The footprint of innovation- regional labour market reactions to macroeconomic shocks*

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The rise in European unemployment during the last decades is characterized by substantial differences between large European nations with high unemployment rates and small European nations with more favourable developments of employment. However, besides national differences in unemployment we have also experienced substantial differences in regional unemployment rates within a nation state. These unemployment differences among regions reflect diverse sectoral and labour market structures and are a result of distinct reaction patterns to macroeconomic shocks (e.g. changes in taxes, see Roeger, 2007). Hence, in order to analyze these reaction patterns, we propose a macro econometric labour market model and test its explanatory power by using regional labour market data from a selection of Western German regions. Specifically, we pose the following question: **Do labour markets of regions that have a high share of innovative industries and knowledge-intensive services respond differently to exogenous shocks than regions with less innovative industries and services?**

Keywords: labour market, policy, innovation, shock, region, Germany

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1. Introduction

In March 2000 the European member states agreed upon the Lisbon Strategy – an agenda to make the EU the world's most dynamic and competitive knowledge-based economy by 2010. José Manuel Barroso, President of the European Commission, states: "Our clear aim is to achieve more and better jobs in a more dynamic, innovative and attractive Europe. With this strategy I believe we now have the right tools to achieve our goals." EU (2007)
This overall goal is pursued through the formulation of various policy initiatives and sets a focus on innovation[1].

In order to facilitate these policy initiatives the demand for quantitative economic investigation has grown rapidly. In addition, the European economic and monetary integration process has strengthened the importance and economic impact of regional economies, thus calling for analytical instruments – tools- aimed at supporting the decision-making process.

In an attempt to provide such a tool for policy analysis, we first examine which ingredients make up distinct labour market models in chapter two. We extract main ingredients of reviewed labour market models; find however, that they fall short in comprising the topic of innovation. Innovation is hence the content of chapter three. Together, chapter two and three provide a solid understanding of the theoretical background. Background on the regions of study such as the main economic characteristics and performance in wealth generation, employment, growth and innovation is provided in chapter four. In chapter five we present the proposed labour market model with the obeyed philosophy and methodology. Chapter six elucidates where the data stems from before we apply the data to the proposed model in part two of the chapter. At the beginning of chapter seven we spend some words on model simulation to examine the fit of the proposed model with the data. In the main part of chapter seven we then model different exogenous shocks and observe the region-specific reaction patterns. We find that the regions show indeed very distinct reaction patterns to the imposed shocks. The conclusion of the finding is provided in chapter eight.

2. Development and structure of labour market models

Besides the increasing application of micro-founded models, macroeconomic models are still wide-spread and applied by many policy decision makers. In the sixties and early seventies macro econometric models became popular as means of policy analysis and as basis for policy

[1]Innovation according to the European Commission is "the renewal and enlargement of the range of products and services and the associated markets; the establishment of new methods of production, supply and distribution; the introduction of changes in management, work organization, and the working conditions and skills of the workforce." COM(1995) 688- Details can be found chapter 3.

decisions. However, advances in econometrics theory and the shortcoming of macro models in sufficiently describing economic responses to supply shocks brought them under attack in the mid seventies. Amongst criticism from other authors such as Sims (1980), Granger & Newbold (1974), it is generally considered the Lucas's critique which prevented large-scale macro econometric models from becoming the standard approach in policy analysis (see Lucas (1976)). Lucas suggested the incorporation of rational expectations in models of dynamic intertemporal optimisation decisions. However, today economists are in quarrel about models based on rational expectations as psychological aspects of the consumer play an increasingly important role. As a consequence the consumer may not always act fully rational.
As a consequence macro econometric models experienced a come-back since the mid nineties because they comprise aggregate data which comprises the different types of consumers.[2]

The increasing application of macro econometric models on an international level is also driven by an **increased degree of accuracy** and by **increasing international interaction**. Already in the 1970s and 1980s more and more economists started to apply macro models not only to a national level but also to a regional level. Important examples are works by Adams, Brooking, Glickman (1974) and Glickman (1977).[3] More recently, Pesaran, Schuermann & Weiner (2004) apply a well-designed global VAR model to 25 countries grouped into 11 regions. It captures a core-set of variables and shows the linkages between national and international factors.

Besides the degree of accuracy and the area of application, also the **modelling strategy** plays an important role in constructing a macro economic model. In the 70s the modelling strategy was heavily influenced by the economic development -characterised by rising unemployment rates in the OECD countries (see Blanchard, 2006). The rise in unemployment rates was imputed to macro economic shocks such as the oil price shocks. The phenomenon of unemployment becoming more severe, researchers accounted for that by including unemployment rates in their macroeconomic models. The inclusion of wage equations permitted to model different hypotheses on wage determination processes and finally to model the unemployment rate.[4] In the 1980s the focus of labour market analysis shifted away from shocks. And more recently in the 1990s, besides the role of supply side economic factors, it was the role of the adjustment process of economic variables towards their theoretical equilibrium level which attracted more attention. The capability of understanding these different adjustment processes has been enhanced by the application of co-integration[5] and error correction representation models.

[2] The popularity is expressed by manifold application of national and international institutions such as central banks (Bank of Italy, 1986), government research units (Fiorito et al., 2000; or Fitz Gerald, 2002) and international organizations like the IMF (1998), the European Commission (Roeger & Veld, 1997), or the OECD (Barrel et al., 2001).
[3] They applied large national econometric models to a small open economy of a Keynesian (IS-LM type) general equilibrium model.
[4] Bolton (1985) provides an excellent review of the philosophy and structure of these approaches.
[5] For common tests of cointegration see Johansen (1995) or Pesaran, Shin and Smith (2000).

Besides these **methodological developments** regional modelling has also been influenced by **theoretical** and **empirical advancements**. Within these, especially the new growth theory with its underlying convergence controversy has added new insights to regional modelling.[6]

The dynamics of European regional convergence are at the core of Fingleton (2001). He uses a spatial econometric approach and simulations based on suggestions made by Fujita, Krugman & Venable (1999) who called for a computable geographic equilibrium model. Utilizing this geographic equilibrium model allows Fingleton (2001) to consider the role of employment and population in the US regional growth process. Furthermore by utilizing another tool – the so called panel co-integration technique – and causality tests he is able to point out the relative role which the **demand-side** (e.g. export driven) and the **supply-side** (e.g. regional amenities) play in explaining the regional growth process on a sub-national level.

At the end of the 90s attention shifted away from merely modelling labour supply and labour demand towards the inclusion of the **institutional setting** determining the efficiency of the matching process between labour demand and labour supply. Good examples of this stream of research are Bertola (1999), as well as Blau & Kahn (1999). They analyse the impact of different institutions and regulations on labour market outcomes. They find that wage adjustment and labour mobility are affected by minimum-wage provisions, unemployment benefits and welfare payments. In addition, Bertola (1999) finds that relatively high unemployment remuneration indeed reduces the incentive of job seekers to accept comparatively low wages. His analysis supports the hypotheses that "mental minimum wages" induced by relatively high remuneration schemes do have an impact on the lower end of wage distributions. In addition he adds that centralised wage bargaining processes further increase the pressure on the wage curve. Epifani & Gancia (2001) address the question of matching by constructing a core-periphery model with unemployment benefits and equilibrium unemployment. They conclude that frictions in the job-matching process lead to equilibrium unemployment. Furthermore they show that search costs generate a positive externality effect of agglomeration on the labour market. Their model is also able to explain the empirical puzzle of declining labour mobility despite increasing labour market disparities experienced by many European regions. Attempting to minimise the phenomenon of unemployment, Nickell & Layard (1999) recommend that regulations and institutions should act towards a reform of social security systems combined with active labour market policies where they expect a positive impact on employment. On the other hand they show that strict labour market regulations, employment protection and minimum wages should not be the main target areas of policies aiming at a significant decline of unemployment. Nickell et al. (2003) include dynamic aspects by investigating the relation between labour market institutions and unemployment in OECD countries. They find that changes in the institutional structure of various labour markets over time do explain a substantial proportion (about 55 percent) of the rise in European unemployment from the 1960s to the 1990s.

[6] Good examples of this development are Fingleton (2001) and Freman (2001).

Following these studies we find that the structure of a labour market should not be neglected when proposing a labour market model. Thus, a labour market model should comprise the main market forces **labour demand** and **labour supply** as well as the **matching process** in order to capture friction between the market forces and reflect the institutional setting.

3. The Innovation Phenomenon

Innovation has become a key aspect when considering modern economic systems. This is not only true for studies about economic growth (see Guimaraes and Langley, 1994) but also for labour market studies. In order to address the relationship between innovation and the labour market, we first have a look at what exactly is understood by innovation. The second paragraph explains why innovation is particularly important for modern economies. Knowing about the importance of innovation we want to address the issue of how to measure the complex phenomenon of innovation. Finally, we examine whether we are able to find evidence that innovation and employment are related.

3.1 Defining innovation

Hall (1986) defines innovation as the activities of developing and commercialising new products and processes. These innovation activities can generally be of two different types according to Freman (1986). Firstly, they can be fundamental in nature. A fundamental innovation is characterized by the creation and utilization of a piece of novel scientific, technological or organizational knowledge. The second type of innovation is less “dramatic” in its nature and is called “incremental”. Opposed to a fundamental innovation, an incremental innovation is based on the application of existing knowledge. These two types of innovation have two major areas of application, namely products and processes. While product innovations deal with the question *what* is produced, process innovations are targeted at *how* products are produced. Innovation is present in all sectors of the economy. In the industrial sector of the economy we find technological products and process innovations in the appearance of goods as material outcomes. In contrast, in the service sector organisational process innovations and product innovations lead to intangible outcomes. Edquist & Res (2000) argue that intangible innovations in the service sector are not to be considered less important than innovations yielding material outcomes, which could be assumed.

3.2 The role of innovation in modern economies

Literature on innovation has been popular since long ago. One of the first comprehensive works is List (1841). At the end of the nineteenth century the topic of innovation was mainly linked to the upcoming strength of the nation states. Economists at that time examined innovation on the search of the most powerful national system of innovation. More recently, the question of the best national system of innovation is still relevant, however, the focus shifted towards exploiting innovation as a source of job creation and a weapon to fight

unemployment (see Freeman, 1995). As economic development evolves and countries become more and more industrialized their sectoral focus changes from production of low technological goods – like wood products or textiles and paper - to technologically more advanced goods and services with significant innovative activity like pharmaceuticals or ICT[7] products and services. Countries slowly transform from developing to highly developed economies. Highly developed countries show lower growth rates with respect to their level of gross domestic product. They score comparatively high in per capita income and show high levels of capital stock and R&D[8] activities. The large R&D potential is needed to develop more innovative products and services.[9] According to Krumm & Strotmann (2004) a country - being a technological and economic leader – has to develop continuously new products and procedures in order to be able to hold its prosperity level and level of employment. This is also true for Germany.

3.3 Measuring Innovation

Following the previous section about the role of innovation, we now ask ourselves how innovation can be measured.

Innovation is a multi-dimensional phenomenon and hence difficult to be measured. Therefore, the Maastricht Economic Research Institute on Innovation and Technology (MERIT) and the Joint Research Centre of the European Commission in the framework of the European Innovation Scoreboard (EIS 2007) calculate a summary innovation index comprising 26 different indicators for the 27 EU member states. The indicators are assigned to five dimensions and grouped into firstly, drivers contributing to innovation input and secondly, others that measure innovation output.[10]

Restricted by data availability we search for the most important drivers of innovation. A key element driving a knowledge-based economy is - according to EIS (2007) - investment in research and development (R&D). The Eurostat Yearbook 2005 emphasizes (EUROSTAT, 2005, 209): “Research and development (R & D) is a driving force behind economic growth, job creation**, innovation** of new products and increasing quality of products in general, as well as improvements in healthcare and environmental protection.”

The relationship between **R&D expenditure** and innovation intensity- on an aggregate level- can be observed by the following figure:

[7] ICT= Information and Communication Technology
[8] R&D=Research and Development
[9] RWI (2005) shows the more economically advanced a country, the higher the need for research and innovation.
[10] Besides R&D expenditures, diffusion and adoption, patterns of innovations play a fundamental role and can lead to fundamental differences between the structure of R&D expenditure and innovation output. This can be illustrated by the fact that countries, sectors and enterprises which are less research intensive can via knowledge spillovers benefit from R&D expenditures of other entities. Nevertheless, we can experience a close relationship between innovation inputs - like R&D expenditure - and innovation output – like number of patents/GDP as proposed by Paci & Pigliaru (2001). They find this relationship to be 0.91 for European Regions in 1990.

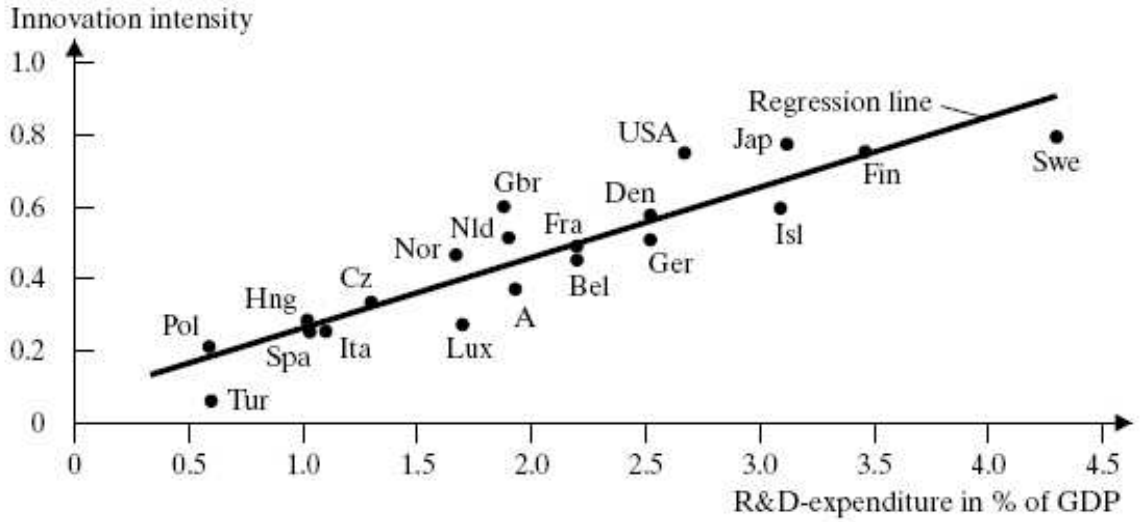


Figure 1: Research and Innovation Intensity (Source: RWI (2005), p.8) [11]

We can observe a close relationship between the composite indicator innovation intensity and R&D expenditure in % of GDP. Hence, taking R&D expenditure in % of GDP is a fairly good single indicator capturing the phenomenon of innovation. However, besides R&D expenditure economic literature suggests a second crucial factor for innovative activity, human capital. "Nothing will matter more to Europe's future than the ability of countries, governments, workers and companies to innovate – a process which will depend in no small degree on the efficiency of our decision-making and the quality of our **human capital**" (see Ederer 2006, 2).

The importance of human capital is affirmed by Taylor (2005, 150) who states: "… the innovativeness of regions is significantly associated with their economic performance [measured as log GDP per capita] and by the presence of high-skill workers [measured by log % of workers with high-level education]."[12]

[11] RWI (2005): "The innovation intensity is a standardized indicator between 0 and 1, which consists of 12 partial indicators, including, among others, indicators for human resources, patents and for R&D intensity. In this respect, a part of the very close correlation of both data rows (determination coefficient of 84%) is to be explained by the fact that the innovation intensity is also affected by R&D indicators. However, for some countries, there is no better way to represent innovation performance. And for some EU countries, CIS data are only available for some years.

[12] Griliches (1979) proposes a model of the knowledge production function which is characterized by incumbent firms who engage in the pursuit of new economic and technical knowledge as an input into the process of generating innovative activity. New economic and technical knowledge is one of the major input factors, which is according to Cohen & Klepper (1991 and 1992) generated by R&D. Other inputs of the knowledge production function are indicators like human capital, skilled labour, and educational levels, as previously stated. Thus, according to Audretsch (2005) the model of the knowledge production function whose output is the degree of innovative activity can be represented as $I_i = \alpha RD_i^{\beta} HK_i^{\gamma} \varepsilon_i$ where I stands for the degree of innovative activity, RD represents R&D inputs, and HK represents human capital inputs. Audretsch (2005) emphasizes that the explanatory power of the abovementioned equation is particularly strong on an aggregated level, such as industrial sectors or countries (See also Griliches, 1984).

3.4 Innovation and the labour market

Having defined innovation and having an idea about how it could be measured, we now examine whether we find evidence for a relationship between innovation and employment. Referring to RWI (2005) there is at least a correlation between research intensity and employment as shown by the following figure.

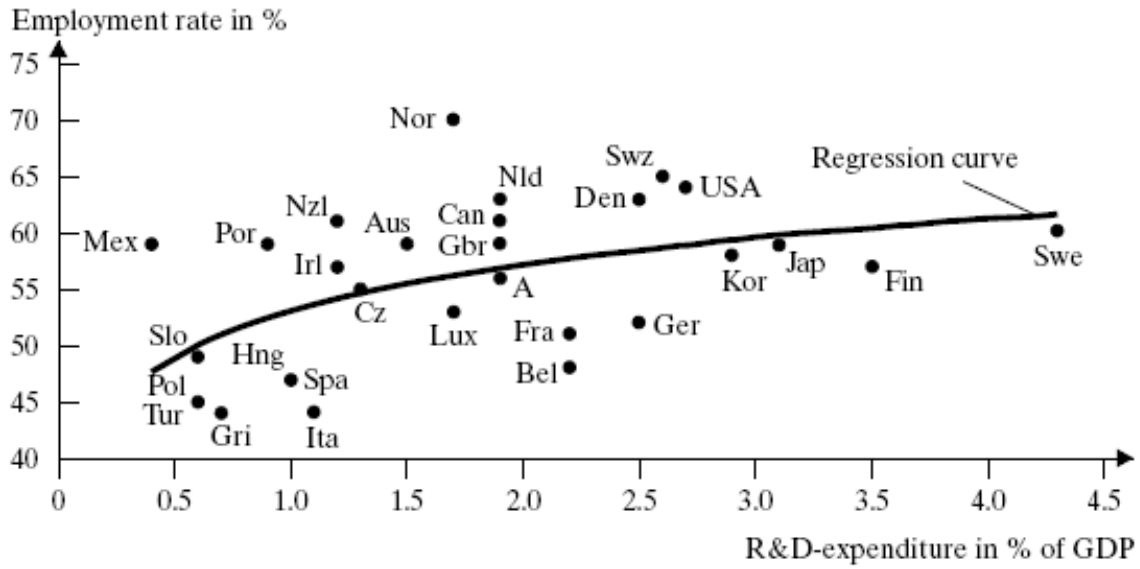


Figure 2: Research Intensity and Employment Rate (Source: RWI (2005), p.12)

The relationship indicates that an increase in research intensity is accompanied by a higher employment rate, at least in tendency. Even though the relationship on a national level is not very strong, R&D expenditure impacts on employment and on innovation and hence, innovation and employment are related through R&D expenditure. Missing out on a very strong relationship between R&D expenditure and employment does not come as a surprise because innovation (through R&D) has only been considered a possible additional factor in explaining employment and unemployment of countries or regions.[13]

This section has shown that evidence calls for consideration of innovation when analysing labour markets. To understand the causal relationship between wealth, employment and innovation, the next chapter observes the main economic facts of the regions under study.

