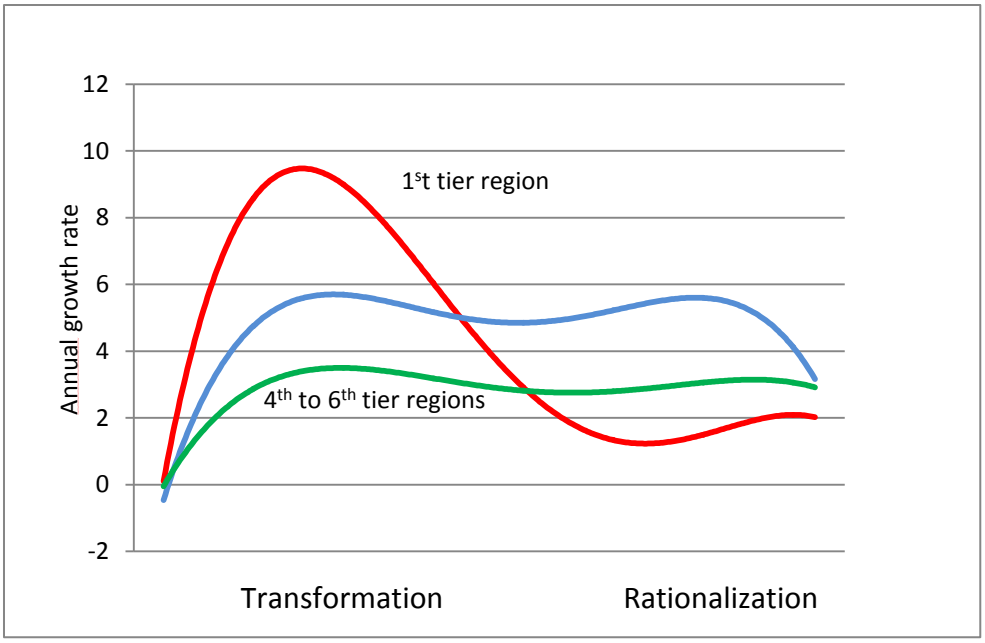

Figure 2. Hypothetical growth trajectories for regions in a technology shift process

and resources to newly emerging activities. Regions at lower levels of a regional hierarchy, lacking sufficient locational advantages and receiver capacity, are not able to attract new industries resulting in a slower aggregate growth in output, productivity and employment.

With time new general purpose technologies introduced in particular market niches start shaping new production configurations outside industries of their origination through industrial interactions, demand pressures and technical competition (Canter and Vannuccini 2012). This allows a wider spectrum of industries to benefit from opportunities offered by the new technology. At the same time as transaction costs gradually fall and large regional markets become strained on a resource side industries drawing upon new technologies or incorporating them into their core activities start to disseminate regionally leading to an accelerated growth in value added, productivity and employment in a wider set of regions.

Thus, the most advanced regional receiver and development competence is found in the large regions, where new technologies can be received and developed because the big regional markets which give early economies of scale, superior agglomeration advantages and advanced sets of human capital inputs. Increasingly smaller regions, where the regional receiver and development competence diminishes correspondingly, have on the other hand low relative cost structures. This becomes beneficial as new technologies gradually mature and congestion effects in the bigger regions force a decentralization and re-location of the industries especially drawing from the new possibilities of the technology shift (Lundquist and Olander 2011). Indeed, variations in the regional receiver and development competence in different parts of the regional hierarchy should give rise to

lead-lag relationships between industries and regions in different stages of the technology shift process.

Technology shift process assumes, as mentioned, that due to initial various endogenous capacities regions will play different roles over time in the economic development of a country. Divergence among regions might therefore prevail during certain time-periods, while being counteracted by convergence in later periods. If this is correct technology shift theory might contribute to modern endogenous growth theories when dealing with divergence and convergence issues. These theories share many processes with technology shift theory like the importance of innovations, accumulations of skill and localized collective learning, which prevents returns from investments from diminishing. Suggestions have been made that this will lead to convergence amongst similar regions, but no convergence between different regions (Martin 2001). At any rate technology shift theory seems to divert substantially from conventional neo-classical growth theory predicting absolute or unconditional convergence between all kinds of regions over long time.

Industry roles in the process

This periodization of a technology shift and its characteristics inspired us to define stylized combinations of growth and productivity trajectories for industries in the Swedish economy from 1978, with different industries assuming different roles in the technology shift process. As an auxiliary variable in this process, we used information on industry price-volume development. Industries producing key inputs for new products associated with new GPT would for example show combinations of trajectories and price-volume changes which are differentiated from those of industries with other roles to play. The latter could for instance be early or late adopters of the new technologies, industries that serve as demand-driven suppliers to technology-driven industries, consumer goods industries driven by real wage increases, or industries that are very little directly affected by the technology shift.

In essence, we analyse the production volume, productivity and relative price development of Swedish industries during 1978/1985 and 2008. Following the arguments of the technology shift thesis, we make extensive use of sub-periodization, as these mark important variations in the movement from transformation to rationalisation during the technology shift process. Four ideal market situations for the different industries emerged from combining relative price and relative volume development on markets over time: market push (growth by strong innovation implementation or marketing), market pressure (increasing competition from product and process improvements), market pull (induced effects from growth/demise of other industries), and market contraction (increasingly obsolete manufacturing). These four market situations, derived from

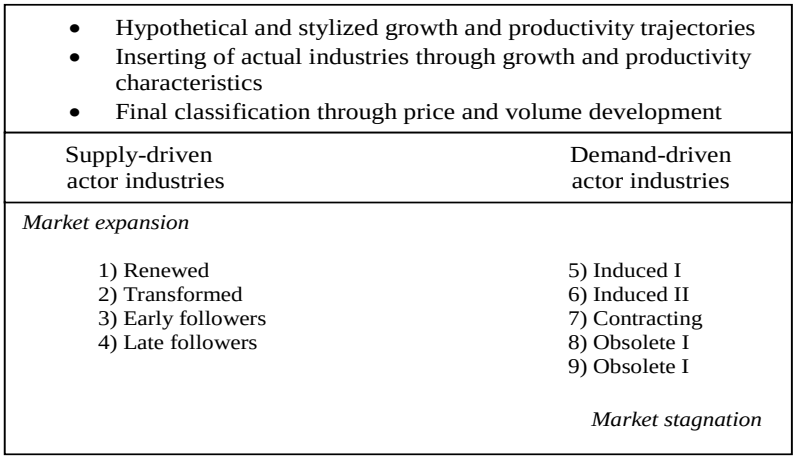

Figure 3. Classification of manufacturing industries.

literature in the field (Dahmén 1950, Josefsson and Örtengren 1980, Ljungberg 1990), can be used to determine whether industries have been relatively supply-driven or demand-driven during a specific period. The four categories of industry market situations enable us to create theoretically informed stylized industry groups, each assumed to have a different role to play during the technology shift process1.

Empirically, we sorted 170 Swedish manufacturing industries into one of these groups using consistent time series data for the years 1978 to 2004. The procedure consists of three stages: (1)identification of industry groups exhibiting similarities in their growth of value added over time, (2) dividing these industry groups into sub-groups based on similarities in their growth in labour productivity (3) distinguishing between those industries that could be assumed to be more supply-driven in their development and those that could be assumed to be more demand-driven, based on analysis of their relative price and relative volume development. These final groups of "role" industries represent a sliding scale from 'supply driven' to 'demand driven' and from 'market expansion' to 'market stagnation'. The procedure is summed up in Figure 3, which also contains the names of the different role industries. This classification will be used as a guide for selection of those manufacturing industries that could be used as main indicators of the economic transformation.

For the service sectors, we had to proceed according to quite a different logic because of data restrictions (Figure 4). At a first stage, service industry data created in the effort of constructing consistent time series (however restricted to 1985-2004) were sorted into three groups based mainly on service user orientation. In a second stage, we divided these user-oriented groups into two sub-

[1] A thorough exposition of method and data used for manufacturing industries is given in Svensson-Henning (2009) and Lundquist, Olander, and Svensson-Henning (2008a). For service industries a similar account is given in Lundquist, Olander, and Svensson-Henning (2008b).

- Groups of services according to market and user orientation
- Division of services groups through growth characteristic
- Final classification into supply and demand driven groups based on temporal growth variations.

Strong to medium growth service industries	**Medium to weak growth service industries**
Producer services	
Supply-driven	*Demand-driven*
1) ICT services	5) Financial and legal services
2) Advertising, design and other consultancy	6) Technical and engineering consultancy
3) R&D laboratories	7) Leasing of man. equipment
4) Security services	8) Industry-related wholesale
Consumer and general services	
Mainly demand driven	
1) Cleaning and sanitation	7) Other retail
2) Cons. related wholesale	8) Vehicle trade and maint.
3) Restaurants and hotels	9) Communication, postal s.
4) Retail/occasional products	10) Construction
5) Recreation and cultural s	11) Other consumer services
6) Food retail	12) Dept stores/hypermarkets
	13) Electricity, gas, water

Figure 4. Classification of service industries

groups: 'strong to medium growth'; and 'medium to weak growth'. These were based mainly on value added development, but controlling for productivity development. Since no relative price series are available for service industries for such an extensive time period, service industries within the sub-groups could not be classified into supply-driven and demand-driven following the price/volume logic. Therefore, we let the growth rates over time for the service industries, in combination with productivity development, decide together with product/market characteristics if the industry should be classified as supply-driven or demand-driven.

A national picture

The growth trajectories for industry groups, assembled from the classification schemes earlier, are displayed in figures 5 and 6. Their shares of the economy in value added are displayed in Table 2. The somewhat late starting year (1985) is explained by data restrictions for the service industries. The ITC-services and the advanced producer services grew very fast in the second part of the 1980s and all through the bank- and budget crisis in the beginning of the 1990s. New manufacturing industries some of which were producing new technology hardware to service industries grew somewhat slower than these industries at the time, whereas transformers and followers within manufacturing

industries hardly grew at all (Figure 5). Despite the fact that all these supply-driven industries grew faster than GDP or at least at par with it, they didn't increase their total share of the economy between 1985 and 1992. Their initial shares were too small for that. Demand - driven industries on the other hand like less advanced producer services, consumer services and the rest of manufacturing industries grew at par with GDP or much less than so. They were still keeping the lion's share of the economy in these years (Figure 6). Thus, the period 1985 till 1992, here called early transformation, was the time when new and old technologies began to struggle for supremacy in the economy, with old industries still in command and unaffected by changes to come.

