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**Conference Paper**

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Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Regional Labor Markets, No. B18-V2

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Werner, Daniel (2013) : Regional convergence analysis for skill-specific employment groups, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2013: Wettbewerbspolitik und Regulierung in einer globalen Wirtschaftsordnung - Session: Regional Labor Markets, No. B18-V2, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

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# Regional convergence analysis for skill-specific employment groups

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This version: 1st March 2013

Preliminary - Please do not quote

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## **Abstract**

In most of the developed countries the number of low-skilled workers decreased and the number of high-skilled workers increased. However, it is far from clear whether and how this change in the skill composition of the employees affects the evolution of regional employment disparities. Therefore, this paper investigates the hypothesis of convergence for the total employment rate and skill-specific employment rates of West German regional planning units for the time period 1989 to 2008. This paper considers different concepts of convergence. Following the cross-sectional approach to convergence provides no evidence for a catching-up process between regions. The findings from the time series approach to convergence are mixed. The results indicate for stochastic convergence in the case of total and high-skilled employment rates whereas the hypothesis of stochastic convergence is rejected for regional low-skilled and medium-skilled employment rates.

**Keywords:** Regional Employment Disparities; Convergence; Skill-Specific Employment

**JEL-Classification:** C23; J21; R23

# 1 Introduction

Large regional disparities are a common feature of the labor market in many countries. There are countries where full employment in certain regions coexists with mass unemployment in other regions (see, for example, the comprehensive overview in OECD 2000 and OECD 2005). Furthermore, the magnitude of regional labor market disparities within countries can be as large as between countries (see, for example, Elhorst 2003).

A number of studies exists on the evolution of regional labor market disparities. These studies deal with the following questions: Do regional disparities in labor market performance widen, narrow or remain constant over time? How stable is the geographical distribution of regional labor market performance? The question of whether regional labor market disparities narrow or widen over time is related to convergence. Roughly speaking, convergence means that the differences between regions become smaller or even disappear over time.

The large body of literature investigating the hypothesis of convergence in terms of regional labor markets focuses on regional unemployment disparities. Of course, measurable (negative) correlation between regional unemployment and regional employment exists. Nevertheless, movements in regional unemployment disparities and regional employment disparities are not necessarily symmetrical (see, for example, OECD 2005). Therefore, to get a complete characterization of the evolution of regional labor market disparities it appears to be reasonable to consider unemployment as well as employment. However, there exist only a few studies which provide results on the evolution of regional employment disparities.

The evolution of employment for most developed countries is characterized by rising inequalities between different qualification groups. Employment gains occur for high-skilled workers while the number of low-skilled workers decreases. An increase in international competition promoting specialization in human-capital intensive industries (see Wood 1994, 2002), and skill-biased technological and organizational changes (see Lindbeck and Snower 1996 and Acemoglu 1998, 2002) are considered as the main sources of the change in the skill composition of employment.

The relationship between local skill composition and regional employment growth was investigated in several studies (see, for example, Glaeser et al. 1995, Simon 1998, Simon and Nardinelli 2002, Blien et al. 2006, Shapiro 2006, Südekum 2008, and Schlitte 2011). The results of these studies indicate that regions with a large share of high-skilled workers exhibit a more favorable development of employment. Moreover, Südekum (2008) points out that the change in the skill composition of the employees is more pronounced in regions which started with a relatively low share of high-skilled workers. These results indicate that the changes in the employment prospects for workers with different skill levels seem to affect regional labor markets differently. This in turn implies that the change in the skill composition of employment goes hand in hand with a change in the geographical distribution of employment. However, it is far from clear whether this change in the geographical distribution of employment triggers increasing or decreasing re-

gional employment disparities. To get a comprehensive overview about the relationship between the change of skill composition of employment and the evolution of regional employment disparities, it appears to be necessary to consider skill-specific employment subgroups as well as total employment.

However, the existing literature about the evolution of regional labor market disparities does not deal with the fact that *employees* are a heterogeneous group. Studies investigate the hypothesis of convergence for total employment (and total unemployment respectively) but provide no additional results for different subgroups. To the best of my knowledge, the only exception is Südekum (2008).<sup>1</sup> He tests the hypothesis of convergence for the regional share of high-skilled workers for West Germany. Unfortunately, the study provides no results for further (skill-specific) employment subgroups.

This paper gives a comprehensive overview about the evolution of regional employment disparities in West Germany. It tests the hypothesis of convergence for regional employment rates. Furthermore, it investigates in which way the change in the skill composition of employment affects the evolution of regional employment disparities. Therefore, this study additionally tests the hypothesis of convergence for the high-skilled employment rate, the medium-skilled employment rate, and the low-skilled employment rate.<sup>2</sup>

The main challenge to convergence analysis is to define a concept of convergence that is empirically testable. The analysis of convergence processes has its roots in growth economics. Several concepts of convergence and suitable empirical tests for its existence are provided by the economic growth literature (for an overview see Durlauf et al. 2005, 2009; for the specifics of regional convergence see Magrini 2004 and Rey and Gallo 2009). Many of these techniques were adopted to examine the evolution of regional labor market disparities. This is possible because the concepts of convergence are of purely statistical nature. Hence, they can be applied (more or less easily) to other economic issues. In general, two broad threads of convergence analysis can be identified in the existing literature: the cross-sectional approach to convergence and the time series approach to convergence. These approaches are predicated on different views of the nature of regional disparities and, therefore, different views of the convergence process.

The cross-sectional approach considers convergence as a catching-up process between favorable and unfavorable regions. Hence, this approach appears to be appropriate if the regions under consideration are characterized by transition dynamics where the regions tend to converge to their steady state (see Bernard and Durlauf 1996). As soon as all regions reach their steady state,

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<sup>1</sup> Grip et al. (1997) also present results for employment subgroups. They test the hypothesis of convergence for two forms of atypical employment: part-time employment and temporary employment. Additionally, they present results for the various occupation groups in which part-time workers and temporary workers are employed. However, Grip et al. (1997) test the convergence hypothesis for a cross-section of EU countries and do not choose a regional approach.

<sup>2</sup> The analysis is restricted to West Germany because the education system of West and East Germany before reunification was very different. Hence, the formal qualification level on what this study is forced to focus on, is not comparable in the 1990s.

regional disparities should minimize or even disappear. In this case, regional disparities simply reflect differences in the initial conditions. The concepts of  $\beta$ -convergence and  $\sigma$ -convergence belong to the cross-sectional approach to convergence. Regions exhibit  $\beta$ -convergence if unfavorable regions exhibit higher growth rates than favorable regions. The concept of  $\sigma$ -convergence directly focuses on the inequality among regions by comparing the dispersion of a regional variable at different points in time. Regions exhibit  $\sigma$ -convergence if the dispersion decreases over time (see, for example, Barro and Sala-i-Martin 1991, 1992). Also the distributional approach is related to the cross-sectional approach to convergence. Here, the mobility of individual regions within the distribution of the regional variable is considered.

Regional labor market disparities are often considered as the result of economic disturbances and sluggish adjustment processes after a region specific shock. This in turn implies that regional disparities only disappear if a shock has temporary effects and regions quickly return back to their steady state. Following this point of view, convergence can also be considered as an adjustment process after a region specific shock. The time series approach to convergence deals with this aspect. This approach refers to the concept of stochastic convergence introduced by Bernard and Durlauf (1995, 1996) and Evans and Karras (1996). In the case of stochastic convergence, the differences in economic performance between regions have to follow a stationary process.

There are only few studies following the cross-sectional approach to investigate the evolution of regional employment disparities. Südekum (2008) investigates the hypothesis of  $\beta$ -convergence for the share of high-skilled workers of West German districts. His findings indicate that convergence has occurred within regions and within single industries, but that the speed of convergence differs. The hypothesis of  $\sigma$ -convergence was investigated by Martin (2001), OECD (2005) and Rowthorn and Glyn (2006). Martin (2001) finds no evidence for convergence considering regional (cumulative) employment growth rates in 14 European countries. Regional deviations from the European average appear to be persistent. Especially within Greece, Italy, Sweden, Spain, and the UK, strongly divergent behavior can be observed. The findings in OECD (2005) for regional employment rates of 17 OECD countries suggest that within the OECD, the inequality within the countries decreased slightly. However, a slight increase in regional employment disparities within countries is observable for Europe. In contrast, differences between countries have been reduced over time. The findings by Rowthorn and Glyn (2006) indicate that the employment rates of 48 US states exhibit periods of  $\sigma$ -convergence as well as periods of divergence. A clear trend is not observable.

The majority of the studies provide results for the concept of stochastic convergence examining regional employment growth rates. The findings are rather mixed. The results by Blanchard and Katz (1992) for the US and Decressin and Fatás (1995) for Europe provide no evidence for stochastic convergence. The results by Jimeno and Bentolila (1998) for Spain, Debelle and Vickery (1998) for Australia, and Choy et al. (2002) for New Zealand favor stochastic convergence. Rowthorn and Glyn (2006) infer that the evolution of regional employment rates in the US is characterized by absolute stochastic convergence rather than conditional convergence.