[13] We are well aware of the fact that the employment rate is affected by numerous other factors, such as the demographic development, immigration, labour market rigidities, changes of the labour force structure (e.g. concerning the labour force participation of women), labour market-policy measures (e.g., job-creating measures, mini-jobs etc) and last but not least, statistical recording problems. Furthermore, as described in the previous paragraph, we estimate innovation not solely by R&D expenditure but also by human capital inputs which are not considered in the figure above.

4. Region-specific characteristics leading to divergence in German regions

The strategic goals of stable and sustainable growth and more and better jobs - as outlined in the introduction - is far from being a smooth and homogenous process. In order to see the regional and sectoral differences inherent in such a process in the case of Western-Germany we shall consider the federal states of Baden-Württemberg (BW), North-Rhine-Westphalia (NW), and Schleswig-Holstein (SH). BW is a representative of an innovative, economically strong state characterized by a relatively high share of industry, high export rates (42.7%)[14] and low unemployment. It is situated in the South of Germany. NW represents a medium-innovative, economically average performing state where services play an important role but industry is also important. Its openness is medium (32.9%), it experiences unemployment rate like the German mean and is situated in the West. Schleswig-Holstein is a representative of a low-innovative, economically weak state which is mainly based on services and agriculture and whose economy is not very open (23.7%). Its unemployment rate is similar to NWs. It is situated in the North of Germany. Based on the regional as well as the sectoral dimension we will be able to detect specific strengths and weaknesses of these three German states. Besides a general representation of the main macroeconomic facts we shall examine whether we find evidence for convergence or divergence.[15] We consider the standard measure of wealth – GDP per capita - and by decomposing it, we see which factors added up to the regions growth. We follow the basic causal relationship proposed by Vosskamp & Schmidt-Ehmcke (2006, 8).

$$\frac{GDP}{POP} = \frac{GDP}{totHW} \times \frac{totHW}{TE} \times \frac{TE}{LF} \times \frac{LF}{POP} \qquad (4.1)$$

The first factor is GDP per hour worked or labour productivity. It is considered to be the essential measure of growth emanating from innovation. The second factor is working hours per head and year- which is basically the quantity of labour input, or labour hoarding. Another factor which measures the utilization of potential labour is total employment divided by the labour force- or simply the complement of the unemployment rate. The fourth factor is the ratio of labour force and total population - another quantity measure.

The following table[16] shows the values for 1975, 1991 and 2005 and indicates convergence or divergence:

[14] Figures are in % of GDP 2007. Source: Bayrisches Staatsministerium (2008)
[15] Instead of looking at the whole time span from 1975-2005, we will look at 1975, 1991 and 2005. 1975 being the beginning of the data period, 1991 in the middle and the year from which innovation data is available and 2005 being the end of the data period.
[16] The figures presented in this section are based on data described in the data section and utilized in the model and estimation exercise, where not indicated otherwise.

Table 1: Basic Economic indicators

Figures

	GDP/POP in EUR/head			GDP/totHW in EUR/h			totHW/TE h/head			TE/LF as fraction			LF/POP as fraction		
	1975	1991	2005	1975	1991	2005	1975	1991	2005	1975	1991	2005	1975	1991	2005
BW	9386	23430	30102	14.30	35.12	50.18	1435	1308	1191	0.974	0.968	0.928	0.469	0.533	0.542
NW	9245	21184	27074	15.01	34.54	48.58	1525	1330	1195	0.964	0.937	0.895	0.419	0.493	0.521
SH	8192	19304	23995	14.89	33.48	47.95	1429	1264	1157	0.954	0.929	0.895	0.403	0.484	0.483

Ratios

	GDP/POP			GDP/totHW			totHW/TE			TE/LF			LF/POP		
	1975	1991	2005	1975	1991	2005	1975	1991	2005	1975	1991	2005	1975	1991	2005
BW to NW	1.015	↑ 1.106	↑ 1.112	0.953	↓ 1.017	↑ 1.033	0.941	↓ 0.983	↓ 0.997	1.010	↑ 1.033	↑ 1.037	1.119	↓ 1.081	↓ 1.040
BW to SH	1.146	↑ 1.214	↑ 1.255	0.960	↓ 1.049	→ 1.047	1.004	↑ 1.035	↓ 1.029	1.021	↑ 1.042	↓ 1.037	1.164	↓ 1.101	↑ 1.122
NW to SH	1.129	↓ 1.097	↑ 1.128	1.008	↑ 1.032	↓ 1.013	1.067	↓ 1.052	↓ 1.033	1.010	↓ 1.009	↓ 1.000	1.040	↓ 1.019	↑ 1.079

↑ indicates divergence (between 1975 & 1991; 1991 & 2005)
↓ indicates convergence (between 1975 & 1991; 1991 & 2005)
→ indicates neither con- nor divergence (between 1975 & 1991; 1991 & 2005)

For the first measure **GDP/head** and we see the "strong" region Baden-Württemberg (BW) leading the group of representative states from 1975 until 2005. Whereas the level of wealth was approximately the same as the one of North-Rhine-Westphalia (NW) in 1975, it increased by higher rates so that the divergent development manifests in about 11% higher per capita output in 2005.[17] The per capita output of Schleswig-Holstein (SH) did not only start from the lowest level in 1975 but also showed permanently smaller rates of increase compared to BW until 2005 the measure of wealth of BW is more than a quarter higher than SH's value. Besides this divergence between the Northern and Southern state we observe convergence between NW and SH for the first part up the data period and divergence in the second part so that in 2005 the gap reaches its initial level of 1975.[18]

Having found evidence of divergence in wealth we are most interested in where the divergence in wealth emanates from. We shall keep the labour productivity (GDP/working hour) until the end and start with the quantity measure of total hours worked.

In 1975 employees in Baden-Württemberg exploited their **labour force** 90 **hours** less than employees in North-Rhine-Westphalia and six hours more than employees in Schleswig-

[17] Also Badinger and Tondl (2003) find that there is only little convergence in income per capita within countries if any.

[18] The overall growth performance of BW, NW and SH does not suggest a clear-cut statement in favour of one, or to the disadvantage of another state; Rather a long-term trend of decreasing growth rates from 1975 until 2005 is common to all states. The general trend, however, has been strongly influenced by cyclical up- and downturns; the strongest business cycle was the historically unique "reunification boom": It started after a short cyclical downturn in 1987; together with a standard upswing in the late 1980s it reached its peak in 1990; after that euphoric exaggeration it turned into a severe "adjustment downturn" in the early 1990s. The states experienced similar patterns in upturn and downturn dynamics. None has always been the strongest "winner" or the absolute "loser" in the business upturns or downturns during the 30 years up to 2005. Considering the period after the slump of the early nineties, one might find, at most, a tendency towards relatively higher growth rates in the upturns and somewhat less sensitiveness to a weakening of growth in the downturns for Baden-Wuertemberg, - a sign for more robustness of this state compared to the other two. Particularly in the years of the "New Economy" boom from 1998 to 2001 Baden-Wuertemberg demonstrated its structural strength as a high-tech region.

Holstein.[19] We observe nearly perfect convergence between BW and NW from 1975 until 2005, so that in 2005 the difference of 90 hours melted down to only 4 hours. The picture between BW and SH is different showing divergence from 1975 until 1991 from 6 to 44 hours before slightly converging to 34 hours. We have to note, however, that total hours worked declined considerably from 1972 until 2005 in all regions. In the case of NW relative to SW we find convergence for the entire sample period. We conclude, the difference in the quantity of hours worked is only marginal between the states and tends to converge currently.

The next measure- total **employment divided by the labour force** is also a quantity measure showing the level of employment in region relative to potential employment. With the highest value in 1975 BW also shows the highest value in 2005.[20] Compared to NW - which is the largest of the three states in terms of inhabitants and workers - it has experienced a more favourable development of employment. This is expressed by a converging trend over the entire period. NW managed to increase its employment rate by 22% over the entire sample period, whereas BW experienced an increase of 33%; Schleswig-Holstein's employment rate increased by 28%. This development indicates the fact that NW did have troubles evolving away from its traditional industrial structure of coal mining and steel to a more modern employment structure. It has lost its advantage relative to SH entirely so that the employment rates today do not differ anymore. The difference between the employment rates of BW and SH first increased until 1991 before in the more recent period they show a slight tendency of convergence.[21]

The last factor in the table is the share of the **labour force to total population**, or the participation rate. First, the different starting points in the year 1975 are obvious: the participation rate was around 47% in Baden-Württemberg and, in sharp contrast to that, it was only about 42% in North-Rhine-Westphalia and somewhat more than 40% in Schleswig-

[19] Figures for self-employed are not available.

[20] Taylor (2005) refers to Nickell (1997), Martin (1998) and Armstrong and Taylor (2000) when providing reasons for regional unemployment differentials. First, personal characteristics such as age and educational attainment play an important role in becoming unemployed. Second, once high unemployment in a region becomes an enduring phenomenon it becomes increasingly difficult for the unemployed to receive a job offer. The longer they are unemployed the wider becomes the gap in skills between them and the employed and thus, the more employers discriminate against them. Bradley and Taylor (1997) find that unit labour costs of regions with high unemployment rates are relatively higher and policy intervention by minimum wage provisions or unemployment benefit payments restrain wages to decrease to their efficient level.
Third, Taylor (2005, 142) notes that "firms are reluctant to invest in high unemployment localities since these areas often have poor physical and social infrastructure." Having poor physical and social infrastructure means that schooling results and the probability to pursue higher education are low. How important high skilled workers are for employment growth – also for low-skilled workers- is shown by Suedekum (2006). In his study of 326 Western German NUTS 3 districts from 1977 to 2002 he finds that employment growth in high-skilled cities is faster than in low-skilled cities. He explains: "The observed positive impact on total employment growth is […] due to the fact that low-skilled jobs grow faster than high-skilled jobs decline in initially skilled cities. This evidence is consistent with complementarities among skill groups as the major causal link between human capital and employment growth. It challenges theories of self-reinforcing spatial concentration of high-skilled workers due to strong localized spillovers. (Suedekum, 2006, 1)"

[21] The unemployment rate of BW in 1975 was below 3%, in 2005 above 6%. For NW the rate was below 4% in 1975 and above 10% in 2005. The figures for SH are above 4% in 1975 and above 10% in 2005.

Holstein. All three regions increased their rates until 1991. SH managed to increase its rate by over 8% so that it could narrow the gap to BW and NW. In the second part of the period up until 2005, SW lost momentum, however, so that bounces back and diverges from BW and NW. The relationship between BW and NW was also characterised by a converging pattern until 1991 which, in contrast to SH, continued until 2005. As a consequence, the lead in the participation rate of BW relative to NW narrowed down from about 12% in 1975 to about 4% in 2005. NW's participation rate first dropped from being about 4% ahead of SH's in 1975 to only 2% a head, before NW was able to increase its lead to 8% in 2005.

Comparing the development so far, one can state that the time period post 1991 is characterized by convergence in the case of the hours worked per worker, only slight divergence in the employment rate, and convergence in the participation rate between BW and NW. When we compare BW to SH, most obvious we find divergence in the participation rate, whereas the quantity of hours worked converges just like the employment rate. Comparing NW to SH we find strong convergences in all indicators except for the participation rate where NW increases the gap to SH.

Following these findings and comparing BW to SH we reason that the much higher participation rate could be a source of divergence in wealth. In the case of BW and NW, however, we are not able to explain why the growth in wealth of BW is so much higher than that of NW- having found that most measures of the growth rate of working time converge. In taking on this issue we shall look at our first factor **labour productivity**. Looking at the values of BW in 1975 we find that in was about 5% lower than that of NW, whereas today it is more than 3% higher of NW's. Hence, BW managed to be somehow more productive than NW and overtake NW in output per hour worked. Comparing BW to SH we see that in 1975 BW was about 4% less productive than SH whereas in 1991, BW was about 5% more productive than SH which did not change much since then.[22]

In the section about innovation, we have found evidence that innovation might be an important factor for employment and contributes to growth in general. We shall now look at factors considered relevant for the innovation process for BW, NW and SH in an attempt to examine whether BW undertakes more effort in innovation than NW and SH.

[22] A more precise picture of what constitutes to the different development in labour productivity can be obtained by an inspection of the sector-specific development of productivity. The time paths of productivity in the industrial sector of the three states show a more or less identical development from 1975 until 1991. From the mid of the 90s onwards, however, NW as well as SH showed a weaker productivity increase in industry than BW. However, while SH could not catch up significantly to BW, NW managed to converge almost to BW. The productivity figures of the service sector show a clearly different. In spite of the positive overall trend during the 30 years from 1975 to 2005, the time series demonstrate that NW performed best from 1975 until about 1995. BW and SH both started from a weaker position in 1975. Whereas BW managed to close the gap to NW, the productivity path in SH's service sector still ranked third until about 1995. After 1995 NW lost its leading position and was overtaken by BW, which, since then, has become the strongest state in terms of productivity also in the service sector.

Table 2: Basic Innovation Indicators

Figures	RDexp/GDP[1]		RD staff/TE[2]		EINDH/EINDL[3]		ESERH/ESERL[3]	
	1991	2005	1991	2005	**1995**	2005	**1995**	2005
BW	0.0263	0.0340	0.0138	0.0152	0.7572	0.9233	0.6167	0.7354
NW	0.0135	0.0110	0.0069	0.0050	0.4434	0.4716	0.5792	0.7248
SH	0.0063	0.0052	0.0036	0.0026	0.4547	0.5006	0.5109	0.6112

Ratios	RDexp/GDP in %			RD staff/TE			EINDH/EINDL in %			ESERH/ESERL in %		
	1991	2005		1991	2005		1991	2005		1991	2005	
BW to NW	1.948	3.090	↑	2.007	3.060	↑	1.708	1.958	↑	1.065	1.015	↓
BW to SH	4.161	6.480	↑	3.874	5.799	↑	1.665	1.844	↑	1.207	1.203	►
NW to SH	2.136	2.097	↓	1.930	1.895	↓	0.975	0.942	↑	1.134	1.186	↑

↑ indicates divergence (between 1991 & 2005; 1995 & 2005)
↓ indicates convergence (between 1991 & 2005; 1995 & 2005)
► indicates neither con- nor divergence (between 1991 & 2005; 1995 & 2005)

[1] R&D expenditure in the economic (excl. Public & other sectors) sector as a fraction of GDP; source: Grenzmann & Kladroba. (2007, p.22 & 23)
[2] R&D staff in the economic sector over total employment (dep. empl. & self-employed); source: Grenzmann & Kladroba (2007, p.22 & 23)
[3] Employees in highly innovative industries divided by employees in low innovative industries; source: SLA (2008), RA (2007), refer to the Appendix for details
[3] Employees in knowledge-intensive services divided by employees in non-knowl.-intens.-services; source: SLA (2008), RA (2007), refer to the Appendix for details

Looking at the table above, we find that BW is not only leading in 1991 but also increases its effort in capital inputs -R&D expenditure and human capital inputs- R&D staff in absolute terms and in relative terms to NW and SH. In the case of business R&D expenditure to GDP the gap widens between BW and NW from roughly two to more than three. Relative to SH, BW increases its R&D efforts from about 4 times as much in 1991 to about 6,5 times as much in 2005. In the case of NW to SH we find less movement and NW remains spending about twice as much relative to its GDP in R&D and having about twice as much R&D staff relative to total employment than SW in 1991 and 2005. In the case of BW to NW and BW to SH the pattern for the R&D staff follows that of R&D expenditure.
The second part of the table compares human capital inputs according to the innovation and knowledge-intensity of their sector of employment. We find convergence for the industry sector of BW and NW. In BW the fraction of the highly innovative to low-innovative employees in industry in 1995 relative to NW increased from 1.7 to about 2 in 2005. The gap is also increased relative to SH, although SH manages to show a more favourable development in this measure than NW. For the ratio of employees in knowledge-intensive to non-knowledge-intensive services we find convergence between BW and NW and nearly no change between BW and SH. NW increases the gap in this measure to SH.

Following these figures, we conclude that BW engages by far more in R&D than NW and SH and diverges away from both other regions. The sectoral analysis suggests that BW has a particular advantage in innovative industry over NW and SH, whereas SH has an advantage in innovative industry over NW. NW, in contrast has an advantage in knowledge-intensive services over SH and is on the way to converge to BW. The gap between BW and SH in the services sector remains steady, on a remarkable level of about 20%.

This section has shown that BW is endowed with greater wealth and blessed with lower unemployment than NW and SH. Divergence in wealth[23] is only slightly due to higher employment input through higher labour force participation. The predominant difference is, however, the higher labour productivity which stems from a considerable effort in innovation and a distinct advantage in highly innovative industries.

We now have the necessary background to turn to the regional labour market model.

5. Regional labour market model

5.1 Framework, modelling strategy and philosophy

The pursued modelling strategy tries to fill the gap between traditional regional models and supply-side and economic dynamic issues. The model is specified with an Error Correction Mechanism (ECM) and has the form of a simultaneous equations model. This enables to capture dynamic issues while also incorporating long-term relationships. The increasing relevance of innovation leads us to incorporate aspects of innovation in the modelling strategy. The aim of the modelling strategy is to confront labour markets of regions with a single model specification. Furthermore, applying the same modelling framework to different regions allows confronting reaction patterns to simulated shocks in the next chapter.
We set up a labour market model and apply it to Baden-Württemberg (NUTS 1 level)[24], North-Rhine-Westphalia and Schleswig-Holstein.[25]

The majority of literature on economic performance of regions in Germany has mainly focused on convergence issues rather than on **modelling strategies** of labour market models.[26] Besides the differences in the level of wealth, fore and foremost the difference in unemployment rates between Eastern and Western as well as Northern and Southern German regions dominates the political discussions and the majority of economic literature on German regional economic performance since 1990. In addition, labour market studies are mainly based on individual (individuals or firms) or on national data (see Heckman, 2003) for EU wide comparisons while

[23] Reasons for the slow pace of convergence according to Taylor (2005) are the following: First, barriers to labour mobility within the same country complicate the adjustment of income. Second, firms have been reluctant to relocate from high-wage to low-wage regions. The decisive factor seems to be unit labour cost and not the mere wage. Third, the more knowledge-intensive goods and services are produced, the more the speed advantage of knowledge-rich regions to generate new products and new processes becomes important. The speed advantage of the more fortunate regions mainly stems from a higher qualified workforce. Badinger & Tondl (2003) find that regional growth disparities are positively correlated with regional disparities in the proportion of high-skill workers. Fourth, once a region is experiencing high growth rates, specialist subsidiary activities may allocate which increases the economies of scale. Fifth, the start-up rate and activity of entrepreneurs is lower in low-income regions as there capital may be less available, the cost of seed capital may be higher and local demand may be lower. All these factors are explanations why divergence rather than convergence may be observed.
[24] At the NUTS 1 level spatial effects offset each other and thus are negligible. Hence we there is no need to incorporate spatial econometrics in the model framework.
[25] We confine ourselves to Western German Länder as data availability for Eastern Germany before 1990 is very limited.
[26] We acknowledge the importance of the discussion about convergence or divergence among regions by the previous chapter.

only few studies have used regionally aggregated data. Among these, Rau and Werner (2005) is a good example. They use a shift-share regression approach on a NUTS 3 regional level to highlight regional inequalities in the Western German labour market and inequalities within Western German states (Länder) from 1993 to 2001. However, their focus is on employment growth rather than on modelling the demand and supply side of labour. Models incorporating labour demand and supply are Modigliani, Padoa Schioppa & Rossi (1986). In their modelling strategies, however, they take labour supply as exogenous. As a consequence these models are not able to capture distortions induced by an exogenous change in the labour force. Baussola (2007) offers a solution to this issue by modelling both demand and supply of labour endogenously. We shall consider this specification as starting point. We extend his specification to incorporate innovation aspects and the matching mechanism.