After the crisis 1992 all the supply-driven industries grew very fast all through the transformation till 2000. ITC-services and new manufacturing industries took the lead ahead of advanced producer services. Also transformers and followers within manufacturing industries started to grow at least following the GDP. Among demand-driven industries it was only the rest of producer services that grew faster than GDP. Consumer services followed GDP whereas the rest of manufacturing industries and general services lagged behind. Thus, the transformation was the time when new production and new related producer services dominated the scene and were true drivers of growth and restructuring. Supply-driven industries increased their share to one third of the economy in this period. Demand-driven industries did not contribute much to GDP, rather pressed it down. Especially the rest of manufacturing industries were responsible for the fact that demand-driven industries had

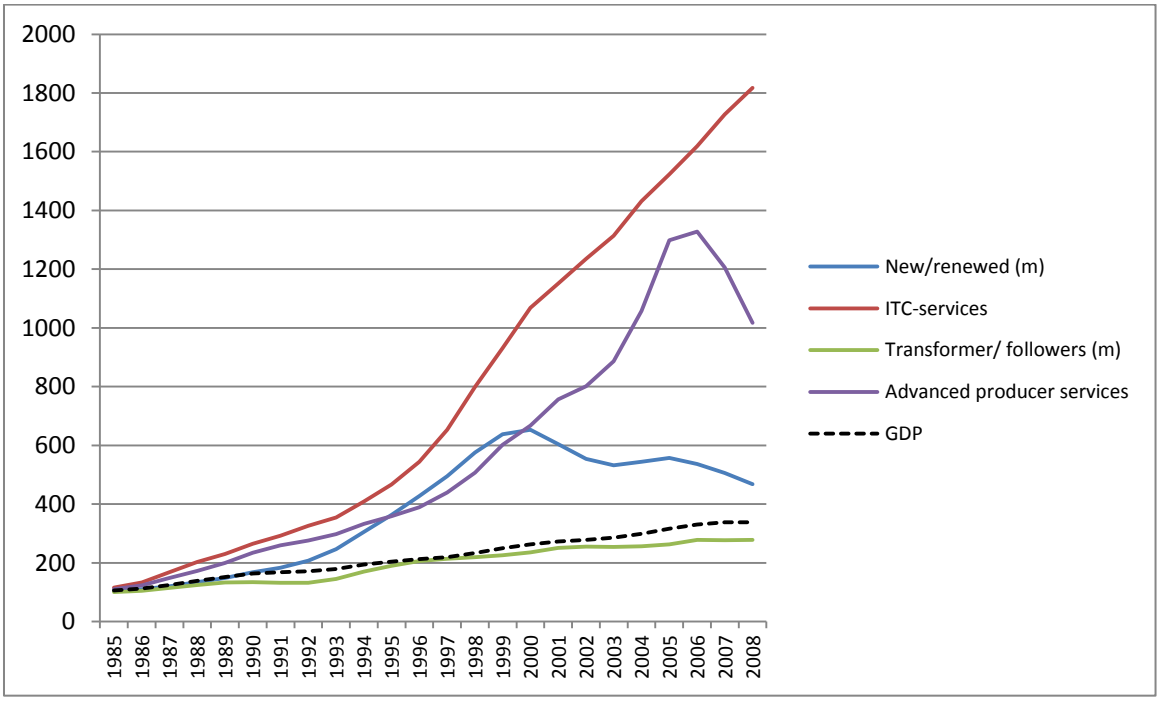

Figure 5. Growth of supply-driven industries in Sweden 1985-2008. Note: Indices (1985=100) calculated on current value added. Original data from Statistics Sweden.

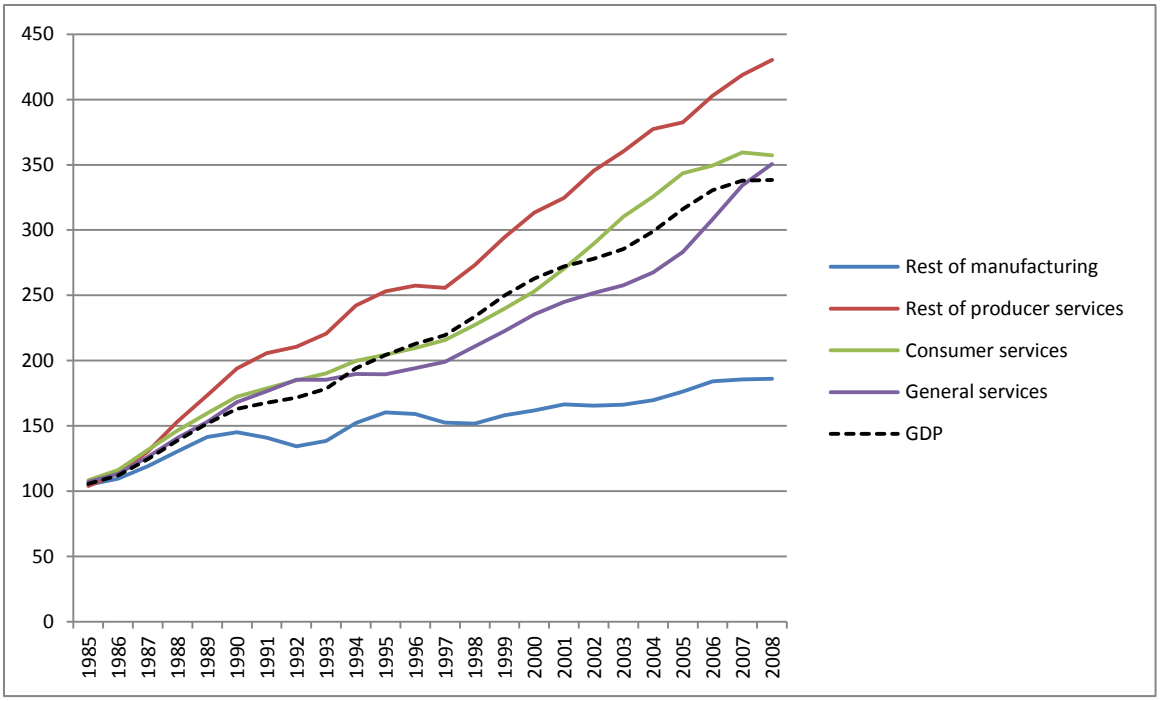

Figure 6. Growth of demand-driven industries in Sweden 1985-2008. Note: Indices (1985=100) calculated on current value added. Original data from Statistics Sweden.

shrunk to two third of the economy in 2000. In rationalization, after 2000, things changed rather dramatically. ITC-services were the only supply-driven industries that kept growing till the end of the period. Advanced producer services reached their peak in 2006 and then turned down. New manufacturing industries lost their momentum already at the starting point and transformers/followers began to lag behind GDP. Instead, demand-driven industries started to grow. Consumer-industries for the first time grew faster than GDP and so did the rest of producer services. General services had also a good rally all through rationalization. Even the demand-driven rest of manufacturing industries had a revival that lasted till at least 2008. In rationalization supply-driven industries lost some of their gained shares back to demand-driven industries, but not all of them.

It is worth noticing that ITC-services and advanced producer services, despite their high growth rates during transformation, did not manage to outperform new and renewed manufacturing industries when it comes to shares of value added before 2000 (Table 2). This emphasises how important the new and renewed manufacturing industries were as drivers of the economy in that period. Not until after 2000, in rationalization, became ITC-services and advanced producer services more important than new and renewed manufacturing industries in value terms. Thus, this was the time when new service industries fuelled the rest of the economy and when new and renewed manufacturing industries met hard competition from imports.

Table 2. Change of industry structure. Shares of value added in 1985, 1992, 2000 and 2008.
Note: Original data from Statistics Sweden.

	1985	1992	2000	2008
New/renewed (m)	5,2	6,1	13,4	6,9
ITC-services	0,9	1,8	3,5	5,2
Transformers/followers (m)	10,8	8,0	9,7	8,4
Advanced producer services	2,3	3,7	6,3	6,7
All supply-driven industries	**19,2**	**19,5**	**32,9**	**27,1**
Rest of manufacturing	29,1	22,6	18,2	15,7
Rest of producer services	9,1	11,5	10,8	11,5
Consumer services	12,9	13,8	12,2	14,0
General services	29,8	32,5	26,0	31,7
All demand-driven industries	**80,8**	**80,5**	**67,1**	**72,9**
Total	*100*	*100*	*100*	*100*

It should also be pointed out that the supply-driven industries taken together have not managed to increase their share of the economy with more than eight percentages (thirteen at the most under way) in more than 20 years. It might therefore be concluded that supply-and technology driven industries are important in at least two ways; to modernize the industry structure and raise employment, but also to keep up the strength of all the demand-driven industries as long as they are not replaced by imports.

Most demand-driven industries were either close to the GDP development or far below in the observed time period. Their growth rates were not more than a third of those observed for supply-driven industries. Rest of producer services, initially the smallest demand-driven industry group, were the only industries that grew faster than GDP. Consumer services and general services were running parallel to GDP until the rationalization period. After that, but not before, began their growth rates to accelerate when real income increased, taxes were paid to higher sums, employment rose and credit markets expanded with small restrictions. The rest of the manufacturing industries grew late in rationalization, but much less than transformers and followers. There was a steady out-phasing of these industries during the whole period due to a strong competition from abroad. This out-phasing was quite strong in transformation, weaker in rationalization. Half their value added was eroded. All taken together, demand-driven industries had their time in the rationalization period. They have, of course, lost some eight percentages of the total economy, as much as supply-driven industries won, but they still dominate the economy, not as renewers, but as holders of a total share of value added of about 70 percent.

In Figure 7 the supply- and demand-driven industries above are added together, creating the annual growth rates of the Swedish GDP from 1985 to 2008. The current structural cycle is visible but not ended. The previous cycle from the early 1950s till the late 1970s is shown as a comparison. All other

previous cycles from 1830 and onwards, however, are not illustrated. In aggregated terms the Swedish economy has been characterized by dramatic shifts from severe downswings and crises to dramatic expansion periods during the last 30 years. As can be seen, the period studied, 1978/1985 to 2008, commences with a severe crisis (1975/1980). This crisis in particular is not covered in detail in this paper. However, the late 1970s were not just a time of crisis but also the starting point of the transformation within the new technology shift and structural cycle. Growth rate therefore began to increase during the 1980s, partly from new technologies and partly from short business cycles favourable to Swedish industries, and was followed by a short but severe bank- and budget crisis (1990/1992) where the last obsolete remnants of the previous cycle were definitely shaken out. From then on growth increased even more during the 1990s, interrupted by a temporary downswing around the millennium shift. The 2000 downswing could be regarded as the transformation crisis of the first half of the structural cycle. This kind of crisis is the result of hectic growth, in the end causing frivolous entrepreneurship, over investment, and sometimes bottlenecks in production. Once this crisis was mastered, the economy ran more smoothly for a couple of years when rationalisation took over, until faced with the global financial crisis and its aftermath.