The different approaches to convergence consider different aspects of a possible convergence process. Therefore, examining different concepts of convergence might lead to ambiguous results (see, for example, Barro and Sala-i-Martin 1991 and the examples given in Quah 1996b and Baddeley et al. 1998). Hence, studies analyzing the evolution of regional labor market disparities usually do not follow solely one approach. Also this study applies different approaches to get a complete picture of the evolution of regional employment disparities.

In the existing literature on the evolution of regional labor market disparities administrative areas like federal states or districts serve as regional units. However, focusing on administrative units causes the problem that borders of such areas are typically the results of political decisions or historical reasons. In general, they do not reflect the distribution of economic activity in space or cannot be regarded as economically independent because functional labor markets extend across administrative borders. An analysis of the dynamics of regional labor market disparities neglecting spatial dependencies runs the risk of capturing only a part of the ongoing processes. For example, an increasing employment rate in a rural area may not be the result of a positive economic development, but of employees moving from a city district to the rural area although still working in the city.

In this study, functional labor markets in West Germany are the unit of analysis. More specifically, the regional planning units (Raumordnungsregionen) provided by the Federal Institute for Research on Building, Urban Affairs and Spatial Development (Bundesinstitut für Bau-, Stadt- und Raumforschung - BBSR) serve to delineate functional labor markets. Based on commuting flows, the German districts were aggregated to 96 units. Here the 71 West German regional planning units are used.<sup>3</sup> The time series covers the period 1989 to 2008.

The remainder of the paper is as follows. The first section describes the underlying data for the analysis and provides some stylized facts on the evolution of regional employment rates in West Germany. Section 3 introduces the different concepts of convergence belonging to the cross-sectional approach and presents results following these different concepts. Section 4 discusses in detail the restrictions imposed by the definition of stochastic convergence. Further, this section introduces the PANIC approach by Bai and Ng (2004) used here to test the hypothesis of stochastic convergence and presents results. The final section concludes.

## 2 Data and some stylized facts

Studies about convergence of regional employment use various measures to operationalize employment, for example, employment growth, the employment rate, or shares of employment sub-

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<sup>3</sup> The BBSR divides West Germany into 74 regional planning units, where the city state of Hamburg and the city state of Bremen represent own regional planning units. According to the BBSR, the regional planning units "Schleswig-Holstein Sued", "Hamburg-Umland-Sued" and "Hamburg" are aggregated to the analysis region "Hamburg" as well as "Bremen-Umland" and "Bremen" to the analysis region "Bremen". Considering these city states isolated from their hinterland is not appropriate with regard to functional labor markets.

groups. This paper focuses on the employment rate. The employment rate corresponds to the relation between employment and the working age population. Using such a relative employment measure is in line with studies about regional unemployment disparities that examine the unemployment rate rather than regional unemployment levels or unemployment growth rates.

The employment rate is preferred compared to the absolute employment level as well as employment growth for several reasons. Using the number of employees in a region has the disadvantage that regions differ in size. Due to the size effect, there will always be a gap between the number of employees in large and small regions and hence persistent labor market disparities. Convergence of regional employment growth rates allows no straightforward conclusion about the evolution of regional disparities in employment opportunities. Assume that all regions are equal in size according to the working age population but the number of employees differs across regions. Then different employment growth rates are necessary to close the gap in terms of job opportunities between the regions whereas identical employment growth rates would trigger divergence. This is what the concept of  $\beta$ -convergence says.

Furthermore, the change in the skill composition of employment is usually considered as reflecting increasing job opportunities for high-skilled workers and decreasing job opportunities for low-skilled workers. The employment rate is defined as the share of the population that is employed. Hence, it reflects the employment prospects of the inhabitants of a certain region. In contrast, a high employment growth rate only says that the employment opportunities increase faster than in other regions. Hence, the region with the highest employment growth rate is not necessarily the region with the highest employment prospects.

In addition to total employment, this study also considers employment groups with different qualification levels. These three groups consist of employees without any vocational qualification (low-skilled workers), employees with completed apprenticeship (medium-skilled workers), and employees with completed tertiary education (high-skilled workers). Skill-specific employment rates are calculated to analyze the evolution of regional disparities for these employment subgroups.

Skill-specific employment rates are considered here instead of employment shares for the three qualification groups because the main interest of this study is to investigate the evolution of regional employment disparities. Examining employment shares of different skill groups provides information on the evolution of the skill composition of employment across regions. However, the evolution of the skill composition of regional employment allows no straightforward conclusion about the evolution of regional employment opportunities. A rise as well as a decline of the differences in regional employment might go in hand in hand with a stable skill composition of regional employment over time.

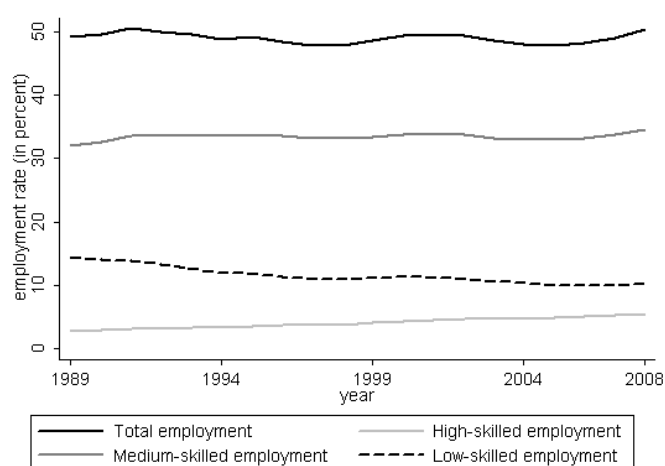
The employment rate is calculated as the ratio of employees between 15 and 64 years, measured by place of residence, and the working age population. The working age population are all people between 15 and 64 years. The skill-specific employment rates correspond to the ratio of employees



between 15 and 64 years in one of the qualification groups and the working age population. Note, that the employment rates for the three qualification groups sum up to the total employment rate. Data on employment is provided by the German Federal Employment Agency. It includes all employees subject to social security contributions. Data on the population is provided by the BBSR. The panel data set for 71 West German regional planning units covers the time period 1989 to 2008.<sup>4</sup>

Figure 1 shows the development of the total and the skill-specific employment rates in West Germany. The total employment rate remained remarkably stable during the whole observation period with 49.2 percent in 1989 and 50.3 percent in 2008. It fluctuated around a mean of 49.0 percent with its highest value in 1991 (50.6 percent) and its lowest value in 2005 (47.8 percent).

Figure 1: Evolution of West German employment rates, 1989 – 2008



Source: Statistic of the German Federal Employment Agency, Federal Institute for Research on Building, Urban Affairs and Spatial Development, own calculations.

In addition, the evolution of the employment rates reflects the changes in the skill composition of employment. The high-skilled employment rate doubled between 1989 to 2008 from 2.8 percent up to 5.6 percent. The low-skilled employment rate decreased by almost one third from 14.4 percent in 1989 to 10.2 percent in 2008. The low-skilled employment rate is still considerably higher than the high-skilled employment rate. Furthermore, a slight increase in the medium-skilled employment rate from 32.0 percent in 1989 to 34.5 percent in 2008 is observable.

For every region, an increase of the high-skilled employment rate and a decrease of the low-skilled employment rate is observable. Hence, regional high-skilled and low-skilled employment rates across West Germany followed a common trend. Although, the West German total employment rate was higher in 2008 compared to 1989, eleven regional planning units reported a lower value in 2008 than in 1989.

<sup>4</sup> Data on employment measured by place of residence is only available as of 1989.

The levels of the employment rates considerably differ between regions. In 2008, the regional total employment rates range between 56.9 percent in Schwarzwald-Baar-Heuberg and 44.4 percent in Trier and Ost-Friesland, a difference of 12.5 percentage points. The distance between the highest and lowest medium-skilled employment rate is similar with 10.7 percentage points. However, the high and low-skilled employment rates exhibit the largest regional differences. The highest value for the low-skilled employment rate in 2008 was reported in Schwarzwald-Baar-Heuberg (15.7 percent). It is two times higher than in Lueneburg (7.8 percent). In Munich, the high-skilled employment rate amounts to 11.3 percent and is more than four times higher than in Ost-Friesland (2.5 percent). Further, the geographical distribution of total employment rates and low-skilled employment rates is characterized by a large degree of similarity. In contrast, the geographical distribution of total employment rates and high-skilled employment rates clearly differs. This means that only regions that provide job opportunities for low-skilled workers can realize above average total employment rates. Or, to state it differently, regions with high employment prospects are those regions where low-skilled people also might get a job.