Besides the explained strategy we adopt a **philosophy** for the labour market model and limit ourselves to modelling the labour market without modelling the goods and financial markets. Furthermore, we use a top-down rather than a bottom-up approach for modelling.[27] A comparative analysis of the responses to supply and demand shocks is only feasible when adopting a top-down rather than a bottom-up approach. The top-down approach implies that characteristics of regional economies are reflected only by differences in their respective parameters and not by different model specifications. We know about this limitation but the bottom up approach would require different model specifications which would limit the possibility of comparing responses to shocks of diverse units of analysis.

5.2 Methodology of the labour market model

We model the labour market comprising labour demand, labour supply, the matching factors and aspects of innovation.

The model captures labour demand and labour supply.[28] It shows a higher degree of detail for labour demand than in other regional models like Minford, Stoney, Riley & Webb (1994).
In detail, the equations of **labour demand** comprise two equations for employees in industry and employees in services respectively.[29] Each sector is further disaggregated into two sub sectors. All industrial firms are allocated into one of the industry sub sectors according to their effort in innovation. Those companies spending at least 3.5% of sales on research and development are clustered into the sub sector labelled “highly innovative”. Whereas those companies spending less than 3.5% of sales on research and development are clustered into the

[27] Modelling goods and financial markets together with the labour market would allow evaluating possible interactions of simultaneous political reforms (see Muenchau, 2006)). Nevertheless, we limit our model to the labour market as our central field of interest. In addition, Rhein (2006) states that Germany ranked last in a study evaluating the functioning of labour markets of 28 OECD countries. Hence, modelling the labour market seems to be the most urgent issue. Consequently, in analysing the response of regional economic systems to different supply and demand shocks we limit our analysis to the response of the labour market.
[28] Labour demand - opposed to labour supply - is the main factor in creating employment as e.g. the labour force by routes of the discouraged worker effect impacts on the participation rate and hence on labour supply. Furthermore, Kromphardt (1999) states that employment is predominantly determined by the planned production output of firms- the labour demand side. Hence we model labour demand more detailed.
[29] We take employees in agriculture as exogenous because of substantial market bias mainly caused by subsidies.

sub sector labelled "low innovative".[30] Companies in the services sector are allocated into the sub sector "knowledge-intensive" when they are classified as such according to NACE (Rev 1.1). The other companies in the services sector are clustered into the sub sector "non-knowledge intensive".[31] The exogeneity of sectoral value added, wages, prices and labour hoarding can be justified in terms of model manageability and in order to evaluate the regional response to a variety of shocks.

Labour supply is modelled by two equations capturing the participation rate and self-employment.[32] We find empirical evidence in a number of studies like De Koning et al (2004) which show that participation rate and employment rate are closely related. Economic theory explains this relationship by the discouraged worker effect. The typical neo-classical argument that labour supply depends on individual choice i.e. on opportunity costs (labour (wage)/leisure choice) is expressed by the participation rate[33] and the self-employment equation which depend on the wages in industry, services and profits of self-employment respectively.

The **matching** of labour demand and labour supply which captures the institutional setting is modelled according to Nickell (2003).[34] He states that the level of unemployment is affected by any variable which influences the ease with which unemployed individuals can be matched to available job vacancies and by any variable which tends to raise wages. Modelling the institutional setting is particularly important when the model is applied to regions of different countries having distinct institutional settings.

[30] The segregation criterion follows the classification of the economic branches (Wirtschaftszweigsystematik) in Germany (see Schumacher et al., 2003) which builds upon the widely used NACE of the European Union (Nomenclature statistique des Activités économiques dans la Communauté Européenne, Rev 1.1) which itself is based upon the ISIC (International Standard Industrial Classification of all economic activities) of the United Nations. The segregation criterion follows the classification of the economic branches (Wirtschaftszweigsystematik) in Germany (see Schumacher et al., 2003) which builds upon the widely used NACE of the European Union (Nomenclature statistique des Activités économiques dans la Communauté Européenne, Rev 1.1) which itself is based upon the ISIC (International Standard Industrial Classification of all economic activities) of the United Nations. Only taking R&D expenditure as a cluster criterion for innovation is not a holistic approach for innovation, however, according to Eurostat (2005a) among the indicators available, R & D intensity (i.e. R & D expenditure as a percentage of GDP) is the most recommended for international comparisons [of innovativeness] and is very significant for comparing countries' R & D efforts. Besides the level of R&D expenditure, as already pointed out in the innovation chapter, other factors like the development level of a national economy, the economic structure, the institutional arrangement of the innovation system, the innovation responsiveness of the general framework conditions, the openness towards new technologies, and also economic dynamics play a role in determining the innovation efficiency of a sector or national system (see RWI, 2005).

[31] As innovation in services is more subtle to measure and there is no single dominant indicator (indicators are for example: Share of employees with higher education, sales of new-to-market goods and services, share of firms that use trademarks) - like R&D expenditure for the industrial sector – we refer to the NACE definition as a classification system which considers manifold factors.

[32] Disaggregating labour supply further according to the degree of human capital could be an advancement of the current model. However, we are currently restricted by data availability.

[33] Note that the participation rate is defined as the labour force over total population; not as the labour force over working age population.

[34] We do not include the co-ordination index supposed by Nickel (2003) as for Germany it is constant over the data period.

5.3 Structure of the ECM model[35]

The structure follows an error correction mechanism, as already stated. Hence, variables are denoted in differences and are current values or one year lagged according to economic theory and their statistical significance.

LABOUR DEMAND

$$\Delta eind h_{i,t} = c_i(1) + c_i(2)*\Delta eind h_{i,t-1} + c_i(3)*\Delta r\_vaind h_{i,t-1} + c_i(4)*\Delta r\_wind h_{i,t-1} + c_i(5)*\Delta lhind h_{i,t} + c_i(6)*\Delta ltax_{i,t} + c_i(7)*eind h_{i,t-1} + c_i(8)*r\_vaind h_{i,t} + c_i(9)*r\_wind h_{i,t} + c_i(10)*uc_{i,t-1} \quad (5.1)$$

$$\Delta eind l_{i,t} = c_i(11) + c_i(12)*\Delta eind l_{i,t-1} + c_i(13)*\Delta r\_vaind l_{i,t-1} + c_i(14)*\Delta r\_wind l_{i,t-1} + c_i(15)*\Delta lhind l_{i,t} + c_i(16)*\Delta ltax_{i,t} + c_i(17)*eind l_{i,t-1} + c_i(18)*r\_vaind l_{i,t} + c_i(19)*r\_wind l_{i,t} + c_i(20)*uc_{i,t-1} \quad (5.2)$$

$$\Delta eser h_{i,t} = c_i(21) + c_i(22)*\Delta eser h_{i,t-1} + c_i(23)*\Delta r\_vaser h_{i,t} + c_i(24)*\Delta r\_wser h_{i,t-1} + c_i(25)*\Delta lhser h_{i,t} + c_i(26)*\Delta ltax_{i,t} + c_i(27)*eser h_{i,t-1} + c_i(28)*r\_vaser h_{i,t-1} + c_i(29)*r\_wser h_{i,t-1} + c_i(30)*uc_{i,t-1} + c_i(31)*dum92_{i,t} \quad (5.3)$$

$$\Delta eser l_{i,t} = c_i(32) + c_i(33)*\Delta eser l_{i,t-1} + c_i(34)*\Delta r\_vaser l_{i,t} + c_i(35)*\Delta r\_wser l_{i,t-1} + c_i(36)*\Delta lhser l_{i,t} + c_i(37)*\Delta ltax_{i,t} + c_i(38)*eser l_{i,t-1} + c_i(39)*r\_vaser l_{i,t-1} + c_i(40)*r\_wser l_{i,t-1} + c_i(41)*uc_{i,t-1} + c_i(42)*dum92_{i,t} \quad (5.4)$$

[35] Small letters denote log values, Δ denotes first difference.

LABOUR SUPPLY

$$\Delta pr_{i,t} = c_i(43) + c_i(44)*\Delta pr_{i,t-1} + c_i(45)*\Delta(se/pop)_{i,t} + c_i(46)*\Delta(e/pop)_{i,t} + c_i(47)*\Delta imig/pop_{i,t} + c_i(48)*\Delta emig/pop_{i,t} + c_i(49)*pr_{i,t-1} + c_i(50)*se/pop_{i,t-1} + c_i(51)*e/pop_{i,t-1} + c_i(52)*imig/pop_{i,t-1} + c_i(53)*emig/pop_{i,t} + c_i(54)*almp_{i,t} \quad (5.5)$$

$$\Delta se_{i,t} = c_i(55) + c_i(56)*\Delta se_{i,t-1} + c_i(57)*\Delta(profse)_{i,t} + c_i(58)*\Delta(eind/e)_{i,t} + c_i(59)*se_{i,t-1} + c_i(60)*(profse)_{i,t-1} + c_i(61)*eind/e_{i,t-1} + c_i(62)*almp_{i,t} \quad (5.6)$$

MODEL IDENTITIES:

$$E_{i,t} \equiv EIND\mathit{H}_{i,t} + EIND\mathit{L}_{i,t} + ESER\mathit{H}_{i,t} + ESER\mathit{L}_{i,t} + EAGR_{i,t} \quad (5.7)$$

$$TE_{i,t} \equiv E_{i,t} + SE_{i,t} \quad (5.8)$$

$$LF_{i,t} \equiv PR_{i,t}*POP_{i,t} \quad (5.9)$$

$$UR_{i,t} \equiv 100*(LF_{i,t}-TE_{i,t})/LF_{i,t} \quad (5.10)$$

$$PROFSE_{i,t} \equiv PROF_{i,t}/SE_{i,t} \quad (5.11)$$

LEGEND:

ALMP	active labour market policies
DUM92	1992 dummy (zero before 1992, 1 after 1992)
E	total employees
EAGR	dependent employees in agriculture
EIND(H,L)	dependent employees in industry (with R&D expenditure >=3.5% of sales/ <3.5% of sales)
ESER(H,L)	employees in services (knowledge-intensive/ non-knowledge-intensive)
EMIG	emigration out of the region
IMIG	immigration into the region
LF	labour force

LHIND(H,L)	labour hoarding in industry (measured in average hours worked per year)
LHSER(H,L)	labour hoarding in services (measured in average hours worked per year)
LTAX	labour taxes: payroll taxes, income taxes, consumption taxes; ancillary labour cost
PR	participation rate
PROF	nominal total profits
PROFSE	a proxy for per head profits of the self-employed
POP	population
R_	real value of the variable (nominal value divided by the deflator)
SE	self employed
TE	total employment
UC	union coverage
UR	unemployment rate
VAIND(H,L)	value added in industry at current prices (with R&D expenditure >=3.5% of sales/ <3.5% of sales)
VASER(H,L)	value added in services at current prices (knowledge-intensive/ non-knowledge-intensive)
WIND(H,L)	per capita nominal labour cost in industry (with R&D expenditure >=3.5% of sales/ <3.5% of sales)
WSER(H,L)	per capita nominal labour cost in services (knowledge-intensive/ non-knowledge-intensive)
i	index of unit (here: Baden-Württemberg / North-Rhine Westphalia / Schleswig-Holstein)
t	time index (year)

The model has six stochastic equations, and five identities. Equations one to four identify labour demand in industry and services. As previously mentioned labour demand is split into employees in innovative industries- equation (5.1) - and employees in less innovative industries- equation (5.2). Likewise employees in services are split into employees in knowledge-intensive services – equation (5.3) - and employees in other services- equation (5.4). We take employees in agriculture as exogenous because of substantive market bias.[36] **Labour demand** or employees by sector depend on real value added, real wages and hence, the specification already accounts for changes in prices by incorporating the real values of the variables. These factors follow the ingredients of a standard inverted Cobb-Douglas production function. Value added is used as a proxy for output and according to the common neoclassical profit maximisation condition, real wages are assumed to reflect labour productivity. Hence, the number of employees depends first of all on output and the main cost of production. Besides the production costs, however, the number of employees also depends on how intense labour is used over the business cycle. De Koning, J. (1989, 155) provides a plausible

[36] Also self-employment is taken as exogenous on the labour demand side for the simple reason that demand and supply in the case of the self-employed are the same and hence has not to be modelled on the demand and supply side.

definition: “Confronting strong output fluctuations, companies are in no position to adjust their labour volume instantly to the technically efficient level. Because of that, they may find themselves with an internal labour reserve at one moment, and be short of labour at another. This phenomenon is called labour hoarding." Hamermesh (1993, 205) describes labour hoarding as: "…a less than proportionate decrease of worker hours in response to a negative demand shock." We follow the proposition of Hamermesh (1993) and measure labour hoarding as average hours worked in difference terms to level the included trend.[37] Other factors influencing the matching process and hence also the demand for labour is captured by the variables labour taxes and union coverage. They are two of the factors Nickell (2003) suggests in an attempt to model the **matching process**. We divide the factors proposed by Nickell (2003) between the labour demand and labour supply side according to the most probable direction of their effect.[38]

Labour supply consists out of equations (5.5) and (5.6). Equation (5.5) is a modified version of the discouraged worker hypothesis. The essence of this hypothesis is that fluctuations in labour supply are triggered by fluctuations in labour demand. The assumed mechanism follows this route: The higher the employment level- captured by the self-employed and the employed over the population- the higher is the participation rate on the labour supply side. More precisely, a decrease in employment may discourage labour force participation, while an expanding job market will encourage workers to join the active labour force and hence increase the participation rate. The same argument can also be applied to emigrants and immigrants. An expanding job market is more likely to attract immigrants while a tight job market is more likely to increase emigration. Hence, we model emigration and immigration as a fraction of population. Like in the case of the labour demand equations we also follow Nickell (2003) and include expenditure on active labour market policies to model the **matching process**.[39] The second equation on the labour demand side, equation (5.6), models self-employment. By modelling self-employment we allow for the fact that besides participating in the labour force as employee, workers also have the opportunity to set-up their own business. The first variable to model self-employment is profits per head of the self-employed. This approach is again based on the neoclassical argument that people’s decision to set-up a company does first of all

[37] In the case of the services sector a dummy is included which captures the economic impact of the political change- West and East Germany became one state in 1990. The dummy for 1990 and 1991 has not been significant for any of the equations on the labour demand and supply side. It is argued that the political change of 1990 only impacts with a two-year time lag on the economic setup of this model. The fact that the 1992 dummy is significant for the services sector only does not come as a surprise. After the German unification emigration from Eastern to Western German regions increased considerably and most emigrants (often women) engaged in the services sector.

[38] The variables employment protection, union density and coordination of wage-bargaining proposed by Nickell (2003) are not included because of the following reasons. The variable capturing employment protection does not change from 1975 until 1993 in the case of Germany and hence does not add much information to the model and has been indeed not significant. The union density variable is very similar to the union coverage variable and has thus been excluded. The coordination of wage-bargaining is excluded as it takes a constant value for the entire data period in the case of Germany.

[39] From an analysis side of view it would be interesting to include the replacement rate as a measure for a “policy-induced reservation wage“ of the unemployed. However, the replacement rate variable is Baden-Württemberg significant only at the 15% level and in Schleswig-Holstein and North-Rhine-Westphalia insignificant.

depend on the per head profits of the self-employed. As a structural variable we include the number of employees in industry divided by total employees. This allows us to measure the marginal component of workers who eventually decide to set up an independent activity in response to adverse job market opportunities especially in the industry sector. We consider the **matching process** by including the variable expenditure on active labour market policies. [40]
The identities complement the model. It can be seen that unemployment is endogenously determined (5.10) by the interaction of labour supply (labour force (5.9)) and labour demand (total employment (5.8)). Labour supply (5.9) is simply obtained by multiplying the participation rate as determined in equation (5.5) to total population. Total labour demand (5.8) is the sum of employees in industry, services, agriculture (5.7) and the number of self-employed (5.6). Equation (5.11) provides the proxy for the equation of the self-employed by the ratio of total nominal profits to the number of self-employed.

6. Data description and estimates

6.1 Data description

The data used to apply the model to Baden-Württemberg, North-Rhine-Westphalia and Schleswig-Holstein has been collected from four major sources. The first is the Regional Accounts dataset (Volkswirtschaftliche Gesamtrechnung der Länder, VGRdL) provided by the Statistical Office of Baden-Württemberg. The second is a continuous household sample survey (Mikrozensus). It is the official representative statistics of the population and the labour market, involving 1% of all households in Germany every year provided and is provided by the National Statistical Office. The third comprises labour market data exclusively provided by the Research Institute of Occupation and Labour Market (IAB Nürnberg). The fourth is the statistic of science from the Foundation for the German science (Stifterverband für die deutsche Wissenschaft, SvdW). The data sets cover different periods. By combining and harmonizing the data it had been possible to cover a time-span with annual data from 1975 to 2005 for the majority of the data from the first three sources. Detailed data on science, like expenditure on research and development as a fraction of GDP, is only available since 1991 and sometimes only biannually. It had been a tough exercise to reconcile the data for two major reasons. First, the political change in 1990 lead to a change of the unit of reference, from West-Germany before 1990 to combined East and West- Germany after 1990. Second, the structure of Germany as a federal republic brings along that not all data is collected in the same manner on the regional and the national level. And last but not least the ambition to construct a model on a regional (NUTS[41] 1) level created further challenges as some variables are only available on a national (NUTS 0) level. This is especially true for data before 1990 and for international databases such as the REGIO dataset of the EU or OECD data. Even though we addressed

[40] The replacement rate has been excluded from the self-employment specification as it is very unlikely that self-employment response depends on the replacement rate of the unemployed. At least for Germany this is the case and hence, the replacement rate has never been significant in the SE equation in any of the three regions.
[41] NUTS=Nomenclature of Territorial Units for Statistics

more than twenty promising institutions and collected data from the abovementioned, it had not been possible to receive data for the whole time span on a NUTS 1 level for all variables. Where appropriate we imposed assumptions and rounded of the available data for the missing years.[42] The diverse methods of data collection and variable definition had also been accounted for. These sources cover the variables needed to model labour demand and supply. For the matching process we rely on data from Nickell (2006) who himself relies on data from different sources like OECD (2000), (1997), (1994), Ochel (2001), Nicoletti et al (2000) and Ebbinghaus & Visser (2000), among others.

Estimates are based on an error correction mechanism (ECM) which allows us to differentiate between long-run relationships and short-run dynamics, as previously mentioned. However, when applying an ECM to annual data over a period of 31 years, we should be aware that the short-run dynamics may not be captured very well. The short sample size also brings along that the significance of tests such as the Breusch-Godfrey LM test for serial correlation or the White LM test for heteroskedasticity is influenced.

6.2 Estimates

As data for the demonstrated model structure is available only since 1995 for Germany, we applied the model from 1975 to 2005 without discriminating between employees in high and low-innovative industries and hence modelled total employment in industry. Accordingly, we had to model employees in services as an aggregate and not split into knowledge-intensive and non-knowledge intensive branches for the same reason.[43] The labour supply-side is modelled as demonstrated.