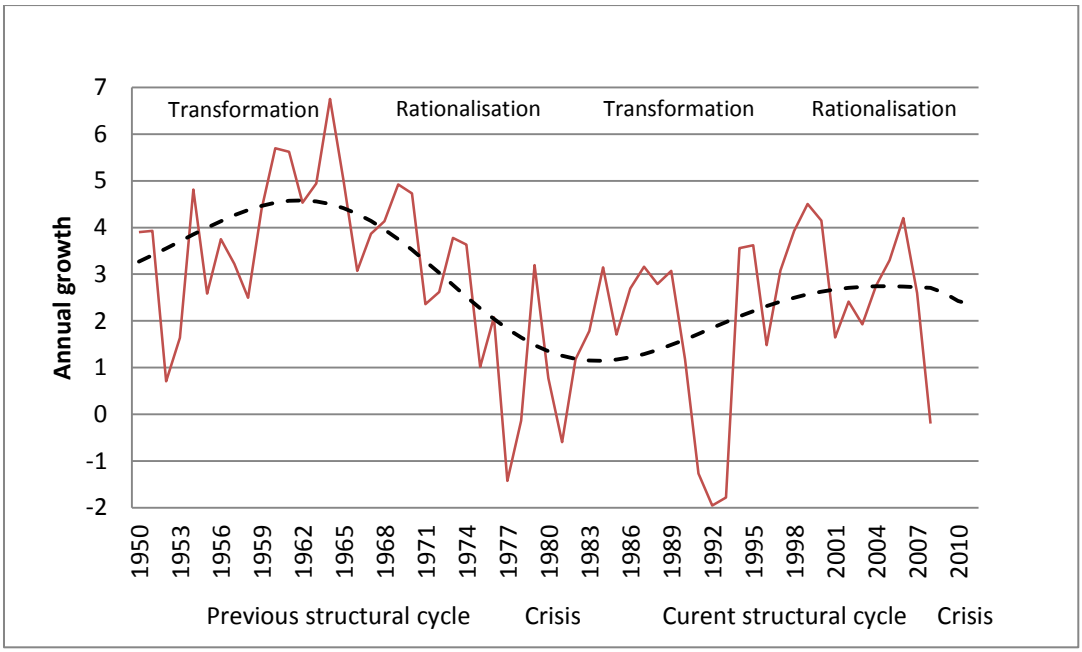

Figure 7. Annual growth rates and the long-term cyclic trend in GDP in Sweden 1950 – 2008 (2010).
Note: Predictions for the last two years are based on the cyclic trend for the period 1830 – 2008. Original data from Statistics Sweden.

A regional system approach

The geographical reference cycle is a stylized depiction of the theoretical expectations of regional lead-lag relationships during a technology shift process. But it stresses that processes of adjustment following the introduction of new general purpose technologies are inherently determined by complex patterns of changing roles of various industries and regions. In the following analysis a system approach will be applied, referring to the notion that technology shift is spread throughout and affects the whole regional system in which all parts are working together. A similar view is shared by Martin (2015). He suggests that an encompassing evolutionary-historical geographical understanding of the economy should embrace the manifoldness of endogenous and institutional approaches to regional development and that we do little such work today. Focus will be set on how regional development at different levels of the regional hierarchy relate to the national development, and to the renewal in other regions.

In the analysis, 92 LA-regions (local labour market regions) have been categorized into six groups based on regional size (population). Beside the three metropolitan regions Stockholm, Gothenburg and Malmö, the rest of the Swedish LA-regions are grouped into medium, small and micro regions. As can be seen from Table 3 mean population and mean industry diversity in groups are well related. Homogeneity within groups is quite high as shown by the variation coefficients. The core of the analysis will be the two main forces of the technology shift already discussed: the primary supply and technology effect, and the secondary or induced demand effect.

We will now focus on supply-driven and demand-driven industries as aggregates, following their growth over time in the regional system (Figures 8 and 9). The most noticeable observation in early transformation was how little regions deviated from each other's growth rates. Stockholm and Gothenburg were the only important exceptions in supply-driven industries, to some extent forging

Table 3. Population and number of industries within tiers in 2000.
Note: Indices relates to the number of industries in Stockholm (100). Variation coefficient is within tier variation of number of industries. Original data from Statistics Sweden.

Tiers	Population (mean)	No of industries (index)	VK	Regions (no.)
Stockholm	2171700	100	-	1
Gothenburg	898400	95	-	1
Malmö	635600	93	-	1
Medium	138500	67	9	29
Small	29500	41	17	35
Micro	7600	22	21	25

ahead of other regions, but Malmoe, medium-sized and small regions moved close to GDP and to each other at moderate rates. Micro-regions which suffered most from the early 1990 crises with its shake out effects had problems keeping up with the other regions. Virtually no deviations at all could be traced for demand-driven industries. There was at the time obviously no transformation at all going on within these industries and regions. Demand-driven industries seem to have been in a steady-state situation in this early period.

In transformation (1992-2000) all regions seem to have been growing in full accordance with the technology shift thesis and its proposals. Stockholm was the first region to grow in supply-driven industries, followed by Gothenburg, Malmoe and medium-sized regions in due order. All these regions grew at their fastest in transformation and peaked a few years into rationalization, before slowing down their growth rates again. Small regions and micro regions on the other hand grew at a much slower pace and did not reach their humble peaks until well into rationalization. Finally, demand-driven industries did not have their time in this period at all. It was only demand-driven industries in Stockholm that started to grow in transformation, whereas all other regions were growing moderately keeping their growth rates close to each other in a bundle-like formation.

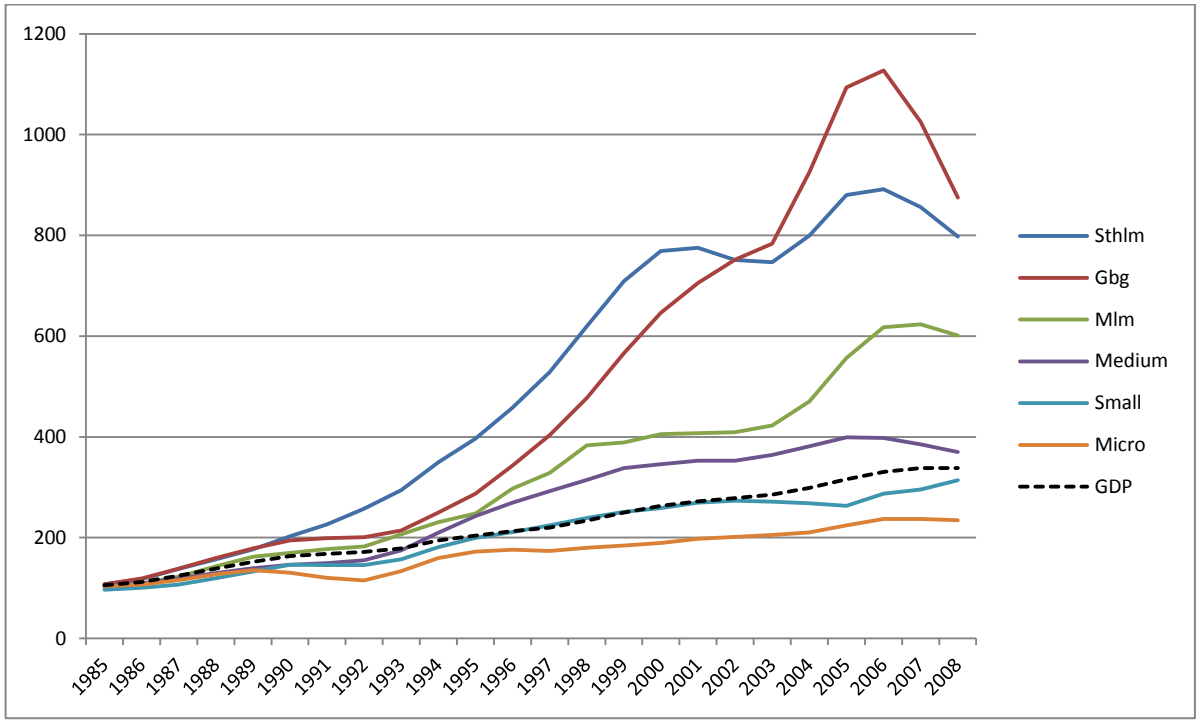

Figure 8. Supply-driven industries. Growth in regional tiers. GDP shown as a comparison. Note: Indices (1985=100) calculated on current value added. Original data from Statistics Sweden.

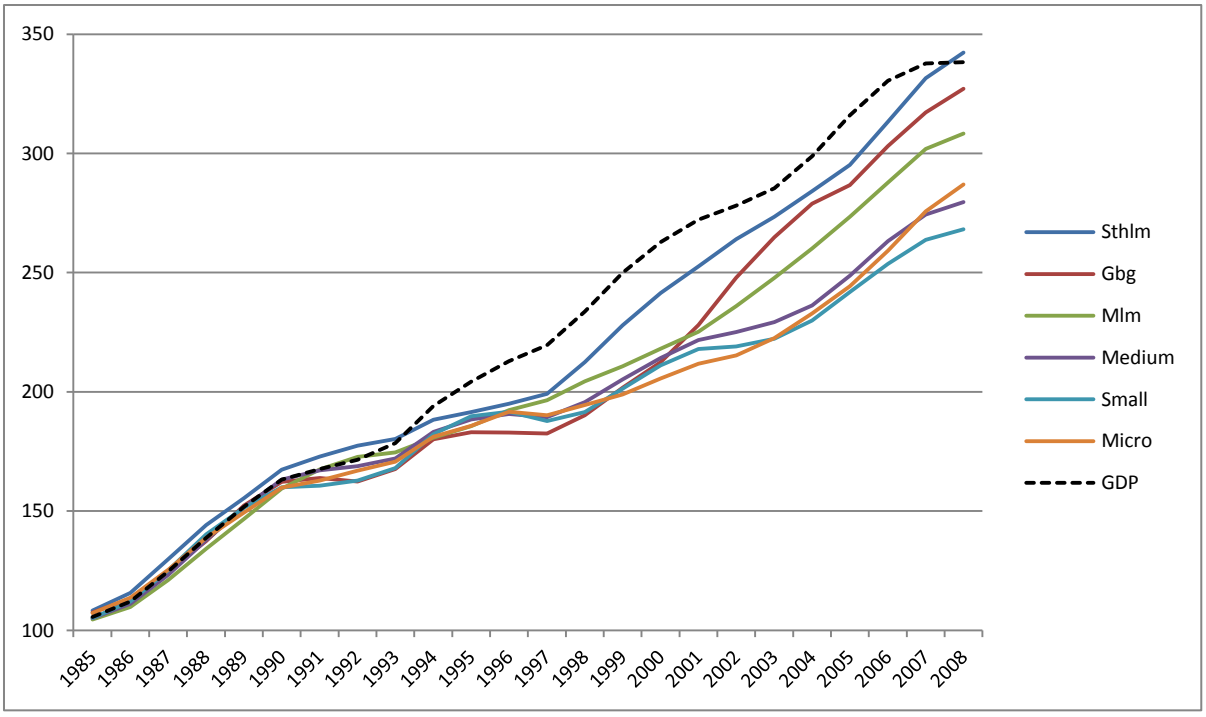

Figure 9. Demand-driven industries .Growth in regional tiers. GDP shown as a comparison. Note: Indices (1985=100) calculated on current value added. Original data from Statistics Sweden.

Late in rationalization supply-driven industries began to develop in a reversed way compared to in transformation. The first region to slow down its growth rates within these industries was Stockholm, later followed by Gothenburg, Malmoe and medium-sized regions. Only small regions and micro-regions were still increasing their growth rates in late rationalization. There was a visible converging trend at the end of this period indicating that in a few years we might be back to a situation like the one in the 1980s when most regions grew at similar rates within supply-driven industries. When it comes to demand-driven industries on the other hand it seems like all regions have been in full swing in rationalization. All regions grew faster than before with a deviating trend amongst them. In 2008, however, there was no converging trend indicating a situation like the one in the late 1990s. It's likely that this point will be reached by demand-driven industries a bit further into the future compared to what was expected a moment ago for supply-driven industries.