### 3 The cross-sectional approach to convergence

This section introduces the different concepts of convergence belonging to the cross-sectional approach to convergence. Furthermore, it examines the hypotheses of  $\beta$ -convergence and  $\sigma$ -convergence for regional total employment rates as well as for regional skill-specific employment rates. Finally, it investigates the intra-distributional dynamics of these measures.

#### 3.1 The concepts of $\beta$ -convergence and $\sigma$ -convergence

There exists a strong connection between the cross-sectional approach to convergence and the neoclassical growth model. The neoclassical growth model implies that regions with a low initial value of output are characterized by a high marginal product of capital. Hence, these regions attract additional capital and grow faster than regions where the initial value of output is already high. This induces a transition process and the unfavorable regions will catch-up with the other regions. The transition process comes to an end once all regions reach their steady state and the marginal product of capital is equal across the regions. In this case, regional disparities should be at a minimum or even disappear. This means that the underlying assumption of the cross-sectional approach to convergence is that regional disparities simply reflect the differences in initial conditions. Thus, convergence is considered as a catching-up process between unfavorable and favorable regions.

If a catching-up process between regions with low and high employment rates exists, then this implies that regions with lower employment rates grow faster than regions with higher employment rates. In this case, a negative relationship between the initial value of regional employment

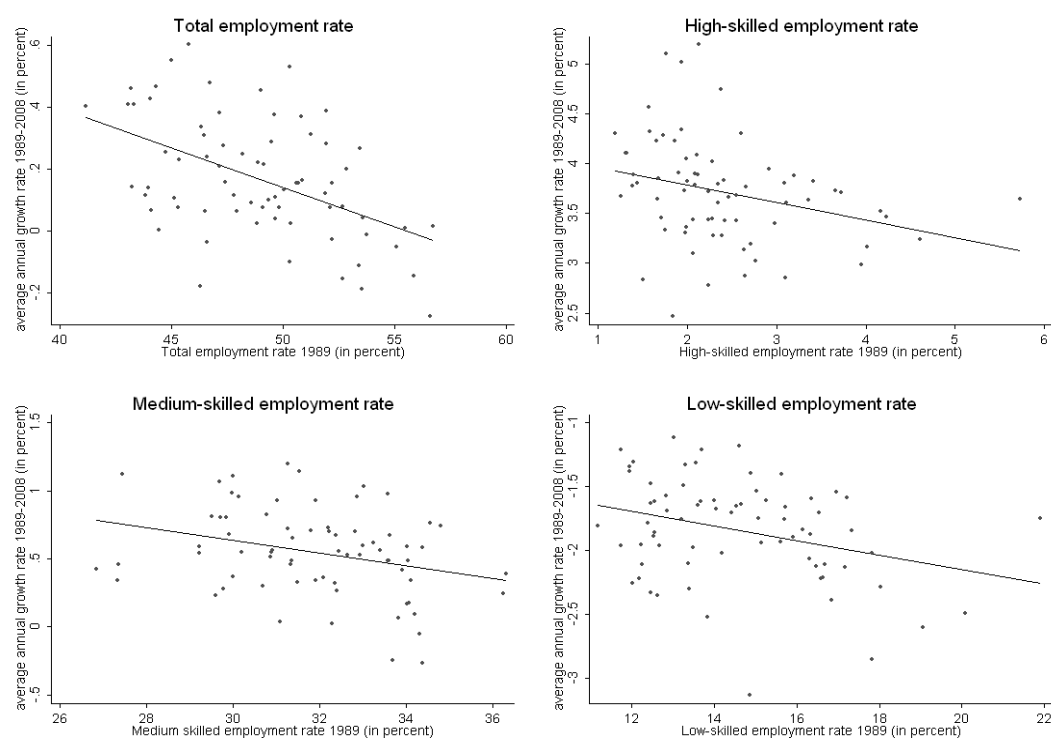
rates and their corresponding growth rates must exist. The concept of  $\beta$ -convergence examines whether such a relationship exists among the regions (see, for example, Barro and Sala-i-Martin 1991, 1992). Let  $\gamma_i^{er}$  denote the average growth rate between the two points in time 0 and  $T$  of the employment rate  $er_{i,t}$  for the  $i$ th region with  $i = 1, \dots, N$ . Further, let  $er_{i,0}$  denote the initial value. The following cross-sectional regression can be used to test the hypothesis of  $\beta$ -convergence for regional employment rates:

$$\gamma_i^{er} = c + \beta er_{i,0} + \varepsilon_i \quad (1)$$

A negative value of the coefficient  $\beta$  in equation (1) can be interpreted as evidence for the existence of (unconditional)  $\beta$ -convergence.

This regression approach to examine the hypothesis of convergence is very popular in the empirical economic growth literature. Due to its strong linkage to the neoclassical growth model, it not only provides evidence for  $\beta$ -convergence, but also permits to test several theories of economic growth. However, no such strong association exists between a certain labor market model and the concept of  $\beta$ -convergence. Therefore, in a labor market context, this regression approach appears to be predominantly a statistical test for the relationship between the initial value of a variable and its growth rate.

Figure 2: Relationship between regional employment rates in 1989 and their average annual growth rates 1989 - 2008



Source: Statistic of the German Federal Employment Agency, Federal Institute for Research on Building, Urban Affairs and Spatial Development, own calculations.

Figure 2 presents the relationship between the initial value of the employment rate in 1989, and their average annual growth rate between 1989 and 2008. Indeed, for employment rates shown in figure 2, a negative relationship is observable. The regression coefficients are significantly different from zero on the five percent level. But the coefficients are only small (total employment rate: -0.03, high-skilled employment rate: -0.18, medium-skilled employment rate: -0.05, low-skilled employment rate: -0.06). Further, the value of the adjusted  $R^2$  shows that the initial level of the employment rate explains only a small part of the variation in the growth rate of total and skill-specific employment rates (total employment rate: 0.23, high-skilled employment rate: 0.07, medium-skilled employment rate: 0.08, low-skilled employment rate: 0.08). These results can be interpreted as evidence of the existence of weak (unconditional)  $\beta$ -convergence.

However, a negative relationship between initial values and growth rates is only a necessary but not a sufficient condition for closing the gap between regions with high and low employment rates over time (see, for example, Barro and Sala-i-Martin 1991, 1992). Even if there is evidence for  $\beta$ -convergence, this does not mean differences between regions decrease and the regions become more equal over time. The mistaken conclusion that regression towards means triggers a reduction of the cross-sectional dispersion is known as Galton's fallacy. Therefore, the concept of  $\beta$ -convergence is often criticized.

The concept of  $\sigma$ -convergence focuses directly on the evolution of regional inequality by examining changes in the cross-sectional dispersion of a regional variable over time. Two regions exhibit  $\sigma$ -convergence if the dispersion across regions declines over time. If the dispersion increases over time regions are said to diverge. Please note,  $\sigma$ -convergence implies  $\beta$ -convergence but not vice versa. Let  $\sigma_{er,t}^2$  denote the dispersion across  $N$  regions of the regional employment rate  $er_{i,t}$  with  $i = 1, \dots, N$  at date  $t$ .  $\sigma$ -convergence occurs between period 0 and period  $T$  if:

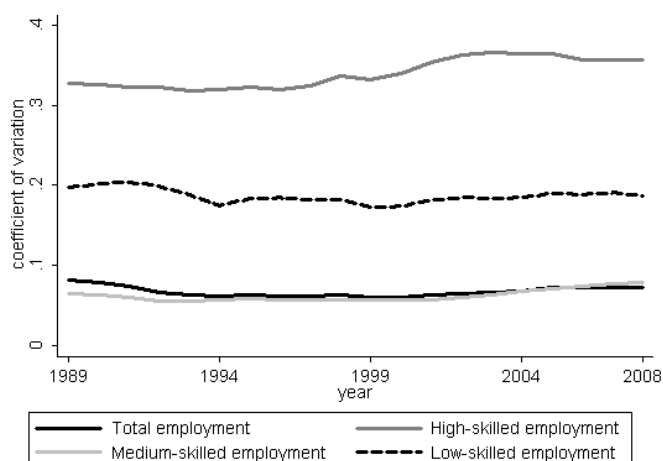
$$\sigma_{er,0}^2 - \sigma_{er,T}^2 > 0 \quad (2)$$

To examine the hypothesis of  $\sigma$ -convergence, different dispersion measures can be used. Due to the trend behavior of low-skilled and high-skilled employment a relative measures appears to be more appropriate than an absolute measure. Hence, the coefficient of variation is applied here to test for  $\sigma$ -convergence.

Figure 3 reveals that regional high-skilled employment rates are characterized by the highest degree of dispersion followed by the low-skilled employment rate. The coefficient of variation is smaller for the medium-skilled employment rate and the total employment rate. For these two measures, the coefficient of variation is nearly identical. For the high-skilled employment rate, a clear increase in the regional dispersion is observable between 1999 and 2003. From then on, the coefficient of variation remains stable. In contrast, medium-skilled, low-skilled, and total employment rates, neither exhibit a clear positive nor clear negative trend over time with regarding to the regional dispersion.