The regression results for BW, NW and SH are as follows. In confronting the results of the regression we shall focus on BW's values as a representative of a very innovative region opposed to the values of NW- a medium innovative region- and SH- a low innovative region.

[42] Details on the data sources and the completion of data can be found in Appendix III.
[43] We attempted to estimate the demonstrated model incorporating the split between highly innovative and poorly innovative sectors for the years 1995 until 2005. However, it has not been possible as the degrees of freedom have been too many for the data period available.

Table 3: OLS estimates for Labour Demand (BW, NW, SH)

Explanatory variables	Baden-Württemberg		North-Rhine-Westphalia		Schleswig-Holstein	
Equation (5,1): $\Delta eind_t$						
$const_t$	2.990	(2,741)**	2.739	(1,788)*	0.163	(0,120)
$\Delta eind_{i,t-1}$	0.922	(5,087)***	0.788	(3,460)***	0.735	(3,323)***
$\Delta r\_vaind_{i,t-1}$	0.267	(2,727)**	0.182	(1,550)	0.006	(0,052)
$\Delta r\_wind_{i,t-1}$	-0.356	(-2,370)**	-0.105	(-0,618)	-0.157	(-0,878)
$\Delta lhind_{i,t}$	-0.048	(-0,156)	0.095	(0,251)	0.011	(0,033)
$\Delta ltax_{i,t}$	-0.311	(-1,411)	-0.276	(-1,067)	-0.109	(-0,428)
$eind_{i,t-1}$	-0.259	(-3,351)***	-0.158	(-2,036)*	0.002	(0,012)
$r\_vaind_{i,t}$	0.168	(1,908)*	0.087	(0,818)	0.225	(1,981)*
$r\_wind_{i,t}$	-0.164	(-2,044)*	-0.131	(-1,324)	-0.238	(-2,052)*
$uc_{i,t-1}$	0.137	(3,108)***	0.148	(2,057)*	0.003	(0,025)
Adjusted R^2	0.697		0.537		0.584	
F-statistic	8.140		4.615		5.369	
LM_1 [1]	-0.528	(0,031) [2]	0.032	(0,957)	-0.449	(0,286)
LM_4 [1]	-1.058	(-0,000) [2]	-0.805	(0,050) [2]	-0.748	(0,022) [2]
LM_W [1]	13.511	(0,635)	14.838	(0,537)	13.091	(0,666)
Equation (5,3): $\Delta eser_t$						
$const_t$	2.416	(3,744)***	2.109	(2,003)*	3.001	(4,685)***
$\Delta eser_{i,t-1}$	0.412	(2,551)**	0.419	(2,433)**	0.479	(3,284)***
$\Delta r\_vaser_{i,t}$	0.148	(1,668)	0.330	(2,386)**	0.281	(2,810)**
$\Delta r\_wser_{i,t-1}$	-0.070	(-0,733)	0.058	(-0,079)	0.038	(0,391)
$\Delta lhser_{i,t}$	0.663	(2,582)**	-0.016	(0,540)	0.218	(2,344)**
$\Delta ltax_{i,t}$	0.220	(1,917)*	0.175	(1,273)	0.117	(1,006)
$eser_{i,t-1}$	-0.319	(-3,054)***	-0.280	(-1,866)*	-0.504	(-4,868)***
$r\_vaser_{i,t-1}$	0.356	(5,068)***	0.395	(2,740)**	0.243	(3,437)***
$r\_wser_{i,t-1}$	-0.257	(-3,109)***	-0.294	(-1,589)	-0.079	(-1,015)
$uc_{i,t-1}$	-0.084	(-2,728)**	-0.145	(-2,760)**	-0.042	(-1,611)
$dum92_t$	-0.015	(-2,122)**	0.001	(0,108)	-0.019	(-2,934)***
Adjusted R^2	0.687		0.664		0.733	
F-statistic	7.135		6.530		8.673	
LM_1 [1]	-0.285	(0,393)	-0.537	(0,171)	-0.405	(0,242)
LM_4 [1]	-0.301	(0,300)	-0.026	(0,940)	-0.561	(0,066) [2]
LM_W [1]	9.945	(0,934)	21.757	(0,243)	17.122	(0,515)

absolute value of the t-statistics in brackets; * 10% significant, ** 5% significant; *** 1% significant

[1] Lagrange multiplier test (Breusch-Godfrey test) for first- and forth-order autocorrelation (small sample version) and the White test for heteroskedasticity, with the associated *p* -values

[2] The Lagrange multiplier test (Breusch-Godfrey test) does indicate serial correlation in these cases, However, the correlogramms indicate that no significant (or negligible) serial corelation exists, The results are likely to be influenced by the small size of the sample.

Labour demand

Labour demand in **industry** in BW is much more affected by short-run dynamics than NW and SH. Indeed, besides the changes of employees which is significant in all three regions, in BW also in the short-run real value-added (0.27) and real wages (-0.36) significantly impact on labour demand in industry. This reflects the highly dynamic pattern of BW's industry which is heavily export oriented[44] and hence, has to be able to react instantly to short-run changes in regional and international demand (value added) and changes in the level of wages. Labour hoarding and labour taxes are in none of the regions significant- in the industry sector. It has to be kept in mind, however, that taxes and the labour hoarding variable are heavily influenced by national specification such as national labour tax rates and laws regulating working time – which are especially strict in the industry sector- so that they may not capture the regional specific properties good enough. In the long-run, we find that employees in industry in BW are less (-0.16) influenced by wages than in the short-run (-0.36) and less than SH (-0.24). Companies in BW seem to be more capable to account for an increase in wages in the long-run whereas in SH a rise in wages leads to higher pressure on employment.[45] The relative importance of unions – measured by union coverage- is expressed by the significance in BW (at the 1% level) and NW (at the 10% level) to about the same magnitude. This is not surprising as the industry sector has traditionally been very strong in North-Rhine Westphalia, is still very strong in BW[46] and unionism plays an important role in industry. In SH the union coverage variable is not significant mirroring the fact that the industry sector plays a minor role.

For the employees in **services** we find that real value added in the short-run is significant in North-Rhine Westphalia and SH showing the relative importance of the services sector in these two regions compared to BW where the variable is not significant in the short-run. The higher value of 0.33 for NW compared to SH 0.28 indicates that changes in value added lead to more employees in NW where services constitute of trading, finance, media, consulting opposed to trading and mainly tourism in SH. The labour hoarding variable is significant for BW and SH reflecting the fact that in these two regions services companies are smaller than in NW and hence do only slowly adjust the amount of labour favouring labour hoarding instead of incurring high hiring and firing cost.[47] Interestingly, labour taxes are only significant in BW. They are positively related to the employees in services because we observe many part-time employees especially in services which do not have to pay taxes.[48] An increase in labour taxes

[44] In 2007, the export rate of Baden-Württemberg was 42% or 150 Bio € compared to the export rate of 31% of the German average. The industry exports go to 60% to Europe (US 10% and Asia 18.4%) and nearly half of all Baden-Württemberg's exports are made out of automotive and machinery (Brenner, 2008, 6&7).

[45] Baden-Württemberg's industry is highly competitive and hence can more easily absorb higher wages- at least in the long-run. The competitiveness is also reflected by the innovation index of calculated by the Statistische Landesamt in which Baden-Württemberg scores first among all Eruopean NUTS 1 regions (Brenner, 2008, 8).

[46] In 2007, still 33% of employment is in the industry sector (Brenner, 2008, 11)

[47] 25 of the 50 largest trading companies of Germany are situated in North-Rhine-Westphalia (Wirtschaft NRW, 2008)

[48] Fulltime employment increased in Baden-Württemberg by 2% whereas part-time employment increased by 142% from 1980 to 2006 (Brenner, 2008, 11)

in services does thus reflect an increase in untaxed employment in services whose social security and pension costs have to be covered by those working more and hence, paying taxes. This phenomenon is much weaker in the industry sector and hence, even though insignificant, taxes are negatively related to employment in industry. In the long-run the employees in services in all regions significantly depend on real value added in services. This is strongest in NW with 0.39, followed by BW with 0.36 and SH with 0.24. We have to keep in mind, however, that the figures in services may underestimate effects, as employees in an industry company may well work in services such as financing, logistics or staff but not being classified as employees in services. The wages are only significant in BW in the long-run reflecting the fact that likewise industry, also services in BW are strongly export oriented- like software and IT or logistics- and hence experience high wage pressure. A negative significant impact for union coverage on employees in services can be found in BW also mild -0.08 and NW somewhat stronger -0.15. The stronger impact in NW may again reflect the sectoral composition where the services sector depends on more traditional services like trading, as already mentioned. The 1992 dummy, to capture the influence of the political change and the following increase in market size and competition, is significant in BW and SH which have been much stronger affected due to their export orientation for the former and to their disadvantageous competitiveness – relatively strong agriculture and not so competitive industry and services sectors for the latter.

The analysis of labour demand has shown that BW is more cyclical than NW and SH and that it depends more heavily on output especially in industry. Furthermore we extract that wages do have a strongly negative impact in industry especially in the short run. BW is also more influenced by unionism than NW and SH. We note that labour taxes have a diverse effect on employment in industry and services even though they are only significant in services and for BW.

Table 4: OLS estimates for Labour Supply (BW, NW, SH)

Explanatory variables	Baden-Württemberg		North-Rhine-Westphalia		Schleswig-Holstein	
Equation (5,5): Δpr_t						
$const_t$	-0.529	(-2,410)**	-0.122	(-0,701)	-0.052	(-0,266)
$\Delta pr_{i,t-1}$	-0.027	(-0,175)	-0.385	(-1,668)	-0.727	(-5,643)***
$\Delta(se/pop)_{i,t}$	0.096	(1,189)	0.164	(1,532)	0.073	(1,089)
$\Delta(e/pop)_{i,t}$	0.380	(3,313)***	0.422	(3,425)***	0.149	(1,687)
$\Delta imig/pop_{i,t}$	-0.028	(-2,401)**	-0.009	(-0,691)	-0.002	(-0,103)
$\Delta emig/pop_{i,t}$	0.042	(2,117)**	0.011	(0,518)	-0.061	(-4,112)***
$pr_{i,t-1}$	-0.389	(-2,702)**	-0.064	(-0,720)	-0.109	(-1,763)*
$se/pop_{i,t-1}$	-0.069	(-1,381)	-0.063	(-1,327)	-0.095	(-1,731)
$e/pop_{i,t-1}$	0.203	(1,682)	0.180	(1,652)	0.238	(2,739)**
$imig/pop_{i,t-1}$	-0.027	(-2,297)**	-0.030	(-3,199)***	-0.068	(-3,166)***
$emig/pop_{i,t-1}$	-0.037	(-1,512)	0.018	(0,706)	0.082	(4,064)***
$almp_{i,t}$	0.030	(1,215)	-0.025	(-1,828)*	-0.085	(-6,311)***
Adjusted R^2	0.740		0.588		0.854	
F-statistic	8.242		4.631		15.873	
LM_1 [1]	-1.144	(0,002) [2]	-0.711	(0,017) [2]	-0.884	(0,015) [2]
LM_4 [1]	-0.640	(0,027) [2]	-0.541	(0,025) [2]	-0.358	(0,441)
LM_W [1]	16.547	(0,788)	23.542	(0,372)	26.651	(0,225)
Equation (5,6): Δse_t						
$const_t$	6.726	(3,211)***	13.016	(2,884)***	6.099	(2,445)**
$\Delta se_{i,t-1}$	-0.014	(-0,091)	0.599	(2,865)***	-0.020	(-0,104)
$\Delta(profse)_{i,t}$	-0.079	(-1,557)	-0.063	(-0,854)	-0.106	(-1,002)
$\Delta(eind/e)_{i,t}$	0.138	(0,473)	0.050	(0,175)	0.092	(0,373)
$se_{i,t-1}$	-0.474	(-3,533)***	-0.808	(-2,984)***	-0.473	(-2,915)***
$profse_{i,t-1}$	-0.068	(-1,507)	-0.227	(-2,409)**	-0.070	(-1,023)
$eind/e_{i,t-1}$	-0.348	(-2,726)**	-0.506	(-3,027)***	-0.242	(-2,426)**
$almp_{i,t}$	0.032	(1,133)	0.113	(2,023)*	0.054	(1,042)
Adjusted R^2	0.632		0.560		0.508	
F-statistic	7.875		6.082		5.131	
LM_1 [1]	1.194	(0,090) [2]	-0.092	(0,846)	-1.295	(0,045) [2]
LM_4 [1]	0.467	(0,121)	-0.332	(0,164)	-0.144	(0,565)
LM_W [1]	10.220	(0,676)	7.994	(0,844)	15.181	(0,296)

absolute value of the t-statistics in brackets; * 10% significant, ** 5% significant; *** 1% significant

[1] Lagrange multiplier test (Breusch-Godfrey test) for first- and forth-order autocorrelation (small sample version) and the White test for heteroskedasticity, with the associated *p* -values

[2] The Lagrange multiplier test (Breusch-Godfrey test) does indicate serial correlation in these cases, However, the correlogramms indicate that no significant (or negligible) serial corelation exists, The results are likely to be influenced by the small sample period.

Labour Supply

Labour supply is described by participation rate and the self-employment equation. In total we find more significant variables in the short-run in BW than in the other two regions indicating its highly dynamic structure. In the regions of NW and especially in SH labour supply is mainly driven by long-run processes. The only significant short-run variable in the **participation rate** equation is the employment rate in the case of NW. Its value of 0.42 opposed to 0.38 for BW indicates a slightly stronger discouragement effect in NW. The discouragement effect in SH is strong in the long-run expressed in a significant and high value of the employment rate (0.23). Besides this variable, the emigration and immigration rates are often significant; however their impact is of a low magnitude. The immigration rate in the short-run is only significant in the case of BW. Its negative impact on the participation rate suggests that people who immigrate do not automatically participate in the labour market. They include religious or political refugees who often only posses a very limited working allowance if any. Emigration is negatively related to the participation rate in SH indicating that people who emigrate out of SH are likely to have had a job in SH. An opposite effect is observed in BW, where the emigration rate is negatively related to the participation rate in the short-run. This indicates that people emigrate out of BW who did not have a job before such as students, pensioners or former refugees.[49] In the long-run immigration has a mild negative and significant impact in all of the three regions. This is a sign that people that immigrate do often not participate in the work force because of an unfavourable job-market opportunities for their skills or because German labour market legislation restricts them from participating in the labour market. Opposed to the short-run, emigration has a positive effect in the long-run in SH. The case of active labour market policy is very interesting as it is in NW and SH significant and – even though mild- negatively related to the participation rate. This suggests that spending more in promoting the labour market has a negative effect in those two regions. In BW it has appositive impact; however, it is not significant.

Self-employment is predominantly driven by long-run impacts in all regions. Only in the case of NW we find a significant variable in the short-run, the change of self-employment in the previous year which is positively related to self-employment as a dependent variable. In the long-run we find that self-employment of all three regions is negatively related to the level of self-employment in the previous period. This somewhat surprising result can be explained first by the crowding-out effect. The early workers who become self-employed, occupy first the markets for self-employed with relatively low entry barriers. The higher the number of self-employed the more difficult it becomes for the following workers to set up their self-employment activity; they are crowded-out of the market. Second, workers do also take up self-employment activities in response to adverse job-market opportunities. This is reflected by the significant negative impact of the structural variable employees in industry relative to total

[49] It has to be noted that among the youth of Baden-Wurttemberg each third person has a migration background (Brenner, 2008, 12). Many of their grandparents who first came to work in the industry of Baden-Württemberg are now as pensioners returning to their country of origin.

employees. This variable is significant in all three regions having the highest value in NW -0.51, followed by BW -0.35 and SH -0.24. It captures the effects of workers being laid-off in industry and as a consequence decide to engage in self-employment. The effect is strongest in NW where the structural change hits the low-innovative industries strongest, followed by BW where even though engaged in innovative industry employment in industry is negative in the long-run. The effect is mildest in SH as its economy depends more on services and agriculture and less on industry. In the long-run also profits are significant in the case of NW even though with a negative sign. This further indicates that people become self-employed not because they might gain a bigger wage but because of adverse job-market opportunities- as reflected by the employees in industry relative to all employees variable. In NW people are further encouraged to set up a self-employment activity by training or education reflected by the significant positive impact of expenditure on active labour market policies.

The analysis of the labour supply side shows that for the participation rate BW maintains its short-run orientation, whereas self-employment is dominated by long-run influences in all regions. We note that the active labour market policy variable does not promote participation in NW and SH in the long-run and that self-employment is often a response to structural difficulties of the labour market especially in NW.[50]

7. Simulation

7.1 Model simulation

The simulation of our approach is dynamic deterministic and comprises the entire data period from 1975 until 2005. Simulation results for each of the three regions can be found in Appendix II. Besides the graphical comparison of the data and the estimated baseline variables, Theil's inequality coefficient (TIC) and the root-mean-square-error (RMSE) are displayed in order to evaluate the goodness of fit of the estimated model.[51] The fit of the model can be considered as good according to the previous measures, at least in capturing the long-run. Hence, we can use the baseline as a robust indicator when comparing reactions of regions to exogenous shocks. Following Baussola (2007, 29) we state: "It is worthwhile underlining the fact that this is a dynamic simulation, and thus it implies that forecasting errors are cumulated through time. This issue is particularly relevant in the present case, as it uses an error correction specification that needs an endogenous variable lag structure in each equation. This consideration may explain some specific results of the simulation exercise, which, although satisfactory on the whole, presents in some cases a less satisfactory performance." The

[50] Brenner (2008, 9) states that in Baden-Württemberg in 2006 only 21% of all start-ups have been start-ups where a big business potential can be expected. This supports the results from the analysis that often rather structural than economic reasons lead to the foundation of a company, even in Baden-Württemberg.

[51] The simulation was conducted over the entire period from 1975 until 2005 even though Germany experienced a considerable political change in 1990 (West and East Germany became one nation).

simulated results for the labour demand in industry and the unemployment rate have the worst fit. The lower fits of the simulation do, however, correspond to the results of the regression.

7.2 Simulation of exogenous shocks

Let us now turn to the shock description. We simulate both demand and supply shocks. A demand shock directly affects the level of activity approximated by sectoral value added. In contrast, supply shocks affect the level of relative prices and through this mechanism the level of activity. Demand shocks show up in exogenous changes in value added in the sectors under study. Finally, these changes are linked to ultimate demand. Supply shocks on the other hand are recognized by changes in the cost of labour relative to product prices. Another shock to consider is a productivity shock (TFP[52] shock) as experienced in the 1970s when Harrod-neutral technological progress[53] declined from about 5% in the 1950s and 1960s to about 2% (Blanchard, 2006)). Still other shocks are induced policy shocks like a change in labour taxes, changing union coverage or changing expenditure on active labour market policy. They can impact on the labour demand and labour supply side by affecting the matching between demand and supply.

In order to capture the impact of a change in a single variable, we only change one variable at a time by 1%. Once a change is induced, it will be held constant – in absolute terms- over the simulation period. The simulation will show how other variables will change over time triggered by the 1% change of the exogenous variable under study. We refer to the *ceteris paribus* assumption when analysing the effect of a shock. We assume that except for the changed variable all other variables remain unchanged for the simulation period. The impact of each shock will be assessed by looking at the change in the participation rate, total employment and unemployment induced by the shock.