GRP for regions, displayed in figure 10, means that supply-driven and demand-driven industries have been put together. It's even more obvious from GRP-development that various regions have been playing distinguished roles over time. The divergent trend in transformation is quite visible, as well as the beginning of a converging trend some years into rationalization. It's likely that this convergence has been strengthened during the six years that have passed since the statistics' end point and that it will be reinforced in the coming years.

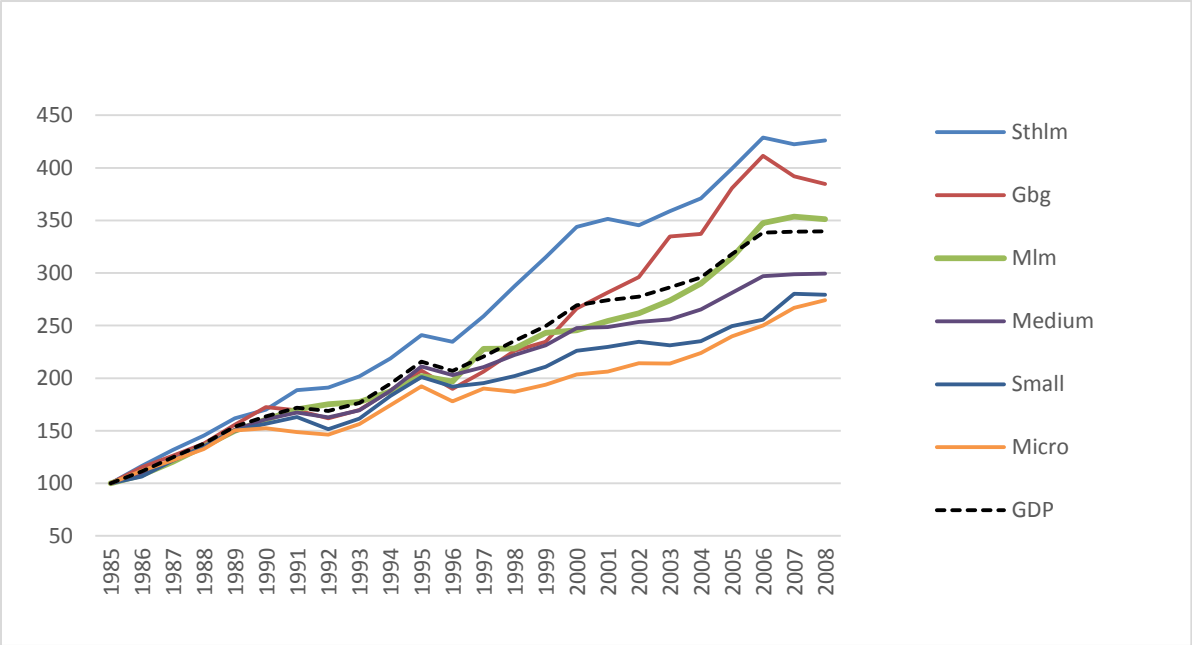

Figure 10. GRP growth in regional tiers. GDP shown as a comparison. Note: Indices (1985=100) calculated on current value added. Original data from Statistics Sweden.

Growth trajectories for industries in different regions will of course make a difference when it comes to how the economic structure changes in regions over time. The following tables (Tables 4 and 5) are designed to find out what's happened in the regional system from 1985 till 2008.

It can then be noticed that regions which were successful starters of growth and transformation also increased their shares of driving industries across the whole time period. The three metropolitan regions for instance increased their added shares of supply-driven industries from one third to half of these industries total value added between 1985 and 2008. Perhaps surprisingly this increase of supply-driven industries was due to a strong growth of the most advanced manufacturing industries. Stockholm and Gothenburg to some extent were actually revitalized within manufacturing industries in the period through becoming the most attractive receiver regions for new technology-driven manufacturing industries. ITC and the advanced producer services on the other hand kept their shares in various regions or increased them outside the metropolitan regions. It seems like the new manufacturing industries were strongly dependent on the big cities' advanced production milieus all through the time period, whereas ITC and advanced producer services although starting in the big cities also had the opportunity to spread their activities to the periphery over time, thereby contributing to the economic restructuring also in smaller regions.

Table 4. Supply driven industries. Regional shares of value added 1985, 1992, 2000 and 2008.

Note: Calculated on current value added. Original data from Statistics Sweden.

1985	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
New/renewed (m)	31,7	5,6	2,9	47,8	11,3	0,6	100
ITC-services	49,1	13,2	7,9	26,8	2,8	0,1	100
Transformers/followers (m)	7,9	4,8	5,9	56,8	18,8	5,8	100
Advanced producer services	51,4	10,6	7,3	25,5	4,8	0,5	100
All supply driven industries	**21,6**	**6,1**	**5,4**	**49,1**	**14,3**	**3,5**	**100**
1992	Sthlm	Gbg	Mlm	Medium	Small	Micro	
New/renewed (m)	45,6	2,7	3,9	37,9	9,5	0,4	100
ITC-services	50,1	11,8	6,6	28,6	2,5	0,4	100
Transformers/followers (m)	7,0	5,6	7,0	59,1	16,6	4,7	100
Advanced producer services	49,9	14,5	6,4	24,0	4,7	0,5	100
All supply driven industries	**30,9**	**6,9**	**5,9**	**43,2**	**10,9**	**2,2**	**100**
2000	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
New/renewed (m)	49,9	8,2	3,6	33,1	5,0	0,3	100
ITC-services	50,4	12,9	6,7	27,0	2,4	0,8	100
Transformers/followers (m)	8,7	5,7	3,6	61,4	17,0	3,7	100
Advanced producer services	50,2	14,1	7,8	22,8	4,4	0,7	100
All supply driven industries	**37,9**	**9,1**	**4,7**	**38,8**	**8,1**	**1,4**	**100**
2008	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
New/renewed (m)	49,2	11,4	4,2	27,4	7,4	0,4	100
ITC-services	50,6	13,5	9,9	23,5	2,3	0,1	100
Transformers/followers (m)	8,3	7,8	4,4	58,7	16,8	3,9	100
Advanced producer services	42,1	11,2	8,6	31,3	5,6	1,2	100
All supply driven industries	**35,1**	**10,6**	**6,4**	**37,3**	**8,9**	**1,6**	**100**

The demand-driven industries exhibit much more of stability in the time-period. The metropolitan regions have increased their added shares between 1985 and 2008 but not at all to the same extent as was noticed for the supply-driven industries. The demand-driven industries have mainly been located in the nether part of the regional system. An impression of relative invariability can be detected in the table. Despite this, some industries have increased their metropolitan shares, especially those which are attracted to increasing population and raising consumption. That's why consumer services, general services and manufacturing where crafts are involved have been further concentrated to big cities, whereas the less advanced producer services have been scattered to more peripheral parts of the regional system. Considering the relative stability that can be noticed for demand-driven industries and the fact that these industries cover about 70 per cent of the economy, it's reasonable to think that stability rather than dramatic changes have been

Table 5. Demand driven industries. Regional shares of value added 1985, 1992, 2000 and 2008

Note: Calculated on current value added. Original data from Statistics Sweden.

1985	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Rest of manufacturing	13,9	12,8	6,6	50,9	14,2	1,6	100
Rest of producer services	41,6	12,6	7,8	32,3	5,2	0,5	100
Consumer services	31,6	10,2	7,3	39,8	9,3	1,8	100
General services	27,1	10,9	7,2	41,8	10,7	2,3	100
All demand driven industries	**24,7**	**11,7**	**7,1**	**43,7**	**11,1**	**1,7**	**100**
1992	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Rest of manufacturing	15,5	11,0	6,8	51,3	13,8	1,6	100
Rest of producer services	39,6	12,8	7,9	33,6	5,5	0,6	100
Consumer services	29,9	10,1	7,5	41,2	9,4	1,8	100
General services	26,9	10,9	7,4	42,2	10,5	2,2	100
All demand driven industries	**26,0**	**11,0**	**7,3**	**43,4**	**10,6**	**1,7**	**100**
2000	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Rest of manufacturing	14,5	10,6	5,6	52,1	15,5	1,7	100
Rest of producer services	39,9	13,5	8,1	32,2	5,8	0,5	100
Consumer services	31,4	11,3	7,6	39,4	8,6	1,6	100
General services	28,3	10,7	6,9	41,5	10,5	2,1	100
All demand driven industries	**27,0**	**11,2**	**6,9**	**42,5**	**10,8**	**1,6**	**100**
2008	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Rest of manufacturing	16,1	13,2	5,4	49,3	14,1	2,0	100
Rest of producer services	34,2	15,0	8,9	34,4	6,8	0,6	100
Consumer services	34,2	11,9	8,1	36,7	7,6	1,6	100
General services	29,5	11,6	7,1	39,7	10,1	2,0	100
All demand driven industries	**28,2**	**12,6**	**7,2**	**40,4**	**10,0**	**1,7**	**100**

characteristic for the arrangement of regions during the whole period. At least, this seems to be the case on tier levels. For individual regions the case might have been quite different.

To sum up, it seems like a radical technology shift in combination with size and related characteristics of regions have much to contribute when it comes to understand regional development over long time. There seems to be a very good fit between growth variations over time and the hypothesized stylized sequence of the technology shift process. There's also a good fit between growth variations in space and what is conjectured by the geographical reference cycle. However, they are still just correlations between theory and the final outcome. To take the analysis one step further we need to fill in with driving mechanisms between theory and outcome. Productivity changes in time and space might be one of these possible mechanisms to look into.

Productivity change in time and space

In connection to the theoretical discussion (see Table 1) it was stated that productivity in transformation mainly comes from structural changes, whereas productivity in rationalization mainly comes from increased efficiency within industries. By structural changes in transformation means that resources are transferred from low-productive to high-productive industries, which in itself adds productivity to the economy on top of the productivity that comes from general efficiency efforts within industries. When structural changes become less apparent, like in rationalisation, productivity will mostly be the result of increased efficiency that comes from efforts to meet over-capacity and hard price-competition in many industries.

It is hypothesized that early transformation comes with a slow over-all productivity rate in the economy. Structural change is initiated at the time but includes just a few industries that constitute only a small part of the economy. Thus, structural change adds very little to productivity. The old economy, still unaffected by the technology shift, dominates and sets a slow pace for the over-all productivity rate. Late transformation on the other hand means an intense restructuring of the economy. This is a time-period when structural change probably has its greatest influence on the over-all productivity. However, new technology is getting standardised and begins to trickle down to old industries, increasing also the productivity that comes from within industries. Added together, structural change effects and effects from within industries, assumedly create a very high productivity rate in this time-period. Finally, structural change is supposed to loose strength in rationalisation, contributing much less than before to the over-all productivity rate in the economy. Productivity contributions from within industries are much more likely to take over. Price competition in stagnating markets and the fact that the new technology applications are widely spread among competitors will probably lead to moderate or low productivity rates.