Figure 3 shows that for regional employment rates, the existence of  $\beta$ -convergence does not

Figure 3: Dispersion of regional employment rates



Source: Statistic of the German Federal Employment Agency, Federal Institute for Research on Building, Urban Affairs and Spatial Development, own calculations.

go hand in hand with the existence of  $\sigma$ -convergence. Regional inequality across West German regional planning units according to their employment rates appears to be persistent and provides no sign of a catching-up process. The evolution of the coefficient of variation neither indicates a clear convergent behavior nor a clear divergent behavior of regional employment rates during the last 20 years.

Moreover, weak cyclical movements of the dispersion of regional total employment rates and regional medium-skilled employment are observable. For low-skilled employment, the cyclical behavior of the dispersion is slightly more pronounced. Usually, if the economic climate is positive, the dispersion increases and the dispersion decreases during economic slumps. Hence, a positive economic climate slightly deepens regional employment disparities whereas an economic slump leads to more similar regional employment rates. These findings imply that those regions with above average employment rates are the ones primarily benefiting from economic booms.

### 3.2 Distribution dynamics

Quah criticized in a series of papers the concepts of  $\beta$ -convergence and  $\sigma$ -convergence because they provide no insights into the dynamics of the entire cross-sectional distribution (see Quah 1993a,b, 1996a,b,c,d). He points out that the concepts of  $\beta$ -convergence and  $\sigma$ -convergence conceal issues such as mobility, stratification, and polarization of regions. For example, persistent inequality across regions can be consistent with marked changes in the intra-distribution of individual regions due to criss-crossing and leap-frogging (see the examples given in Quah 1996b and Baddeley et al. 1998). Hence, no inference can be drawn from the trend of regional dispersion on the intra-distribution dynamics and vice versa. Therefore, it is important to additionally

investigate the mobility of individual regions within the distribution of the regional labor market variable. Studies about the evolution of regional labor market disparities in general investigate the degree of rank-order stability to get insight into the intra-distribution dynamics (see, for example, Eichengreen 1990, Martin 1997, Baddeley et al. 1998 and Gray 2004). Hence, this study follows this approach too.

To get a first impression of the persistence of regional employment disparities, the employment rates of each regional planning unit in 1989 and 2008 are plotted against each other (see figure 4). The dashed lines denote the corresponding West German rates in 1989 and 2008. These lines divide the panels of figure 4 into four areas. In the upper right area are regions with an above average employment rate in 1989 and an above average employment rate in 2008. In the bottom left area are regions with a below average employment rate in 1989 and a below average employment rate in 2008. The other two areas gather the regions that changed between these groups over time. In the upper left area are regions with a below average employment rate in 1989 and an above average employment rate in 2008. In the bottom right area are regions with an above average employment rate in 1989 and a below average employment rate in 2008.

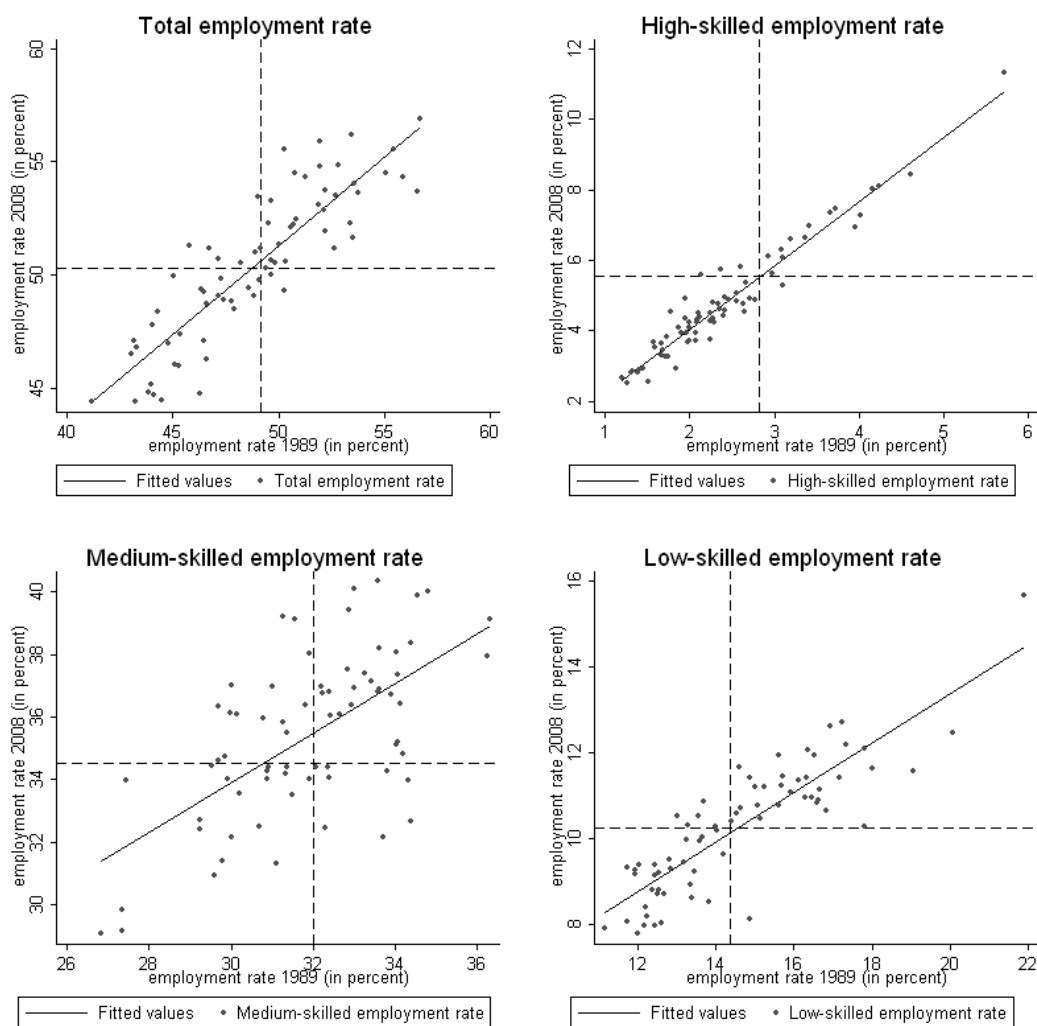
Panel 1 of figure 4 shows that the ranking of the regional planning units according to their total employment rate has remained remarkably stable over time. The regression line has a slope of 0.78 and a  $R^2$  of 0.76. With 0.87, the correlation coefficient for total employment rates in 1989 and 2008 is high. Regional planning units with high total employment rates in 1989 also report high total employment rates in 2008 and vice versa. Only ten of the 71 regional planning units changed their position relative to the West German total employment rate.

For the high-skilled employment rates and the low-skilled employment rates, the results are very similar to the findings for the total employment rate. For the low-skilled employment rate, the regression line has a slope of 0.58 and a  $R^2$  of 0.74 and the correlation coefficient is high with 0.86. There are only six regions which changed their groups. For the high-skilled employment rate, the relationship during the last twenty years is even more persistent. The regression line has a slope of 1.81 and a  $R^2$  of 0.93. The correlation coefficient with 0.96 exceeds the value for the total employment rate as well as for the low-skilled employment rate. There are only four regions that changed their position with regard to the West German average.

In contrast, the ranking of regional planning units according to the medium-skilled employment rate appears to be much weaker. There are 22 regional planning units that changed their position compared to the West German medium-skilled employment rate. 14 regions changed from the group with a below average medium-skilled employment rate to the above average group. Eight regions reported an above average medium-skilled employment rate in 1989 but a below average medium-skilled employment rate in 2008. The medium-skilled employment rate exhibits with 0.62 the lowest correlation coefficient of all employment rates under consideration. The regression line has a slope of 0.79 and a comparatively small  $R^2$  of 0.38.