7.2.1 Value added shocks

The positive shock in **value added** (demand shock) **in industry** increases sectoral employment and total employment. The magnitude of the response is roughly equal in NW and BW whereas it shows a slight decrease in the participation rate and total employment in SH in the short-run. In the long-run the impact on the participation rate is highest in SH confirming the strong discouraged-worker effect from the estimated labour supply equation. The slightly higher discouragement effect in NW compared to BW leads to a slightly lower decrease of the unemployment rate of the former in the short-run. For SH we observe an increase in the unemployment rate in the short-run. We have to keep in mind, however, that SH is fore and foremost driven by long-run relationships so that we should focus on long-run instead of short-run behaviour. After about eight periods the impact of the shock phases-out to zero.

The **valued added shock in services** follows roughly the same patterns as the value added shock in industry for NW and BW. The pattern of SH is different in the case of the impact on

[52] TFP= Total Factor Productivity

[53] Harrod-neutral technological progress is determined through division of the Solow residual by the labour share.

the participation rate and total employment. The impact of the value added shock for NW on the participation rate is stronger than in the case of the industry shock and its positive impact remains over the entire simulation period. The relative less dependence of employment in services on value-added for BW relative to industry is reflected by a smaller reaction to the shock. The more interesting case is SH, however, where the value added shock leads to a steady decline of the positive impact on the participation rate and to no effect on total employment. The presumably favourable impact on unemployment is offset by an increase in self-employment so that the unemployment rate follows a similar pattern like in the case of the value added shock in industry.

7.2.2 Labour cost and product price shocks

In this section we model an increase of **wages relative to product prices** by 1%. Employment effects are highest in NW in the short-run, whereas in the medium run BW seems to be able to compensate for the higher wages and shows a slightly better- even though cyclical-development. The participation rate is again more affected by the shock in North-Rhine-Westphalia than in BW in the short-run. In the long-run we observe the opposite as in the case of total employment. In contrast to the two bigger regions, SH instantly shows a strong positive reaction of the participation rate before declining linearly over the entire simulation period. The employment reaction is also different being negative over the entire period. This reflects the fact that the industry sector of SH has more difficulties to compensate for higher wages than NW and BW in the short-run and especially compared to BW in the long-run. The different reaction patterns are reflected in the unemployment graph which is very diverse. in the short-run. In the long-run, however, the shock-effects balance out so that we observe a similar vanishing effect of all three regions in the long-run.
Again, the reaction pattern in the case of services is similar to that in the industry. The most significant difference is that the reaction of SH is milder than in industry especially for the participation rate.

7.2.3 Innovation (productivity) shocks

We model an innovation or productivity shock like Baussola (2007) who approximates such a shock by an increase in **labour hoarding**. The increase in labour hoarding reflects an increase in labour productivity due to a process innovation, for example. The positive effect on employment in NW and BW can be explained by the increase in competitiveness due to more effective labour. This is not surprising as the industry of both regions is very export oriented and more effective labour leads to a cost advantage on hourly basis which increases competitiveness of the companies. In SH the picture is different. Due to the less competitive industry sector an increase in labour productivity leads to a decrease in employment. Labour supply reacts again according to the discouraged worker effect, as for the other simulated shocks. As a result, the unemployment rate of NW and BW decrease in the short-run. In the long-run, the unemployment rate of all regions approximates the prior-shock level with BW reverting fastest.

The reaction pattern in the case of a productivity shock in services is very similar to the industry case.

7.2.4 Policy shocks

In contrast to the hitherto considered shocks, the policy maker can more easily influence labour tax, union coverage and expenditure on active labour market policy. As the policy variables are included in either both labour demand or labour supply specifications we observe their impact on labour demand and supply as a whole. This is extremely important when considering the behaviour of a **labour tax shock**. For the mechanisms explained in the model chapter a labour tax shock has a positive impact on employment in the case of services and a negative impact in the industry case. What we observe from the graph is that in the short-run the positive effect on the participation rate and total employment of NW is more distinct than for BW. This indicates that NW reacts more sensitive to labour taxes. Another interesting feature is the case of SH where we observe in immediate strong increase of the participation rate, before in the long-run the effect becomes negative. And as the effect on employment is negative for the whole period, we find as a consequence a sharp increase of the unemployment rate in the short run. In NW and BW the unemployment rate first decreases before it increases in the medium run and the effect tends to zero in the long-run together with the unemployment rate of SH.
We observe the same reaction pattern in the case of an increase in **union coverage**. In detail, the reaction is slightly more intense in the case of BW and slightly less intense in the case of NW. In the long-run we observe that BW is slightly better in returning to a more favourable unemployment rate than SH and distinctly better than NW.
In general, we also observe a similar reaction pattern in the case of an increase in **expenditure on active labour market policy**. Diverse, however, is the magnitude of the reaction of the participation rate - especially in the medium and long-run. After a short increase, the participation rate of NW reverts to zero and SH's reaction leads to a value twice as negative as for the other policy shocks. The fact that SH shows the most favourable development of the unemployment rate in the long-run is remarkable.

The maximum impact of the majority of shocks for NW is reached after 2-4 periods with high amplitude, for BW after 3-5 periods with slightly lower amplitude and for SH after 0-3 periods with low amplitude. NW and BW often react similar in the short run, up to five periods after the shock, whereas SH sometimes reacts in the opposite way. After the short-run impact of the shock, NW's curve tends to flatten, whereas for BW the dynamic pattern prevails. The dynamic pattern is expressed in a cosine-curve-like reaction with a further peak in the medium run after about 11 periods. SH's reaction pattern is predominantly driven by the long-term impact such that the impact of the shock is greatest right after the shock. SH's curve often follows a linear pattern without fluctuating. Except for the increase in active labour market expenditure, BW always shows the most favourable development of its unemployment rate in the long-run. As the most innovative of the three observed regions, it clearly shows the most cyclical and dynamic reaction in the short, medium and long-run.

8. Conclusion

Motivated by different employment and unemployment rates of Western German states for the last 30 years, we proposed a regional econometric model to examine the interaction of labour demand, supply and their matching as sources of different labour market outcomes. The model endogenously determined labour demand and supply and was applied to three Western German states. We selected Baden-Württemberg as a representative of highly innovative states, North-Rhine-Westphalia as representative of an "average" German state and Schleswig-Holstein as a representative of low-innovative states. The unemployment rates of these states were determined by the participation rate and self-employment on the labour supply and by employees in industry and services on the labour demand side. Employment in agriculture was taken as exogenous.

A feature of the adopted model specification was to estimate structural characteristics of the three regions and in a second exercise to examine whether the three regions showed different reactions to exogenous shocks.

It should be noted that in the modelling specification we also included policy variables in an attempt to model the institutional framework in which the matching process of labour demand and supply takes place. The significance and impact of these policy variables was different in the regions under study and should hence, not be neglected in labour market specifications. The approach falls short, however, in modelling the labour supply side more distinct; discriminating between workers endowed with high and workers endowed with low human capital. Further restriction of data did not allow us to discriminate between employees in highly and less innovative sectors in the case of the regions under study.

The unemployment reaction of Baden-Württemberg to demand shocks is more favourable especially in the long-run than the reaction of North-Rhine-Westphalia. This is driven by the lower discouragement effects prevailing in Baden-Württemberg which is expressed by a lower reaction in the participation rate to the demand shock. Schleswig-Holstein as the least innovative region shows the highest reaction in the participation rate and the lowest in employment which indicates the highest discouragement effect of the three regions. Productivity shocks have mild effects on unemployment. From the three regions, Baden-Württemberg compensates fastest for the unfavourable impact of these shocks on unemployment. The reactions to policy shocks are diverse. In the case of labour taxes, North-Rhine-Westphalia is more affected whereas in the case of an increase in union coverage Baden-Württemberg shows the strongest reaction. SH reacts different to North-Rhine-Westphalia and Baden-Württemberg. Whereas in the bigger states the effect on the unemployment rate is favourable first, before approaching zero in the long-run, in Schleswig-Holstein the unemployment rises before also tending to zero. Increasing expenditure for active labour market policy affects the unemployment rate of Schleswig-Holstein most favourable of all

regions. The good performance comes at the cost of decreasing the participation rate, however. The most striking insight gained from the shock analysis is that the three regions have distinct reaction patterns prevailing in all shocks. Baden-Württemberg shows a very dynamic reaction which is expressed in a cosine-like shape. North-Rhine-Westphalia often shows the highest reaction of all regions in the short-run, however the curve flattens very fast which results in a hump-shaped line levelling of horizontally. Schleswig-Holstein often reacts in the opposite way than the other regions and its reaction pattern is more driven by long-run orientation. After a peak in the first four to five periods the shape often follows a linear line.

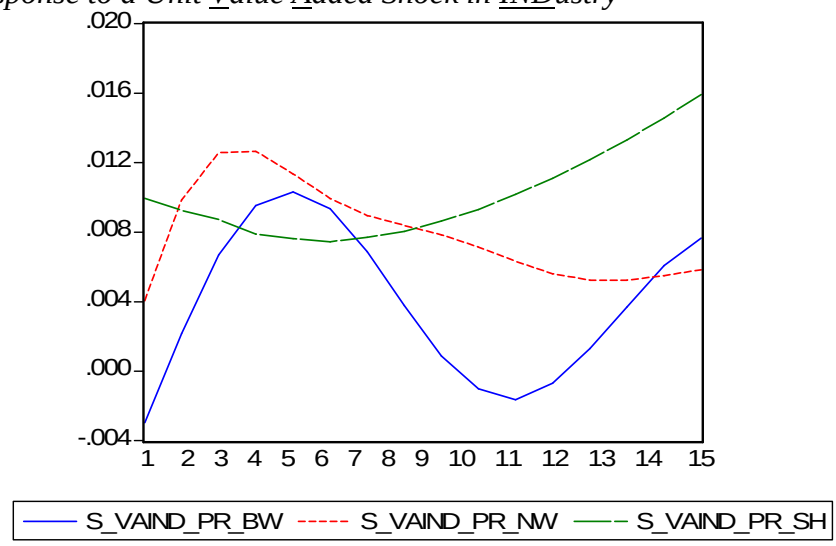
Hence, we find that regions with a high share of innovative industries and knowledge-intensive services respond differently to exogenous shocks than regions with less innovative industries and services. These findings are complemented by the fact that Baden-Württemberg has the highest advantage in highly innovative industries; North-Rhine-Westphalia seems to be on a promising way in catching up to Baden-Württemberg in knowledge-intensive services and Schleswig-Holstein shows the most promising reaction to policy initiatives - like active labour market policies - on the labour supply side.
Policy makers should thus be aware of different structural characteristics and reaction patterns in the short- medium- and long-run of regions when designing policies to foster employment.

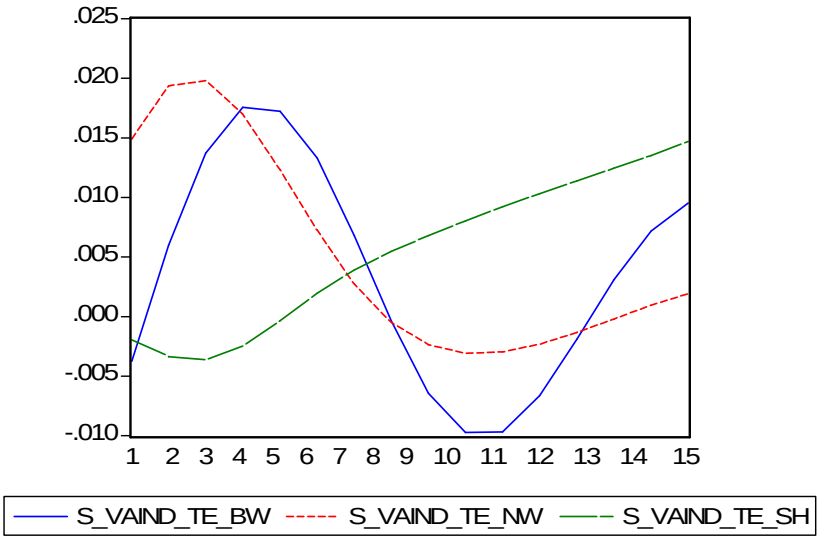
Last but not least, the model can be used for future research also on an international level. Applying the model to different European NUTS 2 regions and analysing reactions to world demand, price shocks and European policy could allow for new insights. The methodology might be further improved by applying a panel-vector-error-correction specification which seems especially appropriate when analysing a big number of regions. One could introduce a measure for sectoral concentration- like the Herfindahl index[54]- or include variables capturing start-up activities in the regions. Modelling wages endogenously and further disaggregating labour supply, as previously mentioned, could also improve the scope for findings about interactions the policy maker should be aware of.

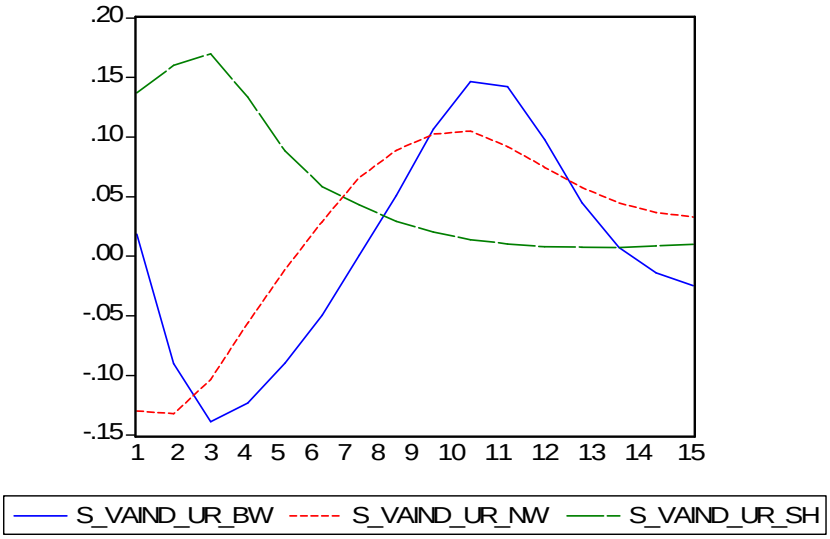
[54] See Kelly, W.A. (1981) for details.

Appendix I: Simulation of shocks

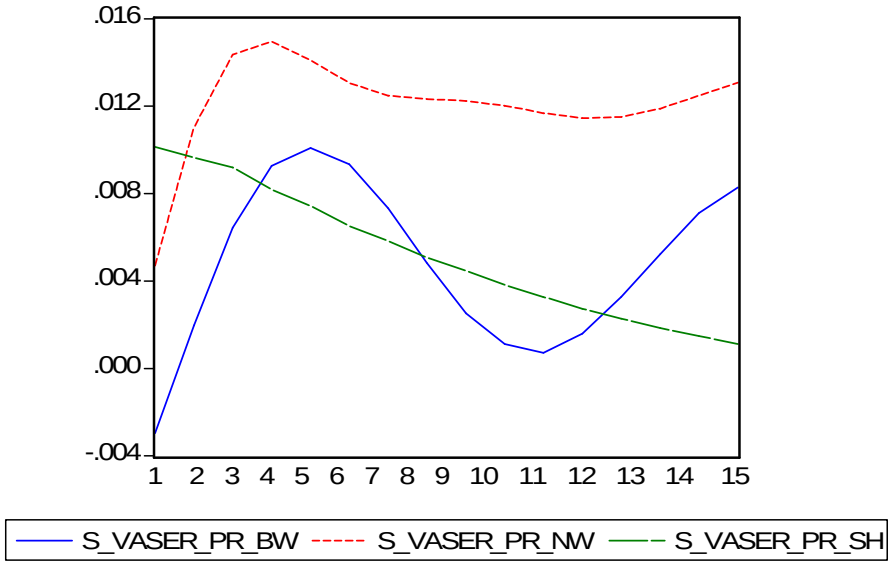
Participation Rate, Total Employment & Unemployment Rate response to a Unit Value Added Shock in INDustry

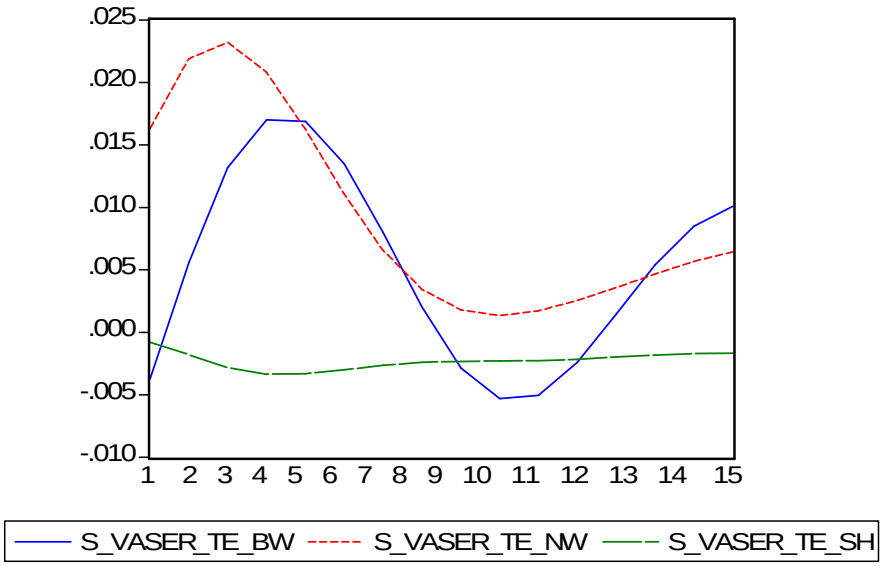


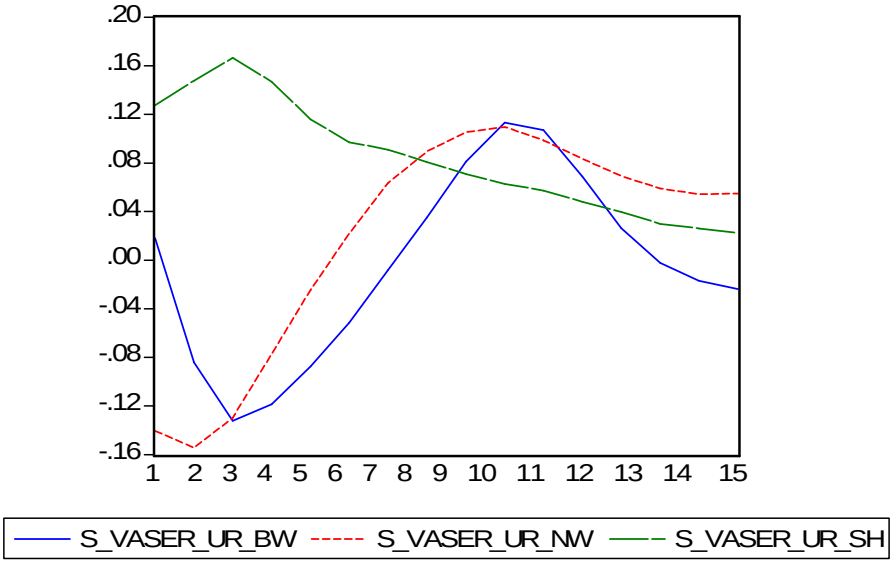




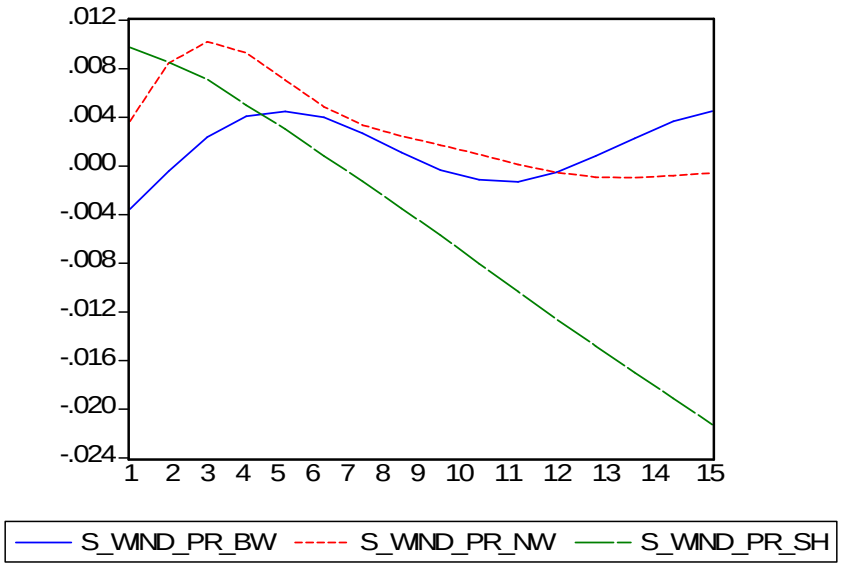
Participation Rate, Total Employment & Unemployment Rate response to a Unit Value Added Shock in SERvices