It's also hypothesized that regions of different sizes will go through this productivity process with lead-lag relations between them. Metropolitan regions probably come first, followed by medium sized and smaller regions. These separate regional processes are supposed to be quite distinct when it comes to structural change effects and effects from within industries. Then depending on the regions relative shares of the economy, their productivity fractions when added together into national figures will create some kind of national mean values over time with characteristics like those elaborated above, quite visible but less distinct than those of regional groups.

To look into these processes we need to know the productivity rates for regions and the whole economy and we need to find a method by which we can decompose these productivity rates into their two fractional effects. True productivity rates for regions and the whole economy are easy to calculate, they are made up by total value added divided by employment. It's a bit trickier with the

fractional effects. We start by setting up the shares of value added for all industries at t0 in regions and the whole economy. These shares are then linked to the true productivity rates for all the industries. We then calculate a weighed total productivity by multiplying the shares with the true productivity rates for industries. This procedure is then repeated for t1 that is the end point of the time - period. We have now got two weighed total productivity rates for regions and the whole economy. Then, we transfer the shares of industries at t0 into the list of true productivity rates at t1 for all these industries. After a multiplication we will get the productivity effects from within industries, by having fixed the t0 structure but having allowed the true productivity rates within industries to change over time. The structural change effect will come out as the difference between total weighed productivity change in a time period and the within industries effect in the same period. This is considered to be a way to decompose productivity over time into the two different fractional effects.

Early transformation was as mentioned the time when new and old technologies began to struggle for supremacy in the economy. As can be seen in Table 6, the 1985-1992 period brought a rather slow annual productivity change into the Swedish economy. New industries were obviously not yet visible in aggregated numbers. This was underlined by a weak structural change effect. More than 90

Table 6. Average productivity change per year, also decomposed into structural change effect and within industries effect.

Note: Fixed prices. Statistics Sweden. Consumer price index 1954-2015. Original data from Statistics Sweden.

1985-1992	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Average change/year	2	0,1	0,9	0,9	0,5	0,4	1,1
Structural change effect	32	0	59	-14	50	89	8
Within industries effect	68	100	41	114	50	11	92
Sum	100	100	100	100	100	100	100
1992-2000	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Average change/year	4,8	4,1	2,3	4,4	4	2,9	4,3
Structural change effect	68	49	39	20	33	-4	37
Within industries effect	32	51	61	80	67	104	63
Sum	100	100	100	100	100	100	100
2000-2008	Sthlm	Gbg	Mlm	Medium	Small	Micro	Swe
Average change/year	0,4	1,6	1,6	0,3	0,4	2,2	0,6
Structural change effect	-14	-46	-269	207	203	88	21
Within industries effect	114	146	369	-107	-103	12	79
Sum	100	100	100	100	100	100	100

percent of the modest productivity growth were due to within industries effect. Late transformation 1992-2000 changed all this completely. Annual productivity change was four folded and almost 40 percent of it was caused by structural change effect in the total economy. This was the time when transformation culminated. In rationalization 2000-2008 things began to swing back again. Annual productivity growth slowed down noticeably and the structural change effect lost half its momentum compared to the preceding period. It should be pointed out that rationalization didn't end in 2008. It's still an ongoing process in which within industries effect is expected to gain more and more ground. The reason why the over-all productivity fell in these first years of rationalization was that demand-driven relatively low-productivity industries took a greater part of the economy and supply-driven relatively high-productivity industries a smaller part. Demand from increasing purchasing power played an important role in this process. Demand was generally drugged by low interest rates and credit market expansion, mitigating domestic and international competition and over-capacity. Therefore, necessary efficiency measures could be postponed into the coming years.

Looking at the spatial outcome makes the technology shift even clearer. Stockholm was an early mover in this process. New technology and new industries were making their way into this region already in early transformation. A third of Stockholm's rather high general productivity increase these years came from structural change effect. It seems like Malmoe and even small and micro regions were going the same way. But they were not. They were rather low productive regions losing manufacturing industries at the time, being prime victims of the "shake-out" crises in the Swedish economy from 1990 and onwards. Structural change effects in these regions thus came from going from low-productive industries to less low-productive industries that already existed. So, in early transformation Stockholm was the only true transforming region, while all other regions were releasing themselves from their weakest industries struggling to keep up productivity within the remnants of their old economies.

In late transformation average productivity change increased impressively in all regions, but came from different sources. Metropolitan regions increased their productivity from mainly structural change effects. In Stockholm structural change effect explained two thirds of the productivity change in this period. In Malmoe and Gothenburg it explained almost half of it. Medium and small regions enjoyed to some extent productivity increase from structural change effect, but mostly from within industries effect. Micro regions had not started true transformation at all at this time, but were benefiting quite well from within industries effect.

Finally, positive structural change effects were completely gone for the metropolitan regions in rationalization. These regions were at this time rather suffering from productivity losses coming from growing demand- and wealth-driven industries with sluggish productivity change. On the other hand

medium and small regions were still in their transformation, although not benefiting from strong productivity increase. Micro regions were the slowest starters in the technology shift process, displaying the best productivity changes of all regions in this period, mostly coming from structural change effect. So, medium, small and micro regions still had to wait in 2008 for their coming rationalization. As mentioned earlier the rationalization period was not completely ended in that year.

To sum up, we found good evidence for what was hypothesized earlier from the technology shift thesis and the geographic reference cycle. Most conspicuous was the distinct spatial processes and lead-lag relations between regions and that the national process and periodization must be understood as an aggregated outcome of these regional processes.

Growth corridors

General purpose technologies and the technology shifts are considered strong drivers of change, causing firms and industries to grow and transform into new and joint directions, even though they are spatially separated. However, it's also recognized that even identical industries' ability to absorb and commercialize new technologies vary considerably between regions and therefore might end in versatile outcomes.

In this part we assume that the technology shift is a pervasive force that will reach all regions sooner or later. It's also assumed that our earlier findings are true, namely that regions of different sizes will be hit sequentially due to endogenous capabilities, causing them to play different roles at different times. We will try to estimate to what extent given conditions in regions at the beginning of a time period will decide the technology shift outcome in terms of growth. Opposed to this we will also estimate to what extent new unknown conditions and unique capabilities in regions will affect the outcome in the same time period. Among given conditions in regions are industry structure at a detailed level, industry width and productivity. These given conditions are called systemic conditions. To these we also add the public sector size and the distances between observed regions and other regions in the national system of regions. These two conditions are half-systemic and control variables. Public sector is added because it's politically dimensioned and tax-financed, having impact on growth through purchasing power and regional home markets. This effect must be controlled for and sorted out from effects coming from pure market-oriented systemic conditions. Distances between regions have to do with access to other markets and knowledge spill-over and will control for possible home-market expansion for regions in various parts of the national system. Finally, new unknown conditions and unique capabilities in regions cannot be predefined. They are considered

residuals not explained within our models to be presented. However, once the influence of the systemic conditions are sorted out, the residuals due to unique local growth incentives open up for multi-theoretical approaches to understand them, within our suggested framework.

Our calculations are carried out in the following way. Stockholm, Gothenburg, and Malmö as first, second, and third tier metropolitan regions are not included for reasons to be explained later. We concentrate on medium, small, and micro regions. These are observed in three time-periods, namely early transformation, late transformation, and rationalization. This gives us nine dataset to handle. To estimate the impact of systemic conditions and new unknown conditions we will use shift-share analysis2 and then regression models. For every single region within a specific size-group we calculate an expected growth value for a specific time-period, based on the mean growth rates of the entire group to which the single region belongs. The calculations are made on a detailed industry level3. The expected growth value makes an independent variable in the regression analysis, which contributes to explain the true growth value, which is the dependent variable. Public sector size and distances are added to the regression as control variables. Together, expected growth value and control variables make up regression model 1. When industry width and productivity in turn are added we constitute regression models 2 and 3. This gives us, with three regional size-groups and three time-periods, nine datasets, nine shift-share analyses and nine regressions (made up by three sub models each). High explained variances in the models tell us that systemic conditions have had a big influence on actual growth rates. The degree of freedom for regions to choose their own growth rates were limited. The growth corridors were then narrow and not open to intraregional unique conditions. On the other hand, low explained variances mean that new unknown conditions have had a great importance. The growth corridors were in these cases wide and open to intraregional particularities. Using the technology shift thesis and the geographical reference cycle, presented earlier, we will interpret the results.

Early transformation

The results of the regression models are presented in Table 7. A first observation is that the initial industry structure's expected growth potential along with the control variables (public sector employment growth and the region's geographical location) has a substantial influence on the individual regions' economic growth rates in all regional groups during the period. The explained variance is between 49 and 55 percent, with the strongest significance in medium and small regions.

[2] Stockholm, Gothenburg, and Malmö do not belong to any group of similar size and characteristics and can therefore not be included in a shift-share analysis.

[3] The initial classification of manufacturing industries and service industries into role industries (Figures 3 and 4) used for descriptive purposes are thus put aside in favour of a detailed industry structure in the calculations.

Table 7. Regression output 1992-2000. Dependent variable: Regional growth rates in VA 1985-1992.

1985 - 1992	Tier 4 (Medium sized regions)			Tier 5 (Small regions)			Tier 6 (Micro regions)			All regions		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
expected	0,654***	0,632***	0,579***	0,662***	0,653***	0,333*	0,750(*)	0,746(')	0,259	0,800***	0,831***	0,435***
Numb_in85		0,001(*)	0,001(*)		-0,001	0,001		0,000	0,006		0,000	0,001(*)
Prod_1985			-0,002***			-0,002**			-0,003***			-0,002***
stock	-0,038	0,066	0,051	-0,240	-0,188	0,007	-1,85		-0,565	-,331*	-0,271	-0,133
pub_emp_growth	0,487	0,739(*)	0,514	0,458	0,585	0,804(*)	0,174	0,157	-0,858	-0,165	-0,061	-0,120
constant	0,177	-0,168	,611*	0,241(*)	0,381	0,970**	0,580	0,560	1.102*	0,196*	0,229*	1,111***
R2	***0,478***	***0,552***	***0,715***	***0,546***	***0,551***	***0,666***	***0,498***	***0,498***	***0,728***	***0,453***	***0,458***	***0,641***
R2 adj	*0,415*	*0,477*	*0,654*	*0,502*	*0,621*	*0,608*	*0,427*	*0,398*	*0,656*	*0,434*	*0,433*	*0,620*
F-test	*0,001*	*0*	*0*	*0*	*0*	*0*	*0,002*	*0,006*	*0*	*0*	*0*	*0*
N	*29*	*29*	*29*	*35*	*35*	*35*	*25*	*25*	*25*	*89*	*89*	*89*

Table 8. Regression output 1992-2000. Dependent variable: Regional growth rates in VA 1992-2000.