The intra-distributional dynamics are examined in more detail by investigating the rank order

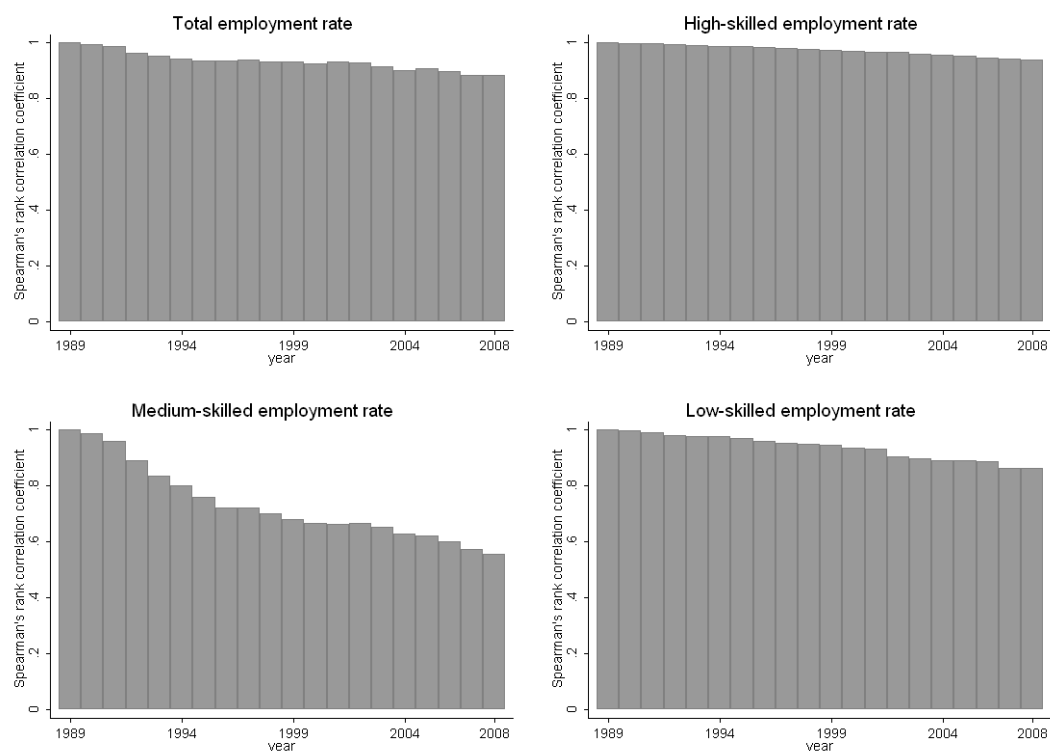
Figure 4: Persistence of regional employment rates



Source: Statistic of the German Federal Employment Agency, Federal Institute for Research on Building, Urban Affairs and Spatial Development, own calculations

stability of regional employment rates over time. To test the rank order stability, a Spearman's rank correlation coefficient is calculated for every year with 1989 as the reference year.

Figure 5: Rank order stability of regional employment rates



Source: Statistic of the German Federal Employment Agency, Federal Institute for Research on Building, Urban Affairs and Spatial Development, own calculations

Figure 5 shows a slight decrease of the rank correlation coefficient for the total employment rate, the high-skilled employment rate, and the low-skilled employment rate. In all three cases, the ranking of the regions according to the employment rate is very stable over time. The rank correlation coefficient in 2008 still exceeds 0.85 in all three cases. In contrast, a clear decrease in rank order stability is observable for the medium-skilled employment rate. In 2008, the rank correlation coefficient is only 0.55. Especially in the 1990s, a sharp decrease of rank order stability is observable. Between 1999 and 2003, the rank correlation coefficient remained stable followed by a slight decrease until 2008. The results confirm that the ranking of regions according to the medium-skilled employment rate are less persistent between 1989 and 2008, and that there is considerably more fluctuation.

Hence, the medium-skilled employment rate was characterized by a strong degree of intra-distributional dynamics during the 1990s, whereas no similar pattern was found for the other employment rates. These findings are somewhat surprising. The medium-skilled workers are by far the largest group of employees. Thus, it seems reasonable to expect that the medium-skilled employment rate and the total employment rate show similar characteristics. However, this is



not the case. It should be kept in mind, that the development of total employment is not first and foremost driven by the largest employment subgroup, but instead by the most dynamic employment subgroup (in absolute terms). The changes in high-skilled employment and low-skilled employment were more pronounced than the changes in medium-skilled employment. Therefore, changes in total employment also appear to be mainly driven by these two measures and they overlay the development of medium-skilled employment. This implies that the ranking of total employment rates is also more similar to the ranking of high- and low-skilled employment rates compared to the ranking of medium-skilled employment rates.

Regional medium-skilled employment rates are characterized by intra-distributional dynamics during the 1990s. However, these changes in the ranking of the regions due to their medium-skilled employment rate did not affect the dispersion of employment rates across the regions. Regional total employment rates, high- and low-skilled employment rates are characterized by both a persistent distribution across regions, as well as persistent regional inequality.

## 4 The time series approach to convergence

A number of studies point out that persistent regional labor market disparities could also follow from regional labor market shocks which then lead to a (long-term) disequilibrium if the adjustment mechanisms are slow or weak (see, for example, Adams 1985, Marston 1985, Topel 1986, or Blanchard and Katz 1992). This implies that regions might not reach their equilibrium permanently or at least for a considerable period of time if economic disturbances have persistent and long lasting effects on regional labor market performance. Hence, in this framework, regional disparities only decline if the effect of a shock is transitory and the regions (eventually) return back to their equilibrium. Therefore, it is also possible to consider convergence as an adjustment process after a region specific shock.<sup>5</sup>

Following this point of view, regional development is no longer determined by differences in the initial conditions. In this case, the cross-sectional approach to convergence does not provide an adequate framework to examine the evolution of regional labor market disparities. The results from the previous section show that the evolution of regional employment disparities does not seem to be characterized by a continuous transition process but rather by changes in the economic climate. Hence, the time series approach appears to be more appropriate in this case.

This approach refers to the concept of stochastic convergence introduced by Bernard and Durlauf (1995, 1996) and Evans and Karras (1996). In the case of stochastic convergence, a stable long-run equilibrium relationship between the regions has to exist. After a shock, the differences in

<sup>5</sup> Note, that the literature distinguishes between region specific and aggregate shocks. So called aggregate shocks affect all regions evenly. Therefore, an aggregate shock can not cause an increase or decrease in regional labor market disparities. In contrast, so called region specific shocks affect regions differently. Hence, they can be considered as an important driving force in the development of regional disparities.

economic performance between regions should return back to their initial value before the shock occurred.

#### 4.1 Structures and restrictions imposed by the definition of stochastic convergence

The discussion of stochastic convergence presented in this section is based on the definition of stochastic convergence given in Evans and Karras (1996). Let  $x$  denote the variable of interest.  $N$  regions are said to converge in this variable if, and only if, a common trend  $a_t$  and finite parameters  $\mu_1, \dots, \mu_N$  exist so that:

$$\lim_{t \rightarrow \infty} E(x_{i,t} - a_t) = \mu_i \quad (3)$$

for  $i = 1, \dots, N$  and  $t$  denotes the time dimension. Stochastic convergence in the sense of definition (3) occurs if, and only if, the deviations of the regional variables  $x_{i,t}$  from the joint trend  $a_t$  follow a stationary process. If all the deviations are non-stationary, the regions are said to diverge.

However, it is not possible to test equation (3) empirically because the common trend  $a_t$  is unobservable and unknown. In general, the cross-section average  $\bar{x}_t$  where  $\bar{x}_t = N^{-1} \sum_{i=1}^N x_{i,t}$  is used as a proxy for the common trend. This leads to the following definition of stochastic convergence:

$$\lim_{t \rightarrow \infty} E(x_{i,t} - \bar{x}_t) = \mu_i \quad (4)$$

In this context, absolute convergence means that all  $\mu_1 = \dots = \mu_N = 0$ . Hence, in the case of unconditional or absolute convergence, the indicator variable takes on the same value across all regions. If some  $\mu_i \neq 0$  exist, convergence is called conditional.

According to equation (4), the deviations of regional variables from their cross-sectional average or national counterpart, so called relative regional variables, have to follow a stationary process in the case of stochastic convergence. Therefore, the traditional approach to examine the hypothesis of stochastic convergence, consists of calculating relative regional variables and testing them for a unit root.

However, the literature provides three different ways to compute relative regional variables: absolute differences, weighted differences, and ratios (see, for example, Martin 1997 and Baddeley et al. 1998). These approaches differ in the underlying assumption about the shape of the equilibrium relationship between the regional variables and their national counterpart. As Baddeley et al. (1998) point out, this is an initial issue in analyzing the evolution of regional disparities.

Please note, equation (4) considers the differences between  $x_{i,t}$  and  $\bar{x}_t$ . Hence, it is assumed that the long-run relationship between  $x_{i,t}$  and  $\bar{x}_t$  is a linear one. A shock which leads to an equal absolute change in  $x_{i,t}$  and  $\bar{x}_t$ , does not affect the difference between the two variables. However,

the ratio between  $x_{i,t}$  and  $\bar{x}_t$  is affected. In contrast, a shock that leads to an equal relative change in the regional and the national variable, affects the difference of the two variables but not the ratio. Therefore, observing convergence or divergence can highly depend on the assumption made about the equilibrium relationship between  $x_{i,t}$  and  $\bar{x}_t$ . However, an alternative approach to examine the hypothesis of stochastic convergence that does not require the calculation of relative regional variables would be to directly investigate the restrictions imposed by the definition of stochastic convergence (see also the discussion in Werner 2012).