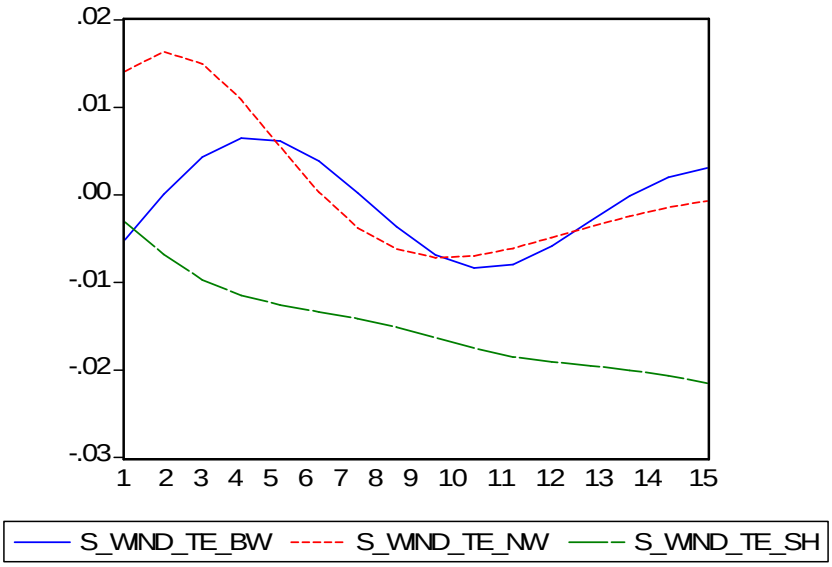


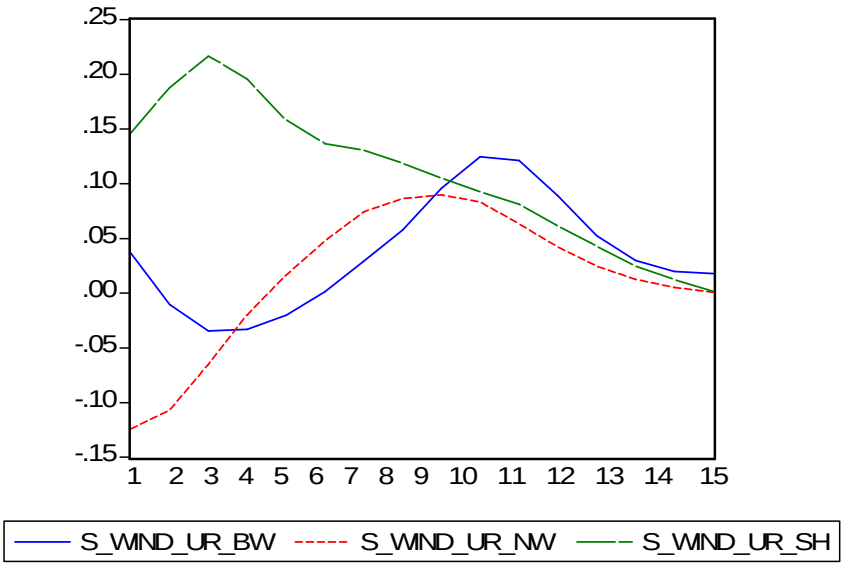




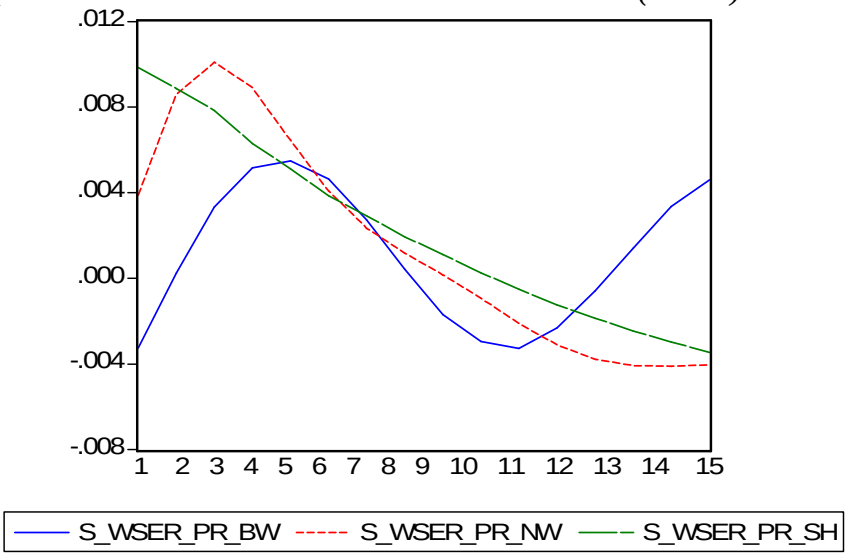
Participation Rate, Total Employment & Unemployment Rate response to a unit real labour cost shock in industry (WIND)

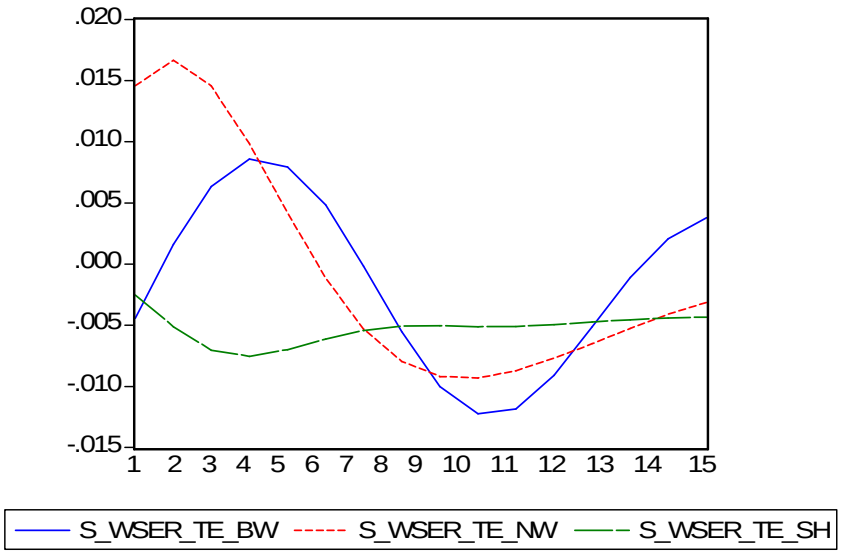


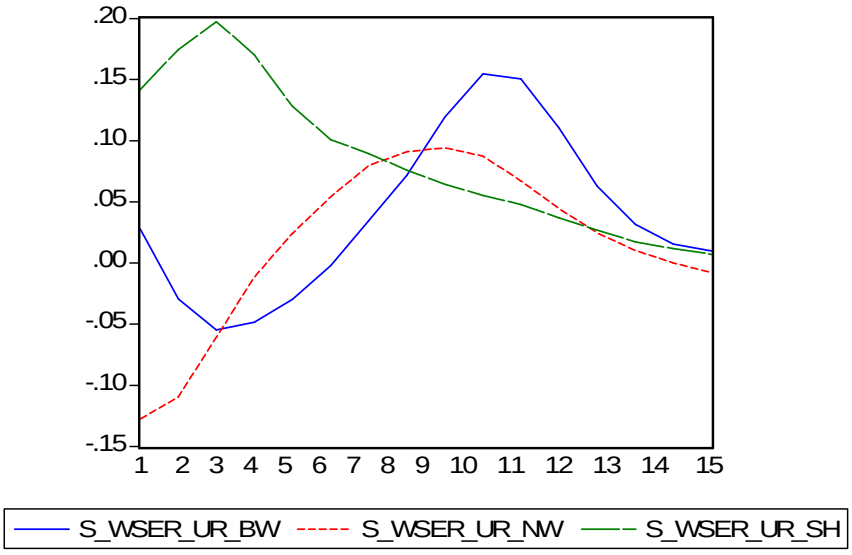




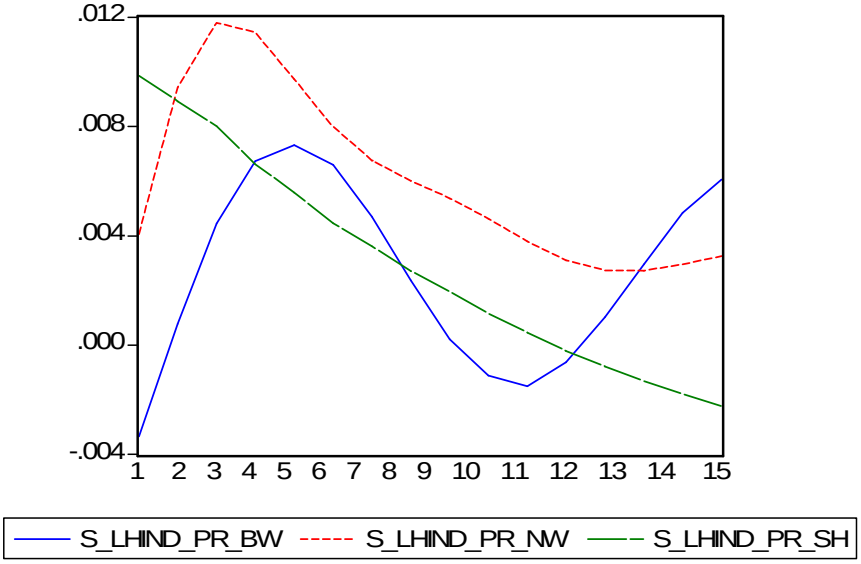
Participation Rate, Total Employment & Unemployment Rate response to a unit real labour cost shock in services (WSER)

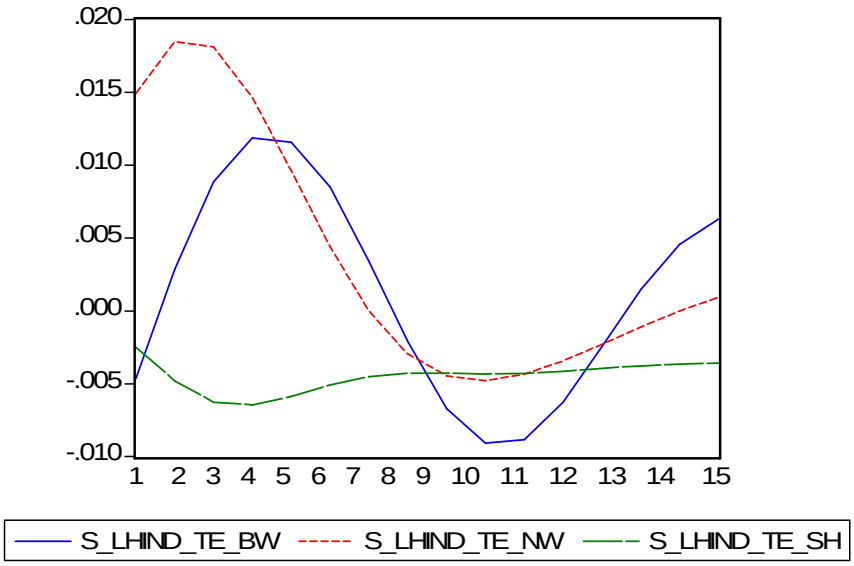


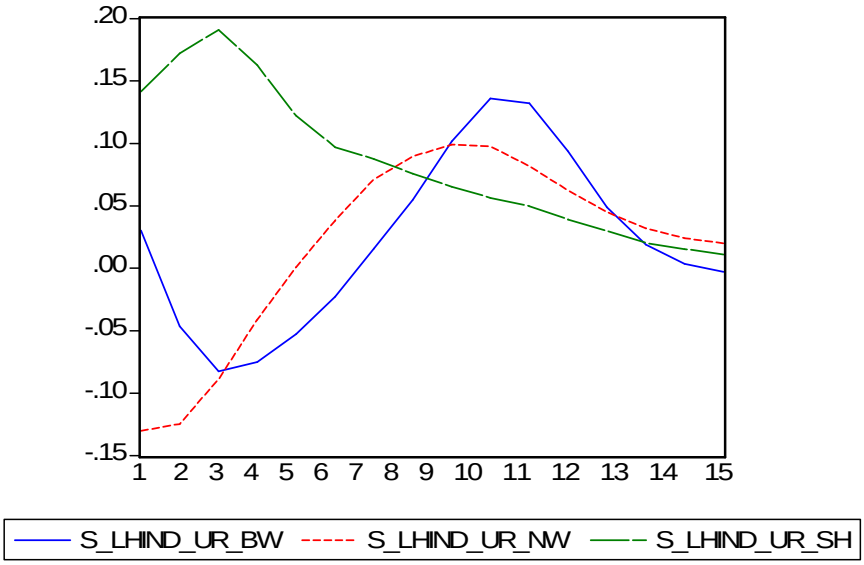




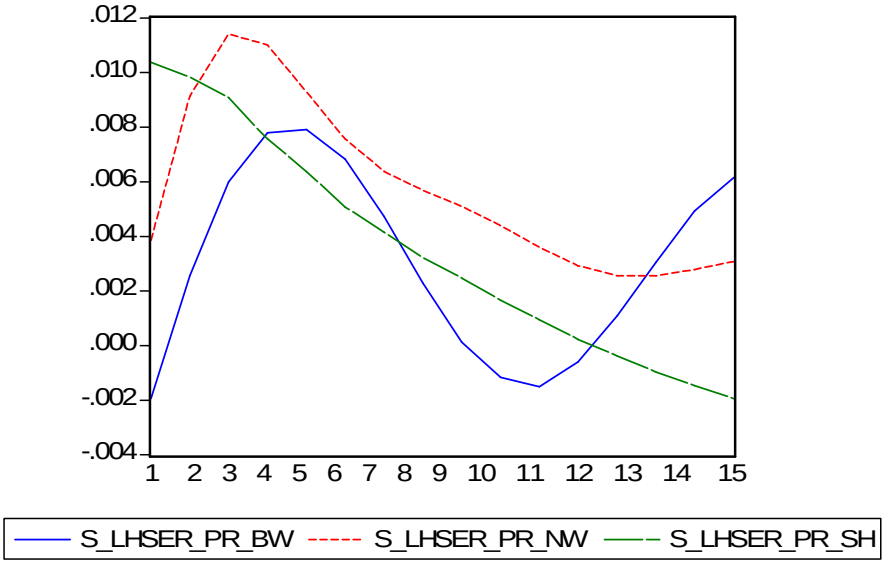
Participation Rate, Total Employment & Unemployment Rate
response to a unit innovation (productivity, labour hoarding) shock in industry (LHIND)

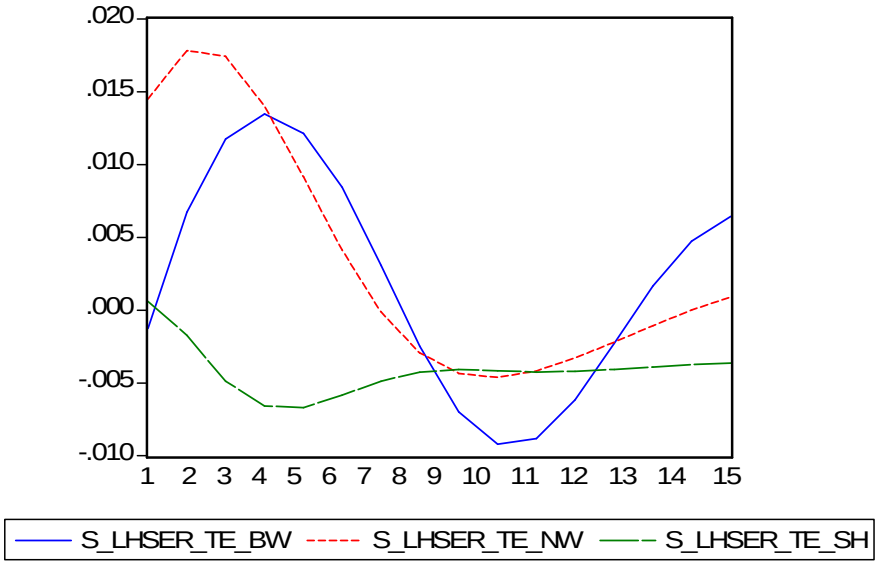


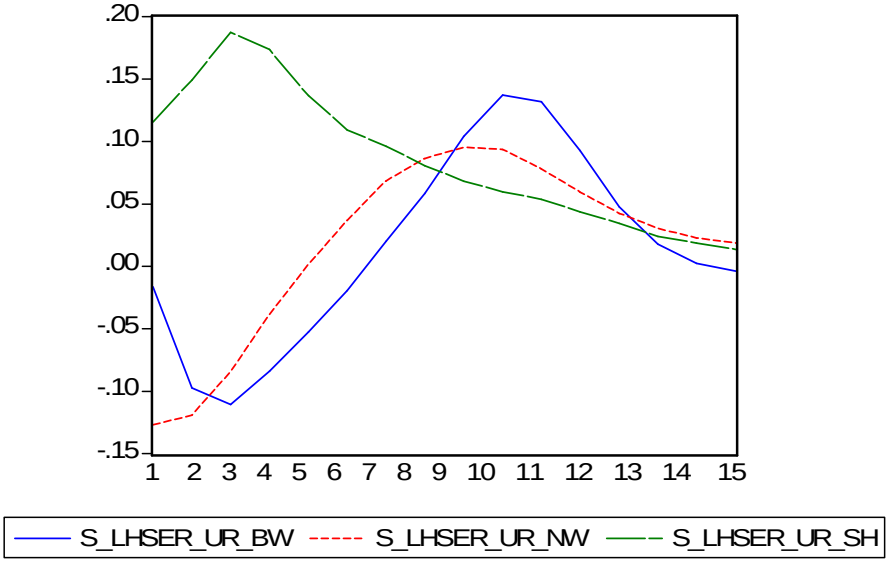




Participation Rate, Total Employment & Unemployment Rate
response to a unit innovation (productivity, labour hoarding) shock in services (LHSER)