1992 - 2000	Tier 4 (Medium sized regions)			Tier 5 (Small regions)			Tier 6 (Micro regions)			All regions		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
expected	0,717*	,822**	0,936**	0,348**	0,391**	0,380**	0,361***	0,352***	0,342***	0,346***	0,377***	0,379***
Numb_in92		0,001	0,001		0,002*	0,002(*)		-0,001	0,000		0,001*	0,001*
Prod_1992			-0,001			0			-0,001			0
stock	0,078	0,199	0,199	0,665*	0,495	0,427	0,080	0,130	0,270	0,301(*)	0,188	0,174
pub_emp_growth	0,462	0,775	0,498	0,968*	0,825(*)	0,870(*)	-0,441	-0,439	-0,567	0,700*	0,452	0,472
constant	0,140	-0,428	0,044	0,202	-0,238	-0,32	0,080	0,143	0,285	0,267***	0,120	0,059
R2	***0,242***	***0,309***	***0,324***	***0,328***	***0,427***	***0,433***	***0,612***	***0,614***	***0,623***	***0,350***	***0,408***	***0,409***
R2 adj	*0,151*	*0,194*	*0,177*	*0,263*	*0,350*	*0,335*	*0,577*	*0,536*	*0,524*	*0,33*	*0,380*	*0,374*
F-test	*0,07*	*0,056*	*0,089*	*0,006*	*0,002*	*0,004*	*0*	*0,001*	*0,001*	*0*	*0*	*0*
N	*29*	*29*	*29*	*35*	*35*	*35*	*25*	*25*	*25*	*89*	*89*	*89*

Table 9. Regression output 2000-2008. Dependent variable: Regional growth rates in VA 2000-2008.

2000 - 2008	Tier 4 (Medium sized regions)			Tier 5 (Small regions)			Tier 6 (Micro regions)			All regions		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
expected	0,874***	0,883***	0,272	0,224*	0,256**	0,186*	0,233	0,109	0,204	0,275***	0,259**	0,172*
Numb_in00		0,000	0,000		0,001	0,001(*)		0,004*	0,004*		0,000	0,000
Prod_2000			-0,001*			-0,001***			-0,001			-0,001***
stock	0,129	0,086	0,042	-0,486	-0,523	-0,282	-0,413	-0,906	-0,551	-0,281(*)	-0,257	-0,090
pub_emp_growth	0,960*	0,991*	0,943*	0,705*	0,597(*)	0,551*	0,246	-0,301	-0,420	0,634**	0,734**	0,691***
constant	-0,041	0,147	0,748*	0,305**	0,098	0,546*	0,326	-0,113	0,257	0,249***	0,296**	0.850***
R2	***0,636***	***0,646***	***0,708***	***0,361***	***0,377***	***0,586***	***0,113***	***0,272***	***0,354***	***0,269***	***0,274***	***0,445***
R2 adj	*0,593*	*0,587*	*0,645*	*0,299*	*0,294*	*0,515*	*-,013*	*0,126*	*0,184*	*0,243*	*0,240*	*0,412*
F-test	*0*	*0*	*0*	*0,003*	*0,005*	*0*	*0,460*	*0,156*	*0,113*	*0*	*0*	*0*
N	*29*	*29*	*29*	*35*	*35*	*35*	*25*	*25*	*25*	*89*	*89*	*89*

Model II, also include the number of industries present in the regions. This variable is expected to reflect the importance of the internal variation in regional receiver and development competence in the different size groups. The variable turns out to be of relevance only for medium sized region. The significance is slightly over 5 percent but increases the explanatory power of the model to around 60 percent. The expected growth from the industry structure retains significance and strength. This indicates that only a few of the best equipped regions in the medium sized group slowly has started to transform as a consequence of the emerging technology shift. For regions further down the hierarchy belonging to the group of small and micro-regions the variable lacks importance. The variation in industry width for small and micro regions thus appears to be having no significant impact on these regions growth rates. This implies that small and micro regions during the early transformation phase of the technology in general are likely far from reaching the industry diversity required to efficiently transform and take advantage of the technology shift. The regional development and receiver competence is in this respect to weak. The impulses of renewal and growth have so far only to a very limited extent reached outside metropolitan areas.

Finally, Model III tests the significance of the regions' productivity level at the beginning of the period. The variable shows consistently strong significance and negative influence on regional economic growth in all regional size groups. For small and micro-regions it also eliminates parts of the significance of the expected growth effect from the industry structure. The negative sign, ie that regions with higher productivity tend to have lower growth rates of total VA, indicates a catch-up from regions with weaker productivity at the beginning of the period. The explanation can be found in the specific character of the time period where old and new economic structures struggle and coexist. Regions displaying strong productivity at the start of the period are in general more characterized by industry structures and competitiveness inherited from the previous growth cycle. These firms and industries have most likely already peaked and will suffer from stagnation and out-phasing during the transformation period. Following from that, regions dominated by these former successful industries will experience overall sluggish growth rates in value added. What was successful in the start of the period is not that in the end. In particularly this is true for small and micro-regions where productivity is largely driven by out-phasing of old industries, while new and remaining industries are not strong enough to compensate for this shortfall, leading to weaker overall growth. Regions with low productivity input values in the start of the period indicate the opposite, stronger potential for increased productivity and overall VA growth. This means that the productivity gap between single regions is converging in each level of the hierarchy. The trend towards convergence is also true for regions included in the medium sized group. In this case however the development is based on, as shown previously in Table 6, a process where less

productive units in the same sectors are able to grow faster than the corresponding firms with higher initial productivity. The industry structure for medium sized region thus appears better prepared for future growth than the case is for small and micro regions.

Overall, it is clear that the systemic conditions to a very large extent explain the variance in growth between regions in different size groups during the early transformation process of the national technology shift. Between 67 and 73 percent of the regions' growth rates are associated with initial conditions in terms of industry structure, productivity level and to some extent also by industry width. In light of what has been presented earlier in the analysis these systemic conditions shapes what could be labeled growth corridors that frame the general conditions and restrictions for growth and structural change. For medium, small and micro sized regions these growth corridors are in terms of growth rates positioned on a considerably lower level compared to metropolitan regions. Further on, during this period the growth corridor appears to be very narrow, ie the restrictions set by the systemic factors leaves limited space for individual regions in the different sizes groups to develop unexpected growth paths (in a positive as well as negative sense). Finally, the hierarchical dimensions in the regional system during this phase of the transformation will primarily take shape between metropolitan regions on the one hand and the rest of the country's regions on the other hand. In addition, it should be noted that the regions geographical position in the country seems to have no impact on the regions possibility for growth and transformation. There is no effect, either positive or negative, that comes from being close to or far away from the regions where the technology shift started. This pattern can be seen as an indication that neighboring regions to metropolitan areas are neither able to quicker create endogenously generated growth nor growth that can be attributed to out sourcing from metropolitan regions compared to regions located on longer distance. This confirms the picture provided by the earlier theoretical discussions and the descriptive analysis. The positive growth effects of the technology shift are at this point of time almost completely isolated to the very top of the regional hierarchy. The remaining parts of the country's regions, with some exceptions for the strongest medium-sized regions, regardless of where they are located in the country are not yet included in the technology shift process.

The group vice regression models thus provides further support for the importance of understanding the time dynamics and lead –lag relations in how and why the technology shift affect growth and change for different kind of regions in a regional system. The regression model further confirms what could be theoretical expected from the technology shift framework and what was indicated from descriptive analysis presented prior in the paper. In the early transformation phase the growth effects are almost completely isolated to the top of the regional hierarchy leading to strong divergence between the core and rest of the country. The restrictions set by the systemic factors in

combination with the strong demand regarding advanced regional receiver and development competences leaves few possibilities to unexpected growth and restructuring for the vast majority of regions in the country.

Late transformation

During the late transformation period 1992-2000 a very different pattern evolves. A hierarchal order of the diffusion of the structural effects is now observable also between different layers of the regional system beneath the top level of the hierarchy. As showed in table 8 the explanatory value falls sharply for medium sized regions. Only the expected growth effect of the industry structure provides significant contributions to the models. Although the industry structure remains important the explanatory value is halved compared with the previous period. This indicates that the degree of freedom for individual regions to develop in different directions is significantly larger in late transformation. Growth corridors are getting broader and the systemic factors does not put as strong restrictions on regional growth opportunities as in the former period. The interpretation is that factors outside the systemic driving forces, i.e. related to unique regional conditions, capabilities or pure chance events, starts to grow in importance. This creates conditions for a much wider range of regional growth trajectories. Thus, the scope for idiosyncratic growth pattern expands strongly for the medium-sized group of regions in the late transformation phase of the technology shift process.

Regarding the group of small regions it may also be noted that the explanatory value falls compared with the previous period, although not as significantly as for medium-sized regions. Expected growth in combination with the public sector development explains 33 percent of the differences in growth of small regions. Model II and III also display a positive significant association between industry width and economic growth, which increases the explanatory power further. The initial level of productivity shows however no influence to overall growth rate. Generally the final model indicates that the growth corridor has widened. The window of opportunity for small regions to develop different growth paths is more open and to a lesser extent constrained by systemic and structural factors. Regional trajectories of growth and change are, compared with the previous period, to a higher degree defined by other factors. This could indicate a greater importance of different forms of unique region-specific capabilities. However the overall explanatory value indicates that the growth corridors still are far more restrictive for smaller regions in late transformation of the growth cycle than the case is for medium sized regions.

For micro regions, the model reveals a very strong connection between initial industry structure and regional growth rate during the period. Over 60 percent of the variance can be explained solely by this variable. Other variables appear to be of marginal importance in this context. This means that

the industry structure at the beginning of the period to a very high extent will frame micro regions growth opportunities during the period. Hence, it is during this period of late transformation micro regions also lags behind most in development compared to higher levels in the regional hierarchy. There is a form of collective lock-in that makes unexpected growth paths beyond what structure allows less likely – the growth corridor for micro regions is even narrower than the case was during the former time period. The ability to take advantage of the technology shift is limited, which is manifested by the generally lower growth rates for the group as a whole while single regional growth paths are locked-in by a disadvantage industry structure. The scope for idiosyncratic growth paths is thus still limited for micro regions.

To sum up, during late transformation appears a clear hierarchical pattern also for the levels below metropolitan regions in the regional system. The growth corridors expanded first and strongest for medium-sized regions, followed by a slight widening of the growth corridors for small regions while these still remains very narrow and put strong restrictions for growth and change among the group of micro regions. It is also noteworthy that there is no correlation between growth and the initial level of productivity for any of the regional groups, suggesting that the convergence within each regional group in terms of productivity as was observed in the previous period, has come to an end. It should also be recalled (see table 7) that the productivity increases that take place in the lower layer of the hierarchy during this period is primarily a result of shifts from low to high productive units within the same industry. This productivity increase does not have any significant relationship with the initial level of productivity but are positively reflected in the regions overall growth rates in value added.