Banerjee and Wagner (2009) discuss in detail the restrictions imposed by the definition of stochastic convergence. If the regional variable follows a stationary process and is  $I(0)$  in each of the regions, this would imply that shocks only have transitory effects. In this case, the hypothesis of stochastic convergence would be valid because the differences between the regions also have to be  $I(0)$ . If the regional variable follows a non-stationary process and is  $I(1)$  in each of the regions, the hypothesis of stochastic convergence requires that non-stationarity of  $x_{i,t}$  only occurs via one joint stochastic trend that is  $I(1)$  and shared by all regions in the same way. Further, the remaining region specific part of the regional variable has to follow a stationary process in each region. Otherwise, the hypothesis of stochastic convergence does not hold. It is possible to consider these restrictions from the perspective of a factor model (see Banerjee and Wagner 2009). In the  $I(1)$  setting, the definition of stochastic convergence allows for the existence of one common factor that is  $I(1)$  but has to be loaded with the same weight in each time series of the panel. Moreover, the remaining idiosyncratic component has to follow a stationary process.

The panel unit root test suggested by Bai and Ng (2004), the so called PANIC (Panel Analysis of Nonstationarity in Idiosyncratic and Common components) approach, applied on the original regional employment rates provides the necessary information on whether these restrictions are valid or not. The PANIC approach combines the principal component method and unit root tests (The procedure is discussed in detail in section 4.2). In the first step, a principal component method is applied to decompose the different time series of the panel into their idiosyncratic components and the common components. This provides information about the (optimal) number of common factors present in the data and whether the corresponding factor loadings are heterogeneous or homogeneous. The second step of the PANIC approach consists of testing the idiosyncratic component and the common factors for a unit root.

Therefore, the results from the PANIC approach applied on the original time series of a regional variable provides information about whether the variable is  $I(0)$  or  $I(1)$ . Moreover, in the  $I(1)$  case, it is possible to examine whether this variable is characterized by one non-stationary common component with homogeneous factor loadings and a stationary idiosyncratic component. These are the restrictions imposed by the definition of stochastic convergence. Hence, the PANIC approach makes it possible to directly test the hypothesis of stochastic convergence based on the original time series without the necessity of calculating relative regional variables. This appears to be a more convenient way to test the hypothesis of stochastic convergence for regional employment rates. No assumptions about the equilibrium relationship between the regional employment

rates and the national employment rate are required following this alternative approach.

As Banerjee and Wagner 2009 show, if the regional variable contains a deterministic trend, the hypothesis of stochastic convergence additionally requires identical linear trend slopes for each of the regions. However, the assumption of a deterministic trend appears to be inappropriate in the case of the employment rate. Trend behavior of bounded variables like the employment rate or the unemployment rate appears to be better characterized by a stochastic trend (see, for example, Gray 2004). Hence, this restriction is negligible here.

## 4.2 The PANIC approach

The PANIC approach belongs to the group of so called second generation panel unit root tests. Univariate unit root tests like the Augmented Dickey-Fuller (ADF) test often fail to reject the hypothesis of a unit root because of their low power with regard to distinguishing the unit root hypothesis from the stationarity alternative hypothesis (see, for example, Campbell and Perron 1991, DeJong et al. 1992). Through the application of unit root tests to a panel of cross-sectional units, it is possible to gain higher power. This leads to panel unit root tests. The so called first generation panel unit root tests assume that the cross-sectional units are independent, whereas the so called second generation unit root tests have relaxed this assumption. A number of studies indicate that investigating (non)stationarity in a panel framework might lead to serious problems if the assumption of cross-sectional independence is violated and this is not taken into account (see, for example, O'Connell 1998, Banerjee et al. 2004, 2005 and Baltagi et al. 2007). O'Connell (1998) and Baltagi et al. (2007) show that the first generation panel unit root tests tend to reject the non-stationarity hypothesis too often if the independency assumption does not hold.

The second generation panel unit root tests count for the presence of cross-sectional dependence through the specification of approximate factor models. These tests model cross-sectional dependence via common factors shared by all cross-sectional units and provide test statistics for the cross-sectionally adjusted time series. Second generation panel unit root tests of this kind are provided by Bai and Ng (2004), Moon and Perron (2004), and Pesaran (2007).

The basic idea of the procedure proposed by Bai and Ng (2004), is to decompose the time series into common factors and idiosyncratic terms, and then test each of these components for a unit root. Bai and Ng (2004) show that it is possible to obtain consistent estimators of the common factors and the idiosyncratic terms by applying the method of principal components to first-differenced data. This is independent of the dynamic properties of underlying time series. Hence, the test for the number of common factors does not depend on whether the idiosyncratic components are stationary and vice versa. Among the second generation panel unit test, the framework by Bai and Ng (2004) is the most flexible and less restrictive approach. In contrast, the procedure of Moon and Perron (2004) requires the common factors to be  $I(0)$  and the procedure by Pesaran (2007) allows for one stationary common factor only.<sup>6</sup>

<sup>6</sup> According to Banerjee and Wagner (2009), the approaches by Moon and Perron (2004) and Pesaran (2007) can be

### 4.2.1 Modeling cross-sectional dependence via approximate factors

The illustration of the method of principal components to estimate the common and idiosyncratic factors in this section follows Bai and Ng (2004). They assume that the data generating process (DGP) for a variable  $x_{i,t}$ , where  $i$  denotes the cross-sectional dimension with  $i = 1, \dots, N$ , and  $t$  denotes the time dimension with  $t = 1, \dots, T$ , can be described as:

$$x_{i,t} = D_{i,t} + u_{i,t} \quad (5)$$

where  $D_{i,t}$  denotes the deterministic part of the process that can consist of a constant and/or a trend.  $u_{i,t}$  denotes the stochastic part. It is assumed that the stochastic component  $u_{i,t}$  of the process is driven by two forces: common factors shared by all cross-sectional units and an idiosyncratic individual-specific component. Examples for such common factors are cyclical development or technological change. Hence, common factors capture the co-movement of the time series and the cross-sectional correlation.

Let  $F_t$  denote a  $r \times 1$  vector of  $r$  common factors,  $\xi_i$  the corresponding factor loadings, and  $e_{i,t}$  the idiosyncratic component. Thus the DGP can be written as:

$$x_{i,t} = D_{i,t} + \xi_i' F_t + e_{i,t} \quad (6)$$

$$(1 - L)F_t = C(L)\eta_t \quad (7)$$

$$(1 - \rho_i L)e_{i,t} = H_i(L)\varepsilon_{i,t} \quad (8)$$

where  $C(L) = \sum_{j=0}^{\infty} C_j L^j$  and  $H_i(L) = \sum_{j=0}^{\infty} H_{ij} L^j$ . Assumptions (7) and (8) imply that the DGP of the idiosyncratic component  $e_{i,t}$ , and the DGP of the  $r$  common factors, can be described as a first order autoregressive process. The idiosyncratic component  $e_{i,t}$  follows a  $I(1)$  process if  $\rho_i = 1$  and is stationary if  $|\rho_i| < 1$ . Furthermore, Bai and Ng (2004) assume that  $r_0$  common factors follow a  $I(0)$  process and  $r_1$  common factors to follow a  $I(1)$  process, with  $r = r_0 + r_1$ . The aim of the PANIC approach by Bai and Ng (2004) is to determine  $r_1$  and to test if  $\rho_i = 1$ .

The assumption of a deterministic trend in regional employment rates appears to be inappropriate. Therefore, this section only considers the case of an intercept only. If equation (6) contains only an intercept, first differences are taken to eliminate the shift term and then the principal component method is applied to the model in first differences.<sup>7</sup> The DGP corresponding to equation (6) in first differences is given by:

$$\Delta x_{i,t} = \xi_i' \Delta F_t + \Delta e_{i,t} \quad (9)$$

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considered as special cases of the PANIC approach.

<sup>7</sup> If equation (6) contains an intercept and a deterministic trend, it is necessary to take first differences to eliminate the shift term and to demean the data to eliminate the deterministic trend. After taking first differences and demeaning the data, the method of principle components described in this section can be applied to the panel.

with  $t = 2, 3, \dots, T$  and  $i = 1, 2, \dots, N$ . Let  $f_t = \Delta F_t$  and  $z_{i,t} = \Delta e_{i,t}$ . Hence, equation (9) can also be expressed as:

$$\Delta x_{i,t} = \xi_i' f_t + z_{i,t} \quad (10)$$

Next, define:

$$X = (x_1, x_2, \dots, x_N) \quad (11)$$

as the  $T \times N$  matrix of all observations where:

$$x_i = (x_{i,1}, x_{i,2}, \dots, x_{i,T})' \quad (12)$$

$\tilde{X}$  is the corresponding  $(T-1) \times N$  matrix of the data in first differences:

$$\tilde{X} = \Delta X = (\Delta x_1, \Delta x_2, \dots, \Delta x_N) \quad (13)$$

Following Bai and Ng (2004), the principal component estimator  $\hat{f}$  of  $f = (f_2, f_3, \dots, f_T)$  is  $(T-1)^{(1/2)}$  times the  $r$  eigenvectors corresponding to the  $r$  largest eigenvalues of the  $(T-1) \times (T-1)$  matrix  $\tilde{X}\tilde{X}'$ .