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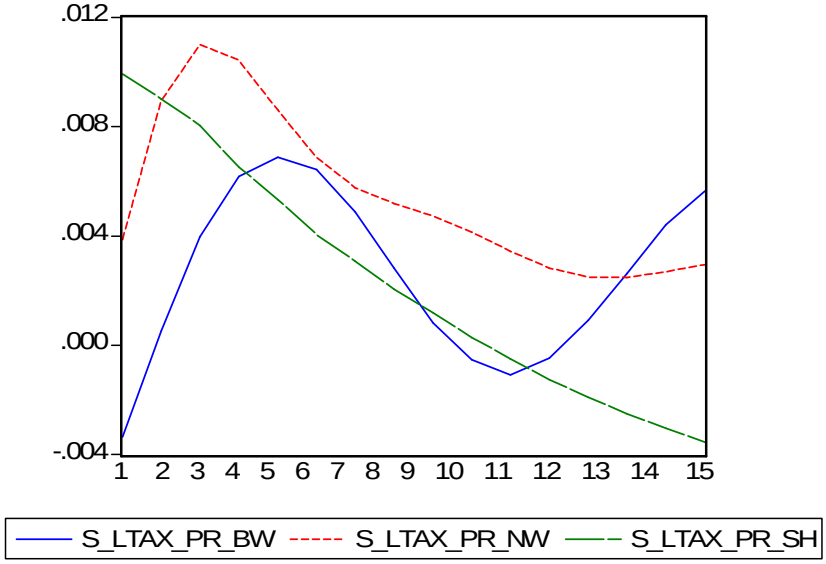
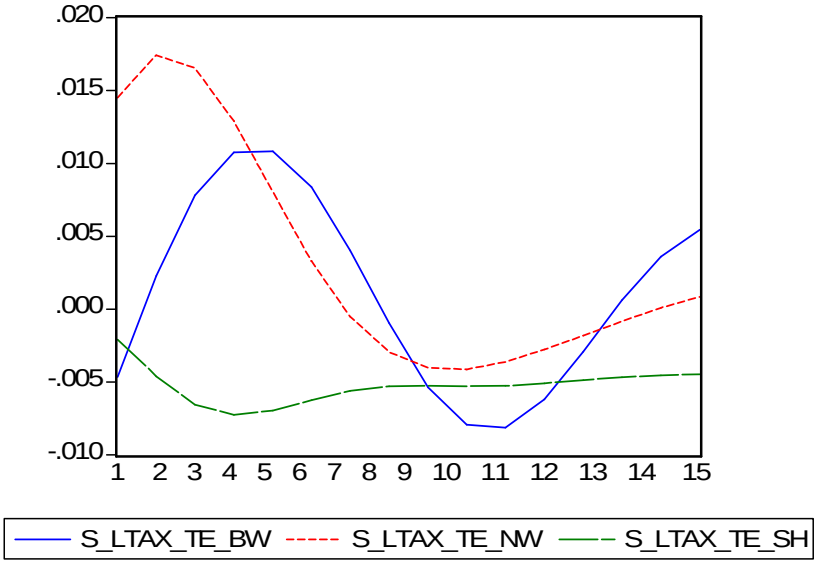
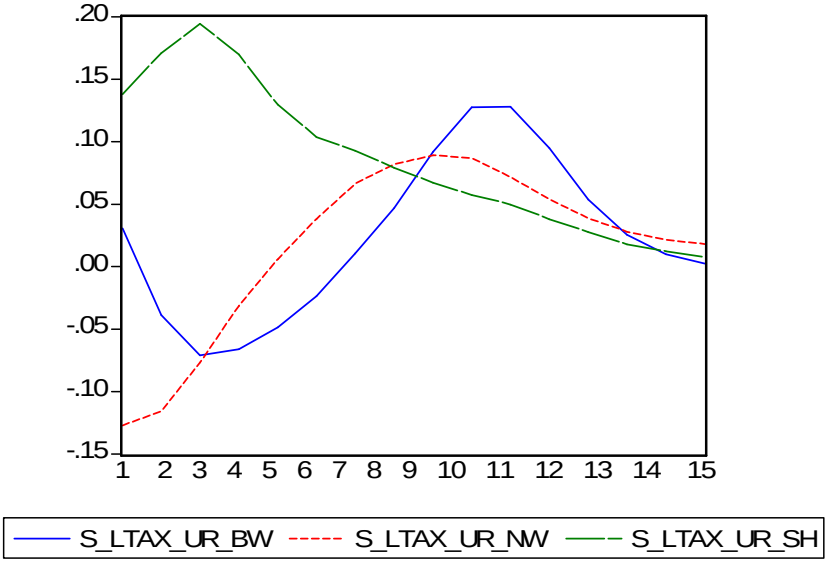
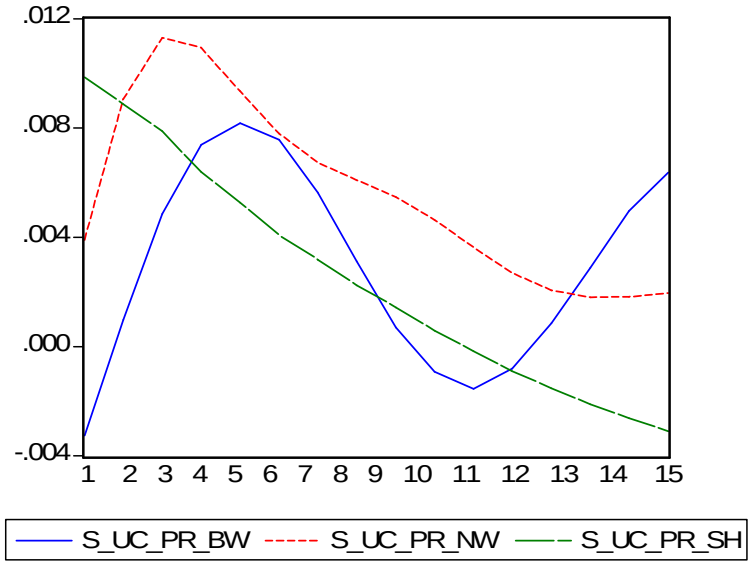
Participation Rate, Total Employment & Unemployment Rate response to a unit increase in Labour TAXxes

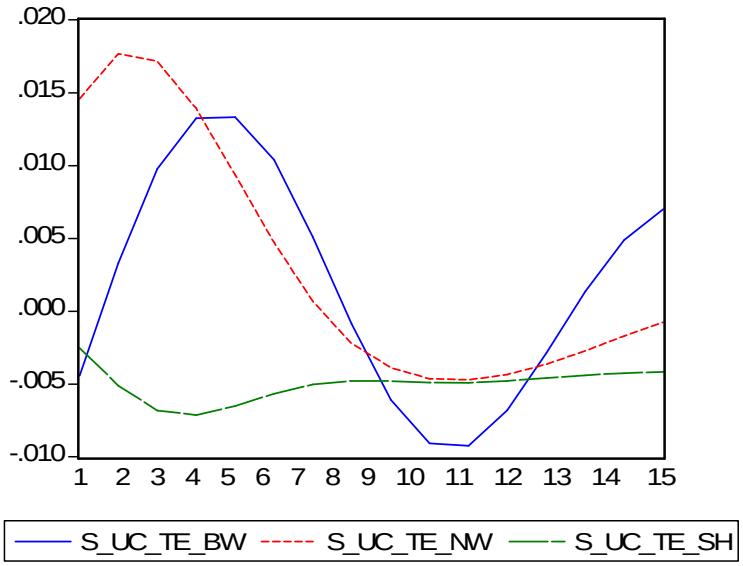


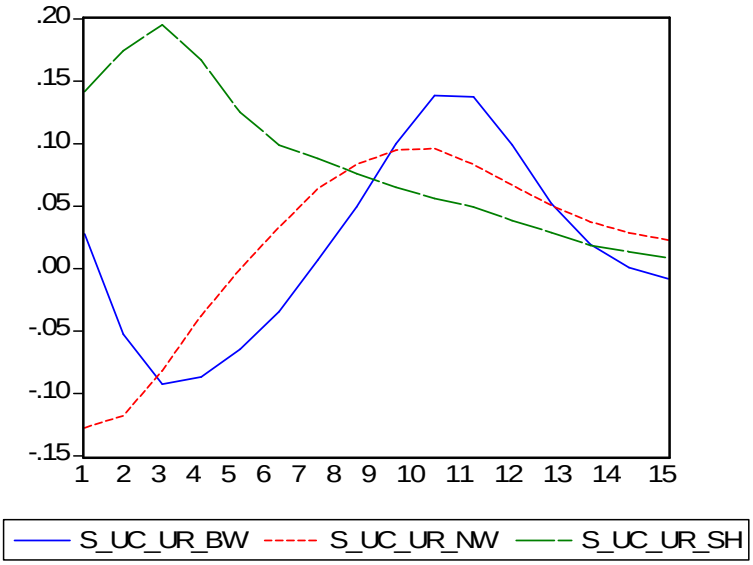




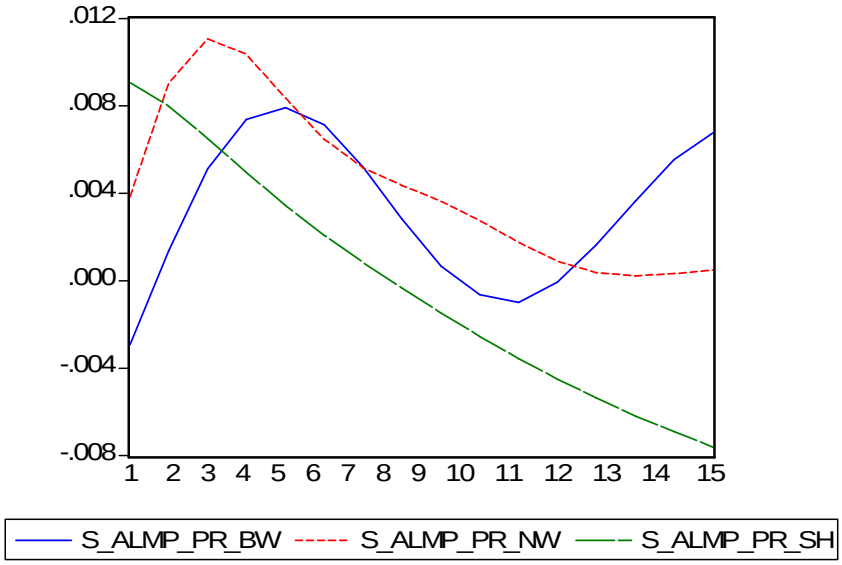
Participation Rate, Total Employment & Unemployment Rate response to a unit increase in Union Coverage

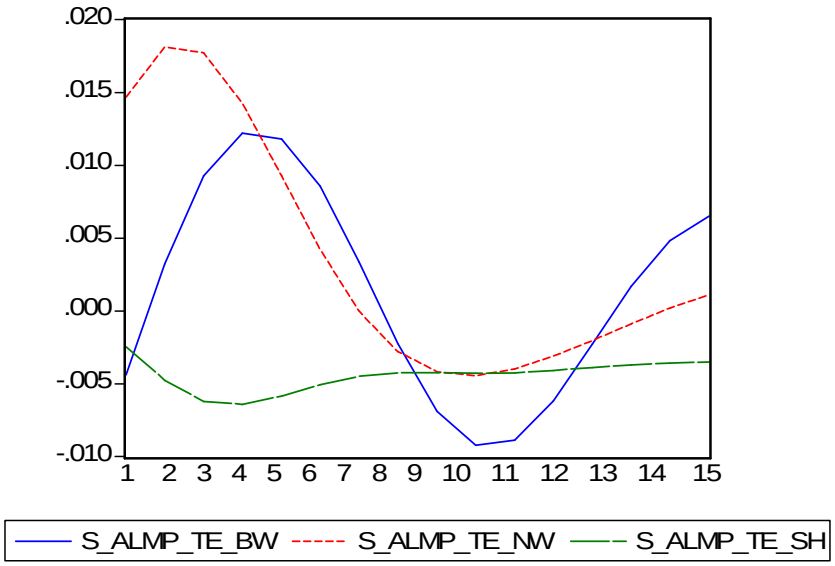


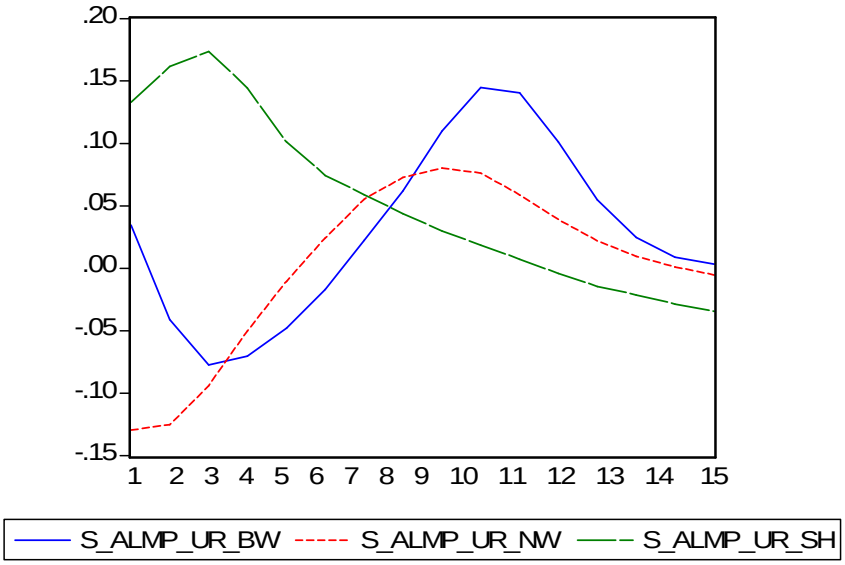




Participation Rate, Total Employment & Unemployment Rate
response to a unit increase in expenditure on Active Labour Market Policy instruments



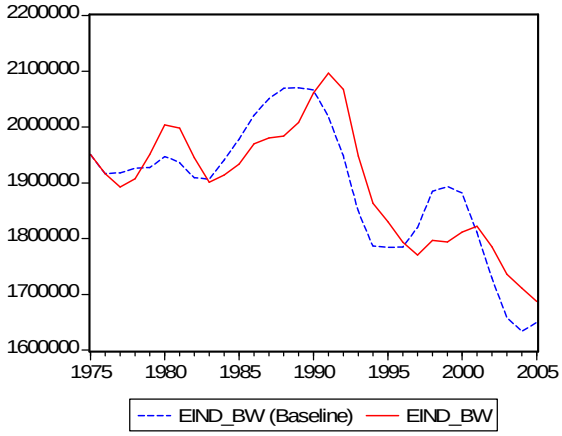


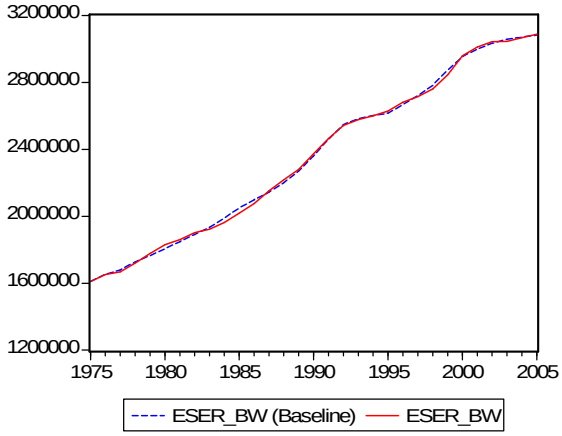


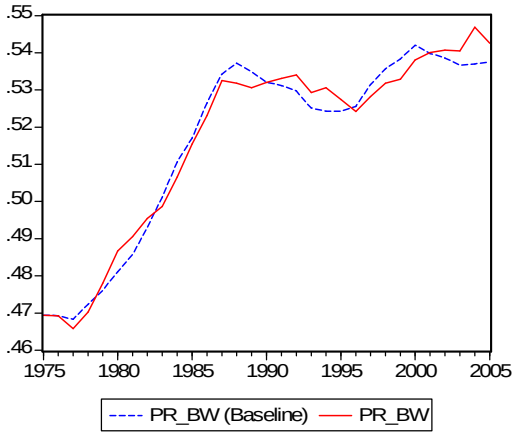
Appendix II: Model simulation

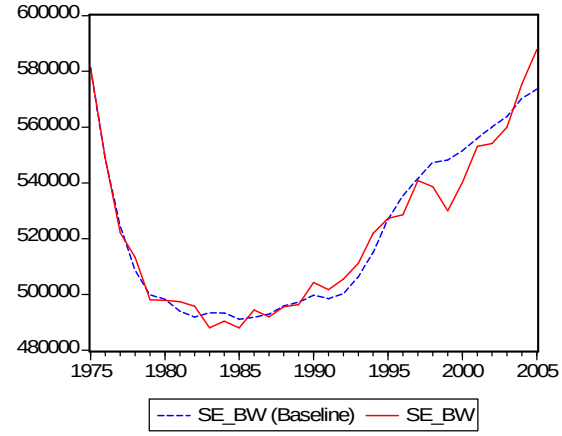
Baden-Württemberg

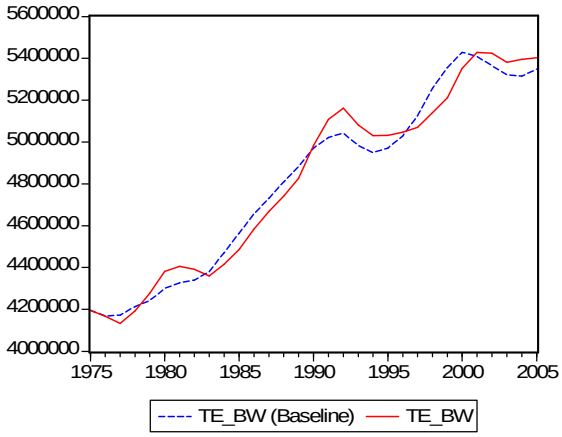
Dynamic-deterministic simulation

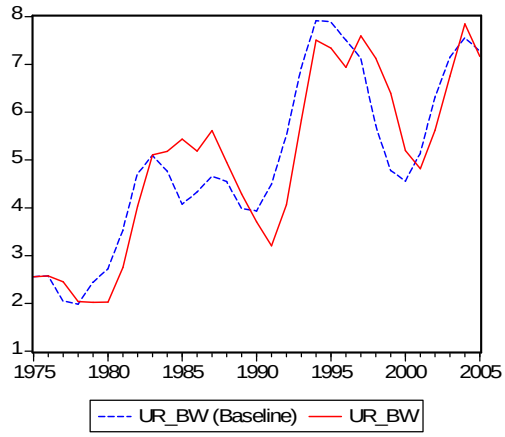








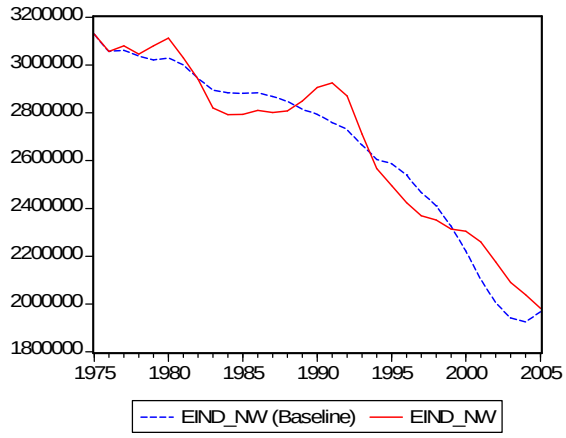


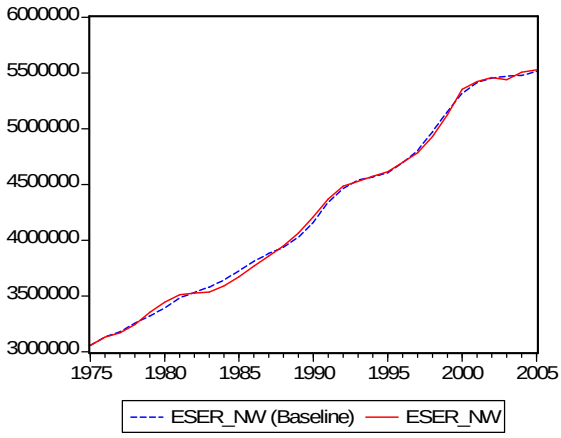


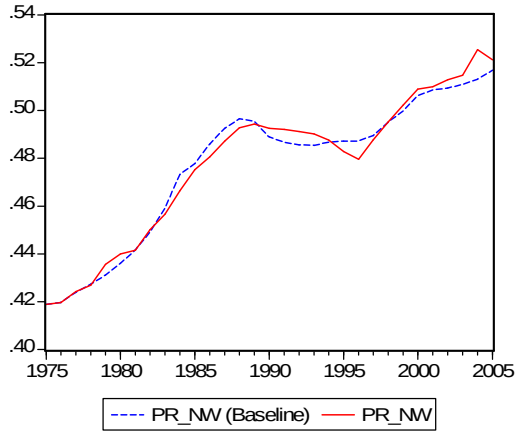
	EIND	ESER	PR	SE	TE	UR
Theil's Inequality Coefficient	0.0158	0.0030	0.0038	0.0057	0.0071	0.0715
Root Mean Square Error	61854	14770	0.004	6178.4	71433	0.7794