Rationalization

As indicated by the high explanatory value in table 9 for system-oriented factors the growth corridor for medium-sized regions is shrinking sharply during the period of rationalization. In model I and II the initial industry structure shows a strong significance and explains together with a growing public sector, close to 65 percent of the variation in VA growth. As in the previous period the variation in number of industries in the regions shows no impact, while the influence of the public sector remains positive and significant throughout the models. Most remarkable, when the productivity level is brought into the analysis it entirely strikes out the influence of the expected growth effect originating from the industry structure. At the same the explanatory power of the model increases to over 71 percent. One explanation is that productivity growth in the period is almost entirely a result of structural change, i.e. shifts from low to high productivity sectors and to very little extent through shifts between firms and units in the same industry. This suggests that medium-sized regions still experience a considerable element of structural adjustments, a process metropolitan region finished

during the transformation period of the national technology shift. Regarding this particular time period and group of regions the initial level of productivity strongly correlate with the industry structures expected growth rate, which explain why the latter variable lose significance. The negative correlation between the level of productivity and regional growth rate is probably reflecting that that regions with low productivity in the takeoff of the period co-varies with a stronger presence of new or renewed industries suffering from sluggish productivity due to bottle necks at start but with a strong future potential to unleash growth. Productivity differences will thus converge between single regions in the medium-sized group of regions. This in-group convergence takes place in an increasingly narrow growth corridor restricting the space for unexpected growth paths compared with the previous period. Following from that these regions' growth rates tends to converge to the average of the regional group behavior. This also means that the group as a whole experience growth rates approaching those of metropolitan areas. The regional system has started to converge as the technology shifts gradually creates renewal and growth in a broader spectra of regions outside the metropolitan areas. For medium-sized regions this also implies that the transformation phase is about to ebb out and medium-sized regions is increasingly characterized by stability and rationalization of existing structures. This process takes off with a clear time delay compared to when it took place in metropolitan areas.

For the group of small regions the growth corridor also narrows down during the rationalization period, although not as much as for medium-sized regions. The industry structure, number of industries, productivity and public sector growth is significant and explain nearly 60 percent of the regional variation in growth. The largest contribution comes from the initial level of productivity which shows a negative correlation. In the same way as for medium-sized regions, the explanation can be sought in that productivity weak industries at the beginning possess a stronger potential for future growth and productivity. This leads, as in the previous case to a productivity catch-up and convergence between the small regions. Since productivity for small regions during this time period primarily is driven by structural change (shift from low productive to high productive sectors) this indicates that small regions finally also has come into transformation. Although the growth corridor shrinks, some scope remains for growth unexpected trajectories within the group associated with factors other than the system-oriented. The window of opportunity is still partially open for idiosyncratic regional growth process that will differ from the expected.

In the case of micro regions, the picture looks quite different. As a first observation it should be underlined that the model as a whole is not statistically robust and the only variable that shows some significance is the number of industries present in the region. This can be interpreted in several ways. The lack of robustness of the model in combination with the low explanatory power, indicates that

the systemic factors is of only marginal importance for the growth dynamics of micro regions at this point of time. One interpretation is that the growth corridor is very wide and allows for very different growth paths within the group of micro regions - from those that will be largely left behind to those able to gear up and run ahead in terms of growth and change. This cannot be systematically linked to the initial industry structure, productivity, location or other more system-oriented explanations. Rather, it suggests that a "window of opportunity" based on other factors, namely unique endogenous conditions or pure chance, has been opened to regions during this period. This leads to that a few single micro regions to a greater extent will be able to benefit from technology shift renewal impulses. However, it is important to recall that this window of opportunity is opened at a significantly lower overall growth rates compared to regions that are positioned on higher levels in the hierarchy. Following from that, this may be a general indication that the technology shift's positive growth effects have not yet, or only to a very marginal extent reached the lowest layers of the regional system. In any cases, the ability to grow cannot be explained by the systemic forces. The converging trends observed between the metropolitan regions, mid-sized regions and partly the small region group has so far not reached the lower layers of the regional hierarchy.

Conclusions

In this paper we have assumed that radical technology shift is a pervasive force that will reach and affect various parts of an economy and all regions in due time. Departing from this assumption and given systemic conditions in regions we have suggested a conceptual and empirical framework for analysing long-term determinants of regional economic dynamics. This framework strongly underlines the necessity of a theoretically and empirically informed understanding of the importance of different phases of structural change processes and how they affect the mechanisms and opportunities for growth and transformation in different parts of a regional system. Our theoretical discussion indicates a strong need for economic geography research to take into consideration how long term economic growth and productivity performance of regions is related to the characteristics of different phases of structural change processes and how this in turn have very asymmetric effects in the economic adaptability in different part of a national regional system.

In understanding the time dimension special emphasis has been given to radical technology shift and its diverse effect in time and space, such as lead-lag relations between industries and regions leading to divergence and convergence in regional growth as consequences of technological change, market integration and economic growth. Following from this, regional winners and losers will change over time and so will what can be explained by the general "wind" of technology shift in combination with

systemic conditions in regions versus endogenous unique regional capabilities.

Our theoretical framework suggests that technology shift in combination with industry structure, industry width and productivity within regions and the existing hierarchy of regions should put strong restrictions on what can be achieved in terms of transformation and growth for single regions in specific time periods but also on how interdependencies in a regional system evolve over time.

Our empirical work, based on an analysis of the Swedish regional system over three decades, provides strong evidence for our conjectures. The technology shift have distinctively targeted various parts of the regional system at different points of time, setting the overall agenda for structural change, productivity and growth for different levels of the regional system. These patterns are so strong that we have found no other way to explain them. Further on we have found that regions at different levels of the regional hierarchy tend to follow different "growth corridors" given the basic precondition for regions to take advantage of the technology shift impact. These growth corridors set the overall standard/pathway for a whole "family" of regions in terms of growth rates. Therefore they also drive the divergence/convergence process between regions belonging to different size-groups in an economy.

Moreover, growth corridors make us better understand the interplay between systemic conditions and endogenous unique capabilities in regions with similar conditions and of equal size. Our research indicates that growth corridors appear and change in character in a hierarchical order among regions, deciding both the average growth rate for a group of regions and the possibility for single regions to divert from the group - behavior. That might lead us to a better understanding of growth variations (residuals) between regions of equal size. This is because once we are able to sort out how much in growth over time that comes from technology shift and systemic conditions in regions, we will get more uncontaminated growth residuals that can be tested against factors that mainly have to do with unique local growth incentives. This might sharpen the results from new and established theories dealing with the internal world of regions. It might also open up for multi-theoretical approaches and more cumulative research within the field of regional development.

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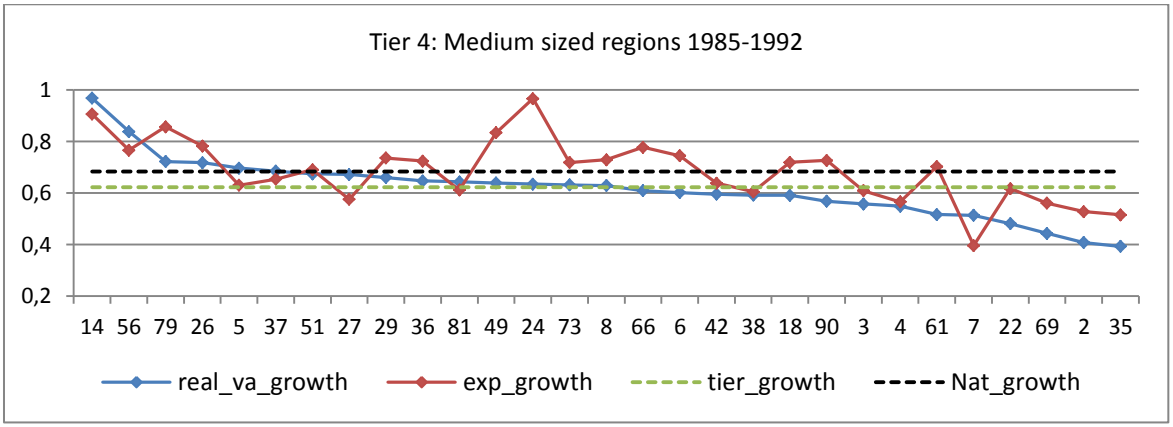
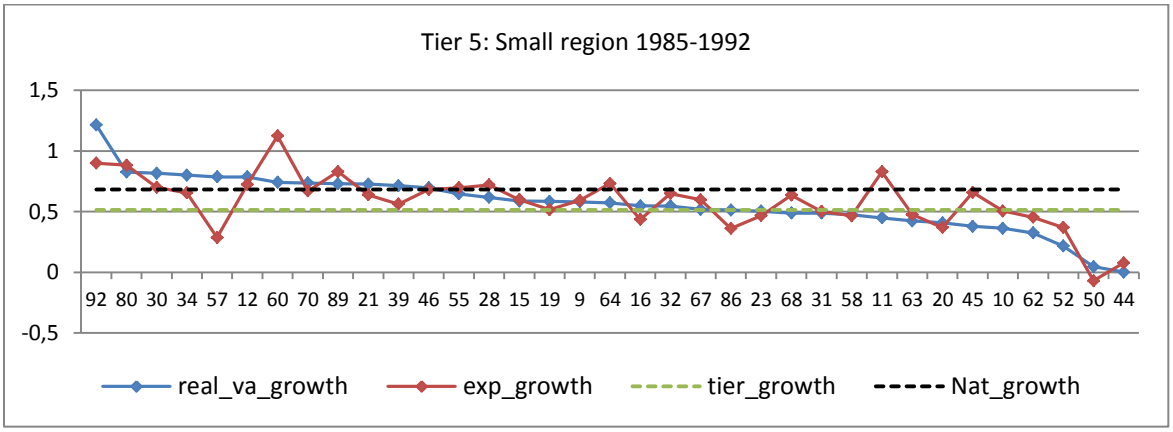
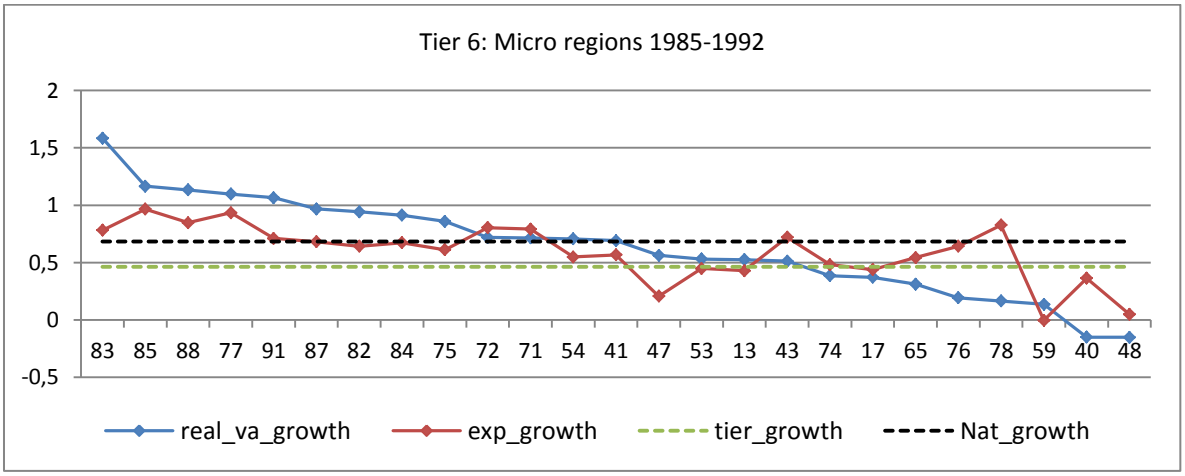
Appendices. Regional growth patterns in different tiers and time periods

The diagrams show the differences between real growth and expected growth (coming from the technology shift "wind" and industry structure in regions and time periods. Public sector size, industry width, productivity and distances within the regional system, when added, make the final residuals smaller.