The optimal number of common factors  $r$  can be determined by using the information criteria provided in Bai and Ng (2002). After determining the optimal number of common factors, it is possible to estimate the corresponding factor loadings given by  $\hat{\xi}$ . Under the normalization  $\hat{f}'\hat{f}/(T-1) = I_r$ , where  $I_r$  is the  $r \times r$  identity matrix, the estimated factor loadings are obtained from the relationship  $\hat{\xi} = \tilde{X}'\hat{f}/(T-1)$ .

Next, the idiosyncratic components  $\hat{z}_{i,s}$  can be computed as:

$$\hat{z}_{i,s} = \Delta x_{i,s} - \hat{\xi}_i' \hat{f}_s \quad (14)$$

Note, the common factors as well as the idiosyncratic components are still written in first differences. However, the main concern is to examine equation (6) and not equation (9). It is possible to recover the estimated factors by summation. Define for  $t = 2, 3, \dots, T$ :

$$\hat{F}_t = \sum_{s=2}^t \hat{f}_s \quad (15)$$

and

$$\hat{e}_{i,t} = \sum_{s=2}^t \hat{z}_{i,s} \quad (16)$$

## 4.2.2 Testing for a unit root

Non-stationarity of the time series  $x_{i,t}$  can result from a unit root in the idiosyncratic component and/or from a unit root in the common component. For the case of a unit root in all series  $x_{i,t}$ , it is sufficient that at least one non-stationary common factor is present if this factor is loaded in all series. That is what Bai and Ng (2004) call integration or non-stationarity due to a pervasive source. If all common factors are stationary, a series  $x_{i,t}$  has a unit root if and only if  $e_{i,t}$  has a unit root. Bai and Ng (2004) call this non-stationarity due to a series specific source. Therefore, appropriate unit root tests for the idiosyncratic and the common component are required.

The idiosyncratic component can be tested for a unit root by applying an ADF test on every single series. Even after controlling for cross-sectional dependence, the power of the univariate unit root test remains low. Therefore, Bai and Ng (2004) suggest two tests for the pooled data that focus on the pooled  $p$ -values from univariate ADF tests for each time series of the panel. Let  $p_{\hat{e}}(i)$  denote the  $p$ -value associated with the univariate ADF test for the idiosyncratic component  $\hat{e}_{i,t}$  from the  $i$ th cross-sectional unit,  $i = 1, \dots, N$ . The  $BN_N$  test which parallels the test proposed by Choi (2001) for cross-sectional independent panels is given by:

$$BN_N = \frac{-2 \sum_{i=1}^N \log p_{\hat{e}}(i) - 2N}{\sqrt{4N}} \Rightarrow N(0, 1) \quad (17)$$

The  $BN_{\chi^2}$  test which parallels the procedure proposed by Maddala and Wu (1999) is given by:

$$BN_{\chi^2} = -2 \sum_{i=1}^N \log p_{\hat{e}}(i) \sim \chi_{(2N)}^2 \quad (18)$$

Choosing a test for a unit root in the common factor depends on the number of common factors. If there is only a single common factor, which means  $r = 1$ , a unit root can be tested for by using an univariate ADF test.<sup>8</sup> Bai and Ng (2004) show that the ADF test for the estimated common factor in the intercept only case denoted by  $ADF_{\hat{F}_t}^c$ , has the same limiting distribution as the ADF test for the constant only case.<sup>9</sup>

In the case of more than one non-stationary common factor Bai and Ng (2004) provide the non-parametrical  $MQ_c^c(m)$  test and the parametrical  $MQ_f^c(m)$  test to determine the number of  $m$  linearly independent  $I(1)$  common trends contained in the common factors. This is equivalent to examining the co-integration rank of the common factors (see Banerjee and Wagner 2009). Both test statistics are computed recursively with the first test statistic based on  $r = m$  common factors. This means that in the first step, the null hypothesis of  $r$  stochastic trends given by  $m = r$

<sup>8</sup> Note, that  $F_t$  is a matrix of size  $r \times T$ . This means that the matrix of common factors is not characterized by the structure of the underlying panel. The size of this matrix only depends on the number of observations in time but not on the number of cross-sectional units. Hence, if there is only one common factor, a univariate unit root test is sufficient.

<sup>9</sup> In the case of an intercept and a trend, the ADF test for the estimated common factor has the same limiting distribution as the ADF test for the case with a constant and a linear trend.

is tested against the alternative hypothesis of  $m = r - 1$ . The recursive test procedure ends when the first non-rejection of the null hypothesis occurs (for details see Bai and Ng 2004).

### 4.3 Stochastic convergence of regional employment rates?

This section examines the hypothesis of stochastic convergence for regional total employment rates as well as for the regional skill-specific regional employment rates using the PANIC approach by Bai and Ng (2004). As discussed in section 4.1, the assumption of a deterministic trend appears to be inappropriate in the case of employment rates. Hence, a constant is considered as the only deterministic part in regional employment rates.

Following Banerjee and Wagner (2009) and Carrion-I-Silvestre and German-Soto (2009), the optimal number of common factors is determined by the information criterion  $BIC_3$  provided in Bai and Ng (2002). According to the simulations by Bai and Ng (2002), this information criterion has very good properties in the presence of cross-sectional correlation. To determine the optimal number of common factors  $r$ , the maximal number of common factors permitted was set to five.

Table 1: Estimated optimal number of common factors in West German regional employment rates

	Common Factors
total employment rate	1
high-skilled employment rate	1
medium-skilled employment rate	2
low-skilled employment rate	1

Source: Own calculations.

For the medium-skilled employment rate, two common factors are identified. For the other employment rates, one common factor is identified (see table 1). In the case of the total employment rate, the common factor captures the cyclical behavior of this variable. For the high- and low-skilled employment rate, the common factor reflects the positive and the negative trend behavior of the time series, respectively. The two common factors for the medium-skilled employment rate are harder to interpret. The first common factor seems to capture the cyclical behavior, while the second common factor seems to reflect the slight positive trend in medium-skilled employment.

Table 2 presents the results of the PANIC approach by Bai and Ng (2004) for regional total employment rates and skill-specific employment rates. In the case of stochastic convergence, the idiosyncratic component has to follow a stationary process. The first two columns of table 2 present the results of the two pooled unit root tests for the idiosyncratic components  $BN_N$  and  $BN_{\chi^2}$  suggested by Bai and Ng (2004).



Table 2: Results PANIC approach by Bai and Ng (2004)

	$BN_N$	$BN_{\chi^2}$	$ADF_{\hat{F}_t}^c$	$MQ_c^c(m)$	$MQ_f^c(m)$
total employment rate	4.455*	217.07*	-3.482*	—	—
high-skilled employment rate	9.787*	306.93*	1.093	—	—
medium-skilled employment rate	-3.078*	90.13	—	2	2
low-skilled employment rate	-0.048	141.20	-1.902	—	—

Source: Own calculations, \* denotes significance on the five percent level

For the idiosyncratic component of regional total employment rates and the regional high-skilled employment rates, both tests reject the hypothesis of a unit root on the five percent level. This means that region specific shocks occurring in a particular region have only transitory effects on the total and high-skilled employment rate. None of the regions deviates permanently from the single global trend identified for high-skilled employment and total employment. In contrast, the hypothesis of a unit root can not be rejected for the idiosyncratic component of the low-skilled employment rate. This means labor market shocks that exclusively affect a certain region have persistent effects on low-skilled employment rates and influence their long run behavior. Therefore, the hypothesis of stochastic convergence has to be rejected for regional low-skilled employment rates. For regional medium-skilled employment rates, the results for the idiosyncratic component are ambiguous. While the  $BN_N$  test rejects the hypothesis of a unit root on the five percent level, the unit root hypothesis can not be rejected by the  $BN_{\chi^2}$  test.

Apart from the idiosyncratic component, the definition of stochastic convergence imposes several restrictions on the shape of the common factors. The common factor also has to follow a stationary process. However, the definition of stochastic convergence also allows for the presence of one non-stationary common factor with homogeneous factor loadings. In the case of the total employment rate, the high- and low-skilled employment rate, an ADF test is sufficient to test for a unit root because only one common factor was identified. The result of this  $ADF_{\hat{F}_t}^c$  test are presented in the third column of table 2. For the medium-skilled employment rate, more than one common factor was identified. Hence, the  $MQ_c^c(m)$  test and the  $MQ_f^c(m)$  test has to be applied. The result for these tests are presented in the last two columns of table 2.

For the medium-skilled employment rate, the results of the  $MQ_c^c(m)$  test and the  $MQ_f^c(m)$  test indicate that both identified common factors are  $I(1)$ . However, the definition of stochastic convergence allows for only one non-stationary common factor to be present in the data. Therefore, the hypothesis of stochastic convergence has to be rejected for the medium-skilled employment rate.