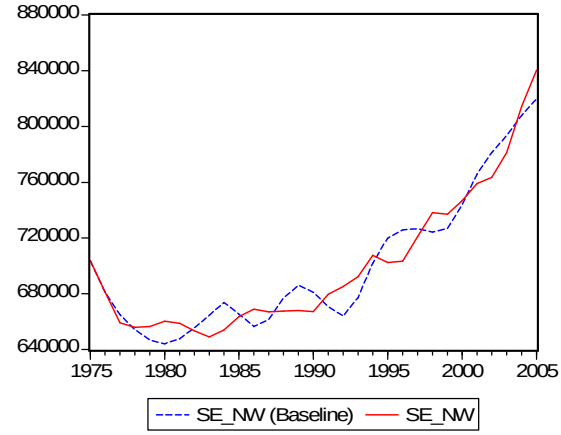
North-Rhine-Westphalia

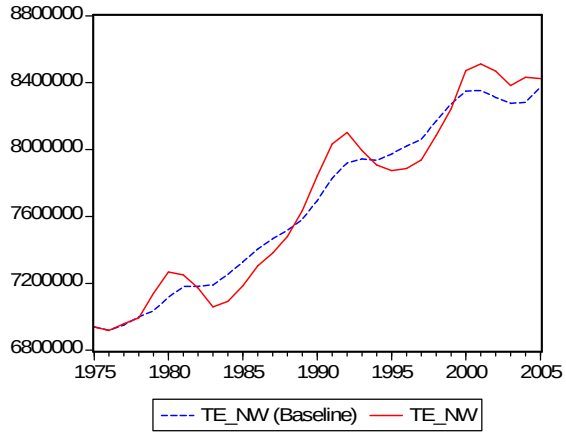
Dynamic-deterministic Simulation

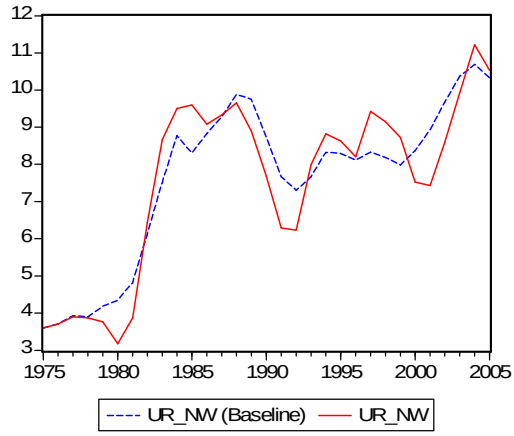








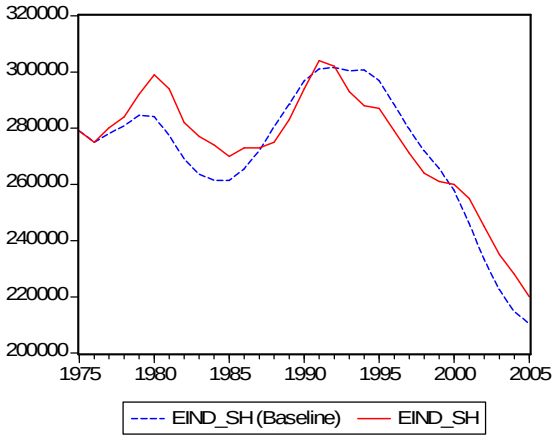


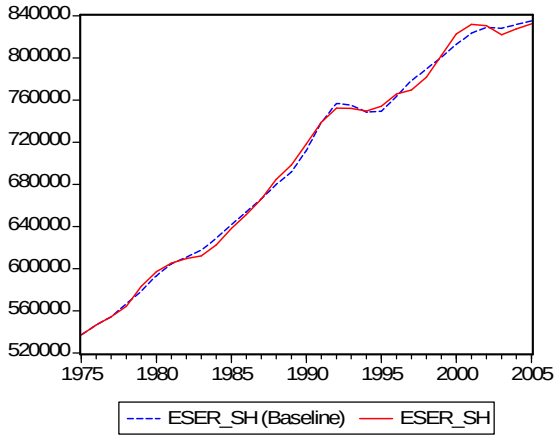


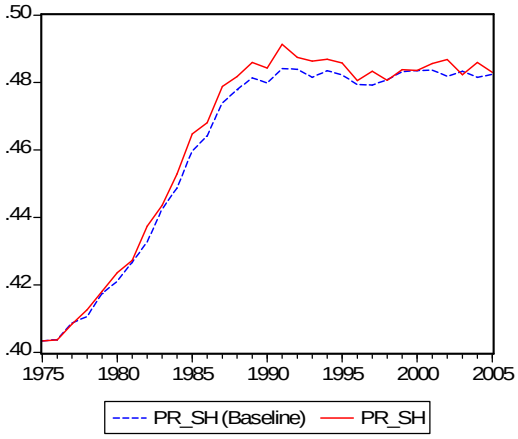
	EIND	ESER	PR	SE	TE	UR
Theil's Inequality Coefficient	0.0163	0.0034	0.0045	0.0089	0.0072	0.0494
Root Mean Square Error	90922	30186	0.0044	12976	114223	0.8067

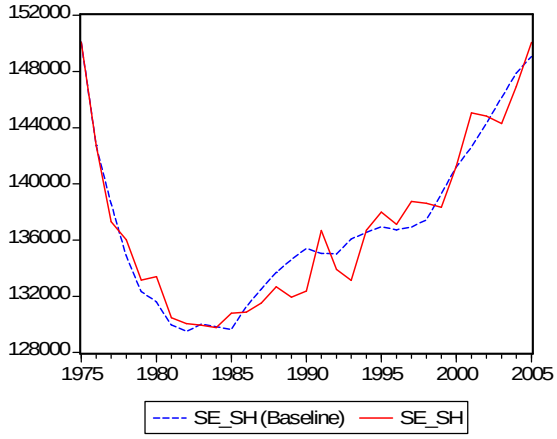
Schleswig-Holstein

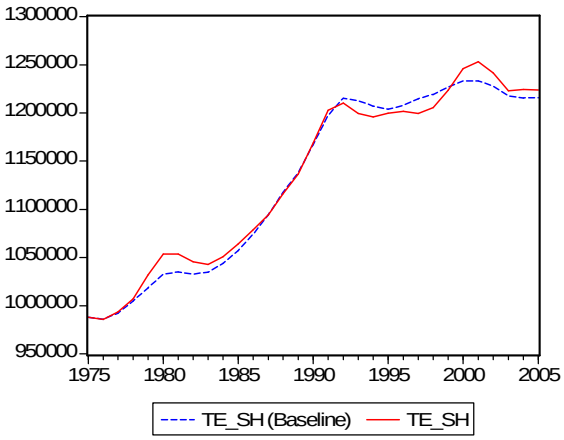
Dynamic-deterministic Simulation

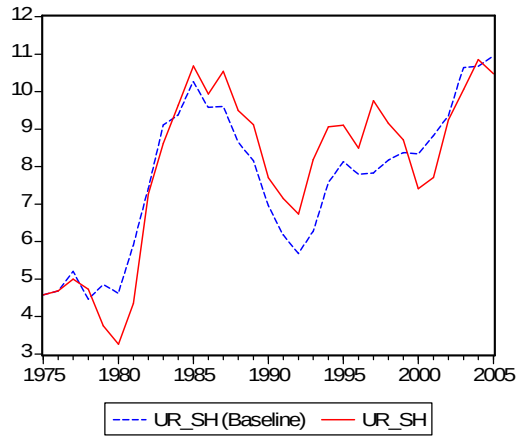












	EIND	ESER	PR	SE	TE	UR
Theil's Inequality Coefficient	0.0164	0.0033	0.0036	0.0050	0.0044	0.0569
Root Mean Square Error	9261.8	4774.4	0.0022	1420.9	10310	0.8067

Appendix III: Data sources

Variable	Variable Meaning	Data Source
ALMP	active labour market policies	NIC (2006)
CO	coordination of wage bargaining	NIC (2006)
DEFIND(H,L)	value added deflator in industry (at 1995 prices)	RA (2007)
DEFSER(H,L)	value added deflator in services (at 1995 prices)	RA (2007)
E	total employees	RA (2007)
EAGR	dependent employees in agriculture	RA (2007)
EIND(H,L)	dependent employees in industry (with R&D expenditure >=3.5% of sales/ <3.5% of sales)	SLA(2008) RA(2007)
ESER(H,L)	employees in services (knowledge-intensive/ non-knowledge-intensive)	SLA(2008) RA(2007)
EP	employment protection (comprises strictness and duration of unemployment benefits)	NIC (2006)
EMIG	emigration out of the region	SBA(2008)
IMIG	immigration into the region	SBA(2008)
LF	labour force	MIK (2008) RA(2008)
LHIND(H,L)	labour hoarding in industry (measured in average hours worked per year)	RA (2007) IAB (2008)
LHSER(H,L)	labour hoarding in services (measured in average hours worked per year)	RA (2007) IAB (2008)
LTAX	labour taxes: payroll taxes, income taxes, consumption taxes; ancillary labour cost	NIC (2006)
PR	participation rate	MIK (2008) RA(2008)
PROF	nominal total profits	RA (2007) SBA (2000)
PROFSE	a proxy for per head profits of the self-employed	RA (2007)
POP	population	RA (2007)
RR	replacement rate	NIC (2006)
SE	self employed	RA (2007)
TE	total employment	RA (2007)
UC	union coverage	NIC (2006)
UD	union density	NIC (2006)
UR	unemployment rate	MIK (2008)
VAIND(H,L)	value added in industry at current prices (with R&D expenditure >=3.5% of sales/ <3.5% of sales) (at 1995 prices)	SLA(2008) RA(2007)
VASER(H,L)	value added in services at current prices (knowledge-intensive/ non-knowledge-intensive) (at 1995 prices)	SLA(2008) RA(2007)
WIND(H,L)	per capita nominal labour cost in industry (with R&D expenditure >=3.5% of sales/ <3.5% of sales) (at 1995 prices)	SLA(2008) RA(2007)
WSER(H,L)	per capita nominal labour cost in services (knowledge-intensive/ non-knowledge-intensive) (at 1995 prices)	SLA(2008) RA(2007)
i	area index (here: Baden-Württemberg / North-Rhine Westphalia / Schleswig-Holstein)	
t	time index (year)	

Notes:	
NIC (2006)	The CEP – OECD Institutions Data Set (1960-2004) William Nickell, Centre for Economic Performance, LSE, September, 2006
RA (2007)	Regional Accounts dataset (Volkswirtschaftliche Gesamtrechnung der Länder, VGRdL) reconciled out of the following: - Rückrechnung 1970-1991, Statistisches Landesamt Baden-Württemberg, Stuttgart, 2007 - Bruttoinlandsprodukt, Bruttowertschöpfung in den Ländern und Ost-West-Großraumregionen Deutschlands 1991 bis 2006 Vorabversion zu Reihe 1, Band 1, Statistisches Landesamt Baden-Württemberg, Stuttgart, 2008 - Arbeitnehmerentgelt, Bruttolöhne und -gehälter in den Ländern und Ost-West-Großraumregionen Deutschlands 1991 bis 2006 Vorabversion zu Reihe 1, Band 2, Statistisches Landesamt Baden-Württemberg, Stuttgart, 2008 - Bruttoanlageinvestitionen in den Ländern und Ost-West-Großraumregionen Deutschlands 1991 bis 2005 Reihe 1, Band 3, Statistisches Landesamt Baden-Württemberg, Stuttgart, 2008 - Entstehung, Verteilung und Verwendung des Bruttoinlandsprodukts in den Ländern und Ost-West-Großraumregionen Deutschlands 1991 bis 2006, Statistisches Landesamt Baden-Württemberg, Stuttgart, 2007
SLA(2008)	Exclusively calculated and provided by the Statistisches Landesamt Baden-Württemberg based on regional accounts data, Stuttgart 2008
SBA(2008)	Provided by the National Statictical Office, Wiesbaden, 2008: Gesamtwanderungen nach Bundesländern, Statistisches Bundesamt, VI A, Wanderungsstatistik, Wiesbaden, 2008

MIK(2008)	Continuous household survey (Mikrozensus). It is the official representative statistics of the population and the labour market, involving 1% of all households in Germany every year provided and is provided by the National Statistical Office: Bevölkerung nach Beteiligung am Erwerbsleben und Ländern, Ergebnisse des Mikrozensus, Wiesbaden, 2008
IAB(2008)	Data is exclusively provided by the Research Institute of Occupation and Labour Market (IAB Nürnberg) and contains the following: - Working hours in six sectors from 1991-2007 (IAB-Arbeitsstunden A6_91_07), Institut für Arbeitsmarkt- und Berufsforschung (IAB) der Bundesagentur für Arbeit (BA), Nürnberg. - Working volume from 1970-1991 (AVR 70-91rev), Berechnungen des IAB (FB 4) - Employees from 1970-1991 (AVR 70rev), Berechnungen des IAB - Components of Working time from 1991-2007 (AZ Komponenten), Berechnungen des IAB
SBA (2000)	Data is obtained from the National Statistical Office (from various Statistical Yearbooks) out of the following: - Statatistisches Bundesamt (1994): Statistisches Jahrbuch 1994 für die bundesrepublik und das Ausland, Wiesbaden - Statatistisches Bundesamt (1995): Statistisches Jahrbuch 1995 für die Bundesrepublik und das Ausland, Wiesbaden - Statatistisches Bundesamt (2000): Statistisches Jahrbuch 2000 für die Bundesrepublik und das Ausland, CD-Rom, Wiesbaden

Notes on Variables	
ALMP	The measure for active labour market policy is available from 1985 until 2003 for West Germany. Values from 1975-1984 and 2004 and 2005 have been proxied by applying a moving average to the last two available years of the data. This procedure is adopted because most of the policy variables are available until 2003 only. In 2002 in Germany the national election brought about a political change and it is assumed that this policy change in 2002 impacts on the 2002, 2003 and follwoing values values. In addition, we are more interested in the most recent values as they make part of the shock excercise and hence adopt this procedure prefering to consider the most recent development at the expense of the historic development (here from 1975-1984).
CO	The measure for coordination of wage-bargaining is available from 1975 until 2000 for West Germany. Values from 2001-2005 have been proxied by applying a moving average to the last two available years of the data. The coordination index is not included in the analysis as it takes the value of "4" throughout the entire data period for Western Germany.
DEFIND DEFSER	Calculated by adjusting sectoral VA values from the change in prices and based on 1995
DEFIND(H,L) DEFSER(H,L)	For Western German regions not available, hence DEFIND and DEFSER are taken.
EP	The measure for employment protection is available from 1975 until 2003 for West Germany. Values for 2004 and 2005 have been proxied by applying a moving average to the last two available years of the data.
LF	The number of unemployed is obtained by reconciling data of the employment rate as a fraction of total labour force from the continuous household survey (Mikrozensus, MIK (2008)). In addition employment data is used from regional accounts (RA (2007).The labour force is obtained by adding the number of the unemploymed to the number of the employed. It has to be noted that the labour force values are only proxies as MIK (2008) and RA (2007) have different definitions of unemployment.
LHIND LHSER	Data is available from 1998 until 2005. The missing data is obtained as follows: Average working hours data of dependend employees from 1975 until 2005 is aggregated (NUTS 0) level. This is down by multiplying the number of workers in the respective subsector (6 in total) times the average working hours in this subsector to get the volume of work. Aggregate the values of the six subsectors corresdondingly to get total volume per three subsectors (agriculture, industry, services). Divide teh respective working volume by number of heads of the respective sector to get the average hours worked by sector per worker for West Germany (NUTS 0 level). From the regional accounts data calculate average hours worked by volume and divide by heads of dependend employees in 3 sectors on NUTS 1 level for 1998-2005. Calculate the sum of all average hours worked of Western german regions (Länder) from 1998-2005 to get simple mean. Confront this simple mean to values obtained from West Germany.Calculate the average discrepancy between these two means (note that in the IAB data West Berlin is included and values are based on "Inlandskonzept" whereas the data from the regional accounts is without West Berlin and based on the "Inländerkonzept"). To correct for these differences, deduct the average discrepancy from the West German data from 1970-1997. Values from 1975-97 are estimated by applying a moving average for 7 periods (max. time span available) for the regions. Finally, adjust the regional values to incorporate the Western German trend: Multiply each regional MA value by (simple mean of regional values / (adjusted) national value).
PR	The participation rate is obtained by dividing TE and LF.
PROF	Data on profits is available from 1980-2005. The values for 1975 until 1979 are obtained by the following procedure: Approximate primary income of households by national income (receipts from business activity and property income) for West Germany (from national accounting). Calculate the wage share by dividing primary income of households through national income for the years 1975-1980 for West Germany (from national accounting). Take the change rates of the wage share for the years 1975 to 1980 and apply them to the values from regional accounting to get the corresponding values for the years 1975-1979 West Germany, based on the regional accounting methodology. Estimate values from 1975-1979 for the Western German regions by applying the moving average procedure (7 periods, as in the case of LH). Sum the yearly values of all regions and compare to the calculated West German values. Adjust the regional values to capture the trend of the national development. Obtain the wage share of Western German regions from 1975-2005. Divide the available values for compensation of employees by the calculated wage share to abtain the primary incor subtracting the compensation of employees from the primary income of households for the Western German regions.
SE	The number of the self-employed are calculated by subtracting E from TE.
VAIND(H,L) VASER(H,L)	Data only available from 1995 until 2005.
WIND(H,L) WSER(H,L)	Data only available from 1995 until 2005.

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