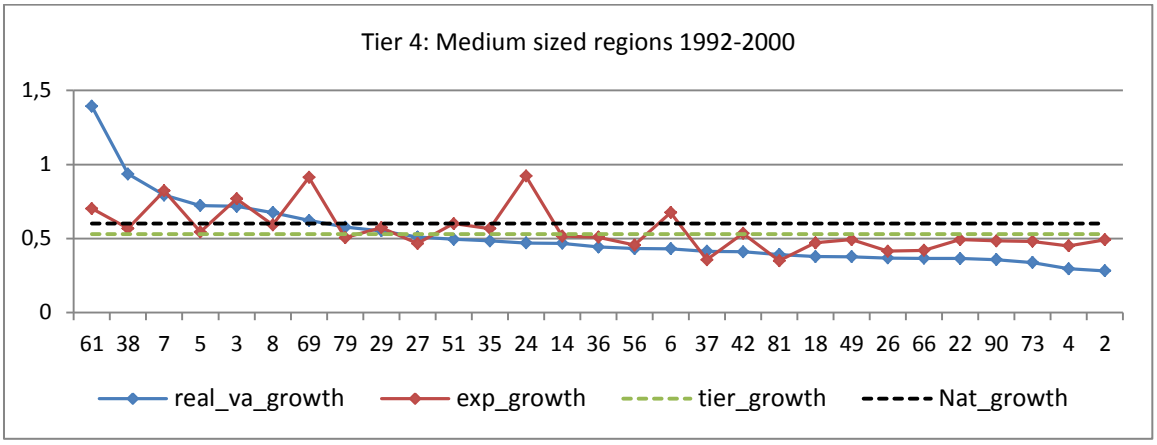
1985-1992

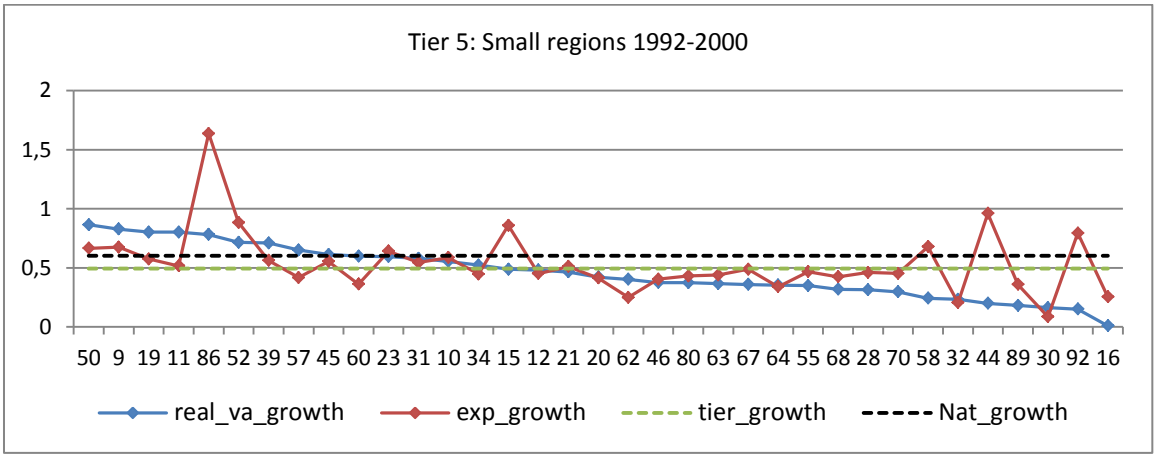


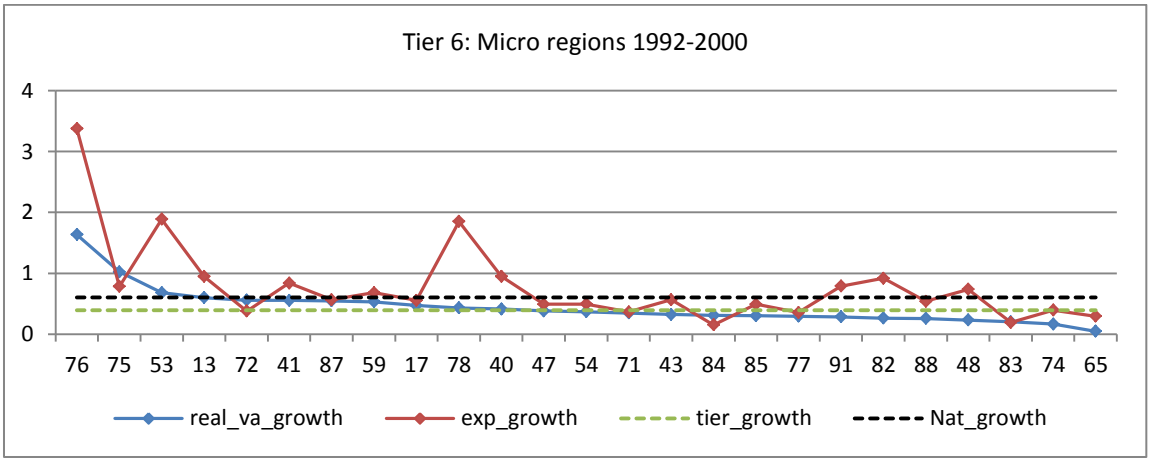




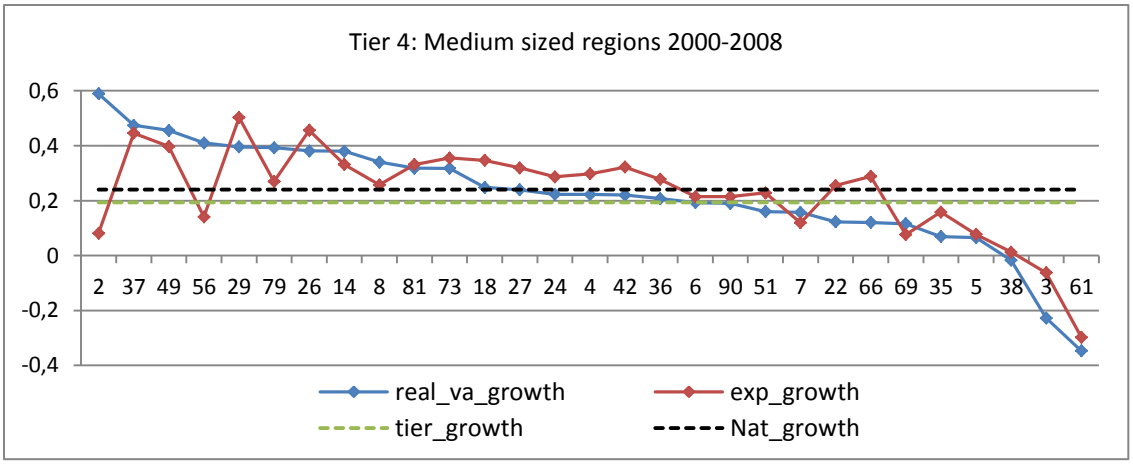
1992-2000







2000-2008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0,6
0,4
0,2
0
-0,2
-0,4
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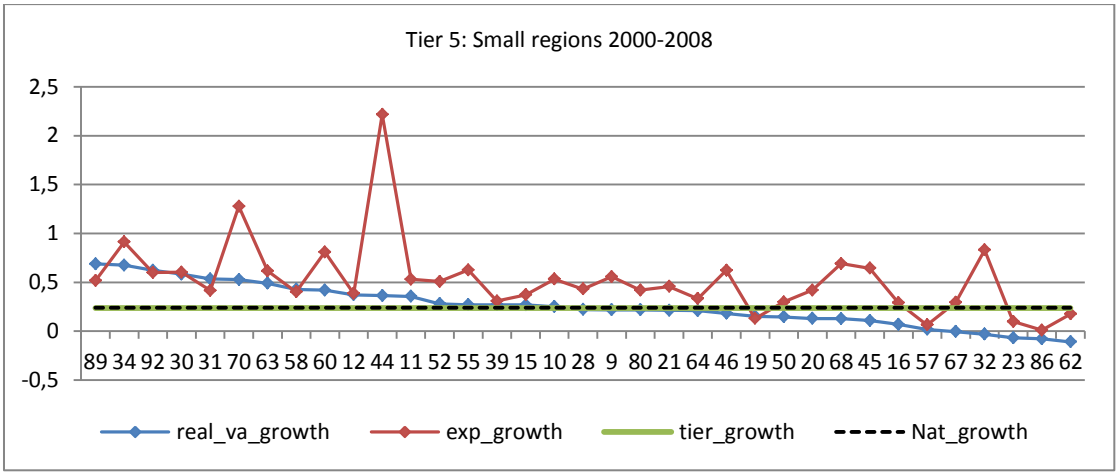
real_va_growth
exp_growth
tier_growth
Nat_growth


Tier 5: Small regions 2000-2008
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2
1,5
1
0,5
0
-0,5
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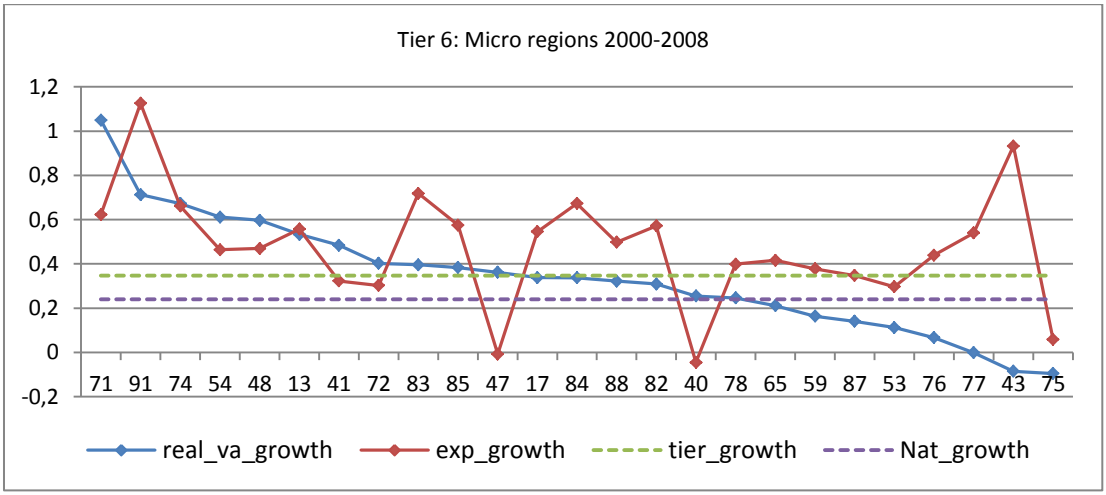
real_va_growth
exp_growth
tier_growth
Nat_growth


Tier 6: Micro regions 2000-2008
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1
0,8
0,6
0,4
0,2
0
-0,2
71 91 74 54 48 13 41 72 83 85 47 17 84 88 82 40 78 65 59 87 53 76 77 43 75
real_va_growth
exp_growth
tier_growth
Nat_growth