For the common factor of regional total employment rates, the  $ADF_{\hat{F}_t}^c$  test rejects the hypothesis of the unit root on the five percent level. Because the common component reflects the cyclical movements of regional total employment rates, it is not surprising that the common factor is

stationary. In the case of the regional total employment rates, the results of the unit root tests for the idiosyncratic component and the common factor provide evidence of stochastic convergence. Stationarity of the idiosyncratic components and the common component implies that regional employment rates follow a stationary process. According to these findings, shocks only have transitory effects on this variable. After a shock, regional total employment rates return back to their steady state. Therefore, disparities in total regional employment rates seem to be mainly characterized by different steady state values.

The  $ADF_{\hat{F}_t}^c$  test favors the hypothesis of a unit root in the common factor of the low- and high-skilled employment rate. If the idiosyncratic component follows a stationary process as in the case of the high-skilled employment rate, the definition of stochastic convergence is in line with the existence of one non-stationary common factor. However, it requires that a stochastic common factor is loaded with the same weight in each time series. Therefore, it is necessary to consider the corresponding factor loadings in more detail.

Table 3: Description of factor loadings

	Mean	Std. Dev.	Min	Max	t-stat, $H_0: \xi_i = 1$
total employment rate ( $\hat{F}^1$ )	0.99	0.12	0.67	1.25	-0.51
high-skilled employment rate ( $\hat{F}^1$ )	0.95	0.32	0.46	2.24	-1.35
medium-skilled employment rate ( $\hat{F}^1$ )	0.98	0.21	0.45	1.44	-0.89
medium-skilled employment rate ( $\hat{F}^2$ )	0.07	1.00	-1.61	1.86	-7.79*
low-skilled employment rate ( $\hat{F}^1$ )	0.98	0.21	0.67	1.63	-0.90

Source: Own calculations, \* denotes significance on the five percent level

Table 3 provides descriptive statistics about the factor loadings for regional employment rates. In most cases, the mean of the factor loadings is near unity. One exception are the factor loadings of the second common factor for the medium-skilled employment rate. Here, the mean of the common factor is near zero. Comparing the minima and the maxima as well as the standard deviation of the factor loadings, reveals that the factor loadings of the second factor of the medium skilled employment rate exhibit a strong degree of variation across regions. This means that the slight positive trend in medium-skilled employment seems to affect the regions very differently.

A  $t$ -test is applied to examine the hypothesis that the factor loadings correspond to unity. The results are provided in the last column of table 3. Only for the second common factor of the medium-skilled employment rate does the  $t$ -test reject the null hypothesis of all factor loadings equalling unity. In all other cases, the null hypothesis is not rejected. Hence, the non-stationary common factor present in the time series of the high-skilled employment rate appears to be loaded with the same weight in each series. Because the idiosyncratic component was found to be non-stationary, the restrictions imposed by the definition of stochastic convergence appear to

be valid for regional high-skilled employment rates.

The findings show that the regional skill-specific employment rates behave differently to the total employment rate. Evidence of stochastic convergence was only found for regional high-skilled employment rates. In contrast, the hypothesis of stochastic convergence has to be rejected for regional low-skilled and medium-skilled employment rates. This means that the evolution of regional disparities in total employment rates does not simply reflect the evolution of regional disparities in skill-specific employment rates.

## 5 Conclusion

This paper deals with the evolution of regional employment disparities within West Germany. It examines the hypothesis of convergence for West German regional employment rates for the time period 1989 to 2008. Next to regional total employment rates, also regional skill-specific employment rates were investigated to take the changes in the skill composition of employees into account. Skill-specific employment rates were calculated for low-skilled workers, medium-skilled workers and high-skilled workers. Further, to get a comprehensive overview, different approaches to test the hypothesis of convergence were applied.

Evidence for weak unconditional  $\beta$ -convergence was found for all four employment rates under consideration. However, the negative relationship between the initial values of regional employment rates and their corresponding growth rates does not lead to a decrease in regional inequality. According to the development of the coefficient of variation, the regional dispersion of regional employment rates was stable between 1989 and 2008. One could even observe a rise in the dispersion of the high-skilled employment rate between 1999 and 2003.

Further, testing the rank order stability shows that total employment rates were characterized by a small degree of intra-distributional dynamics. Similar results were found for the low- and high-skilled employment rate. In contrast, regional medium-skilled employment rates were characterized by a higher degree of intra-distributional dynamics especially during the 1990s.

Following the cross-sectional approach to convergence, the behavior of regional employment rates can hardly be characterized by a transition process. Investigating the cross-sectional behavior of regional employment rates shows no evidence of a catching-up process between favorable and unfavorable regions. Hence, the concept of stochastic convergence appears to be more appropriate in the case of regional employment rates.

This paper discussed in detail the restrictions imposed by the definition of stochastic convergence. In the case of stochastic convergence, the idiosyncratic component and the common component of a variable have to follow a stationary process. However, the definition of stochastic convergence is also in line with the existence of one non-stationary common factor with homogeneous factor loadings. It is possible to test the hypothesis of stochastic convergence by investigating

whether these conditions are valid. The PANIC approach by Bai and Ng (2004) can be applied to test these restrictions. Following this alternative way to test the hypothesis of stochastic convergence provides some advantages compared to the traditional way of calculating deviations of regional variables from their national counterpart and examining whether these deviations follow a stationary process.

The results for the total employment rate provide evidence of the existence of stochastic convergence. The idiosyncratic component as well as the common component present in regional total employment rates are found to be stationary. Hence, differences in regional total employment rates seem to be the result of different steady state values rather than weak and sluggish adjustment processes after a region specific shock.

However, in the case of skill-specific employment rates, evidence of stochastic convergence was only found for regional high-skilled employment rates. The hypothesis of stochastic convergence was rejected for regional low-skilled employment rates and regional medium-skilled employment rates.

For regional low-skilled employment rates, the hypothesis of stochastic convergence is clearly rejected because the idiosyncratic components are found to contain a unit root. Non-stationarity of the idiosyncratic component as a source of divergence means that region specific shocks exclusively occurring in a particular region have long-lasting effects on regional low-skilled employment and might lead to a permanent deviation from the common trend. The studies by Decressin and Fatás (1995) and Kunz (2012) identify labor mobility as the major adjustment mechanism after a regional labor market shock in the long run for West German regions. Compared to the high-skilled employees, the low-skilled employees are less mobile. This could be one explanation for the long lasting effects of a shock in the case of low-skilled employment and for temporary effects in the case of high-skilled employment. Nevertheless, the development of the coefficient of variation did not indicate that the inequality across regions in terms of low-skilled employment rates increased during the last twenty years. One reason might be that the evolution of regional low-skilled employment rates was mainly driven by common movements which conceal region specific movements.

The results for regional medium-skilled employment rates are less clear and hard to interpret. The panel unit root tests for the idiosyncratic component lead to ambiguous results. However, two non-stationary common factors were identified for regional medium-skilled employment rates and this is not in line with the definition of stochastic convergence. The medium-skilled workers are the largest group of employees and contain a wide range of different occupations. This stronger heterogeneity within the group of medium-skilled workers compared to other qualification groups might be a possible explanation for these findings.

The change of the skill-composition of employees is usually explained by the so called skill biased technological change. The technological progress favors high-skilled employment whereas jobs for low-skilled workers get lost. Autor et al. (2003) and Goos and Manning (2007) introduce a more

nuanced definition of skill biased technological change. They emphasize the role of tasks rather than the formal qualification level of an employee. According to their point of view, the skill biased technological change leads to diminishing relevance of routine tasks, while non-routine tasks become more relevant. Hence, this form of skill-biased technological change does not only take place between high and low-skilled employees, but also within different qualification groups. The empirical results by Spitz-Oener (2006) support this point of view for West Germany. Note, that the ranking of the regions according to the medium-skilled employment rate appears less stable during the last twenty years compared to the other employment rates. Further, one of the common factors identified for medium skilled appears to reflect the slight positive trend in medium-skilled employment. However, each region is affected differently by this common factor because it is characterized by heterogeneous factor loadings. Hence, the impact of the skill-biased technological change might differ for the medium-skilled employees on a regional level, depending on the task composition of the medium-skilled workers.

Only little is known about the role of heterogeneous employment groups and the evolution of regional labor market disparities. This study shows that analyzing the evolution of regional labor market disparities by investigating total employment only provides limited insights. Employment subgroups can behave in a different way than total employment. The changes in the skill competition do not seem to affect the geographical distribution of employment prospects for total employment. However, they seem to go hand in hand with a redistribution of skill-specific employment prospects across regions that affects skill-specific labor market disparities. Hence, to get a complete picture of the evolution of regional labor market disparities, a more detailed look on employment subgroups is necessary. They appear to be an important driving force for the differences between regions.

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