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Paper

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Abstract

Studies conducted for the US have found a positive effect of human capital endowments on employment growth, with human capital endowments diverging at the same time. In contrast, studies for European countries have found convergence of human capital endowments. This paper tests these relationships for 99 Austrian districts for the observation period 1971-2011 by estimating how the presence of high-skilled employment affects total, low-skilled and high-skilled employment growth. To this end, OLS, fixed effects and first difference regressions are estimated. The results show continuous convergence of high-skilled employment which, however, slowed downed significantly since the 1990s. In contrast to previous studies, evidence for positive effects of high-skilled on total and low-skilled employment is only weak and varies over time. Furthermore, the results show that total and high-skilled employment in suburban areas grew faster than in other regions, while districts which bordered the Eastern Bloc were disadvantaged. Nevertheless, spatial neighbourhood effects within Austria are only weak.

Keywords: Human capital, employment growth, convergence, smart city hypothesis

JEL classification: J24, O15, R11, R12

Acknowledgments: This work was supported by the City of Vienna as part of the research project "Wien als Migrationsziel von Humanressourcen". The authors would like to thank Assma Hajji for her support as well as Thomas Rusch and Tanja Sinozic for their helpful comments.

1 Introduction

Human capital is widely acknowledged as a main driver of regional and national economic growth in advanced economies (Lucas 1988; Glaeser 2000; Barro 2001; Prager and Thisse 2012; Gennaioli et al. 2013). Broadly defined, human capital consists of the abilities, skills and knowledge of particular workers (Romer 1996). By evolving towards so-called knowledge-based economies, tertiary-level human capital is seen as a crucial feature of economic growth (Vandenbussche et al. 2006; Faggian and McCann 2009). Firstly, human capital as a production factor increases total productivity as well as marginal productivity of other factors. Secondly, by creating externalities such as knowledge spillovers, productivity may be further increased. Nevertheless, the mechanisms of how human capital affects growth of regional economies differ from national economies. As laid out by Faggian and McCann (2009), the presence of human capital can result in a major spatial reallocation of factors, where labour mobility may cause human capital to have different impacts on national as compared to regional growth.

As a result of the increasing importance of human capital in economic theory and policy debates, the concept of a *smart city* has gained some attention, both in science as well as politics. While the label "smart city" is a fuzzy concept (Caragliu et al. 2011), we apply the *smart city hypothesis* following Shapiro (2006), according to which relatively skilled regions experience higher employment growth than other regions. If this is the case, they may attract further human capital, which in turn would lead to divergence with respect to regional human capital endowments. Studies conducted for the US have largely confirmed both: a positive effect of human capital endowments on employment growth, and divergence of human capital endowments across regions (Moretti 2004; Berry and Glaeser 2005).[1]

In this paper, the smart city hypothesis is confronted with long-run regional data for Austria as an example of a developed European industrial economy. To this end, the paper builds upon a strand of literature which was pioneered by Berry and Glaeser (2005) for the US as well as Südekum's (2008) replication for Germany. These papers examine whether regions with higher initial human capital endowments experience higher employment growth and higher human capital growth. Berry and Glaeser (2005) use census data for 318 metropolitan areas for the observation period 1970-2000. Their econometric analysis supports the smart city hypothesis and indicates divergence between metropolitan areas with respect to

[1] Note that the smart city hypothesis with its emphasis on employment and human capital growth differs from Florida's (2002) work on the creative class.

endowment with college graduates, i.e. urban areas with initially higher shares of college graduates were able to increase these shares relatively faster. They also suggest that diverging skill endowments are related to declining income convergence across US cities. Their results are confirmed by Ganong and Shoag (2013).

Südekum's (2008) study considers 326 West German NUTS3 regions for the observation period 1977-2002. Rather than divergence, he finds strong support for convergence of the share of high-skilled workers, which points to important differences in spatial dynamics between the US and Germany.[2] Moreover, Südekum (2008) corroborates a positive relationship between initial shares of high-skilled employment and subsequent employment growth. A further European study by Rattsø and Stokke (2013) for 89 Norwegian regions finds evidence on convergence of regional educational levels and income levels. However, they also note that they are not able to conclude whether their results follow from the special characteristics of Norway with its relatively equal distribution of income and resource-oriented periphery, and to what extent other countries would show similar patterns (ibid., p. 13).[3] The different results for the US and European states call for further studies to improve our knowledge on that matter and to inform regional policy makers about the spatial dynamics in various varieties of market economies and welfare-state regimes.

In what follows, a data set is applied which spans four decades of development from 1971-2011 and which contains a rich set of control variables. The present study's aims are to (i) examine the effect of human capital endowments on employment growth and to (ii) test whether human capital divergence or convergence can be found for Austria. Hence, the paper contributes to the literature in three ways: Firstly, the studies by Berry and Glaeser (2005) and Südekum (2008) are adapted for Austria in order to provide evidence (i) whether the spatial distribution of skilled labour in Europe differs from that in the US and if so, (ii) which differences between European economies can be found. Secondly, potential heterogeneity of effects over time is considered by accounting for temporal discontinuities. Thirdly, geography is controlled for by considering location effects, regional characteristics and neighbourhood effects.

[2] An earlier descriptive study for Western Germany by Bade et al. (2000) finds regional de-concentration processes of human capital between 1976 and 1996.

[3] Note that in contrast to Barry and Glaeser (2005), the cited European studies do not restrict their regional sample to urban areas. Instead, they include all regions in the respective countries – an approach that is followed in this paper, too. For this reason, the comparability of these studies is limited. For example, if human capital externalities matter more for cities than rural regions, differing conclusions may be just resulting from different sampling strategies.

The paper is organised as follows. The next section discusses the theoretical background of this study. The two succeeding sections describe the data, followed by an explorative analysis based on descriptive statistics. The fifth section presents an explanatory analysis based on cross-sectional regressions. After that, the explanatory analysis is enhanced by panel econometric specifications and estimations. The final section summarises the results and interprets them in comparison with findings from other countries.

2 Theoretical Background

The causality which drives the relationship between skills of the workforce and total employment growth as suggested by the smart city hypothesis is subject to interpretation. One explanation is that human capital causes productivity growth, leading to a decrease in production costs, price cuts, rising output and finally increasing labour demand by regional firms (Shapiro 2006; O'Sullivan 2009). Evidence from various countries suggests that the role and mobility of human capital is becoming more important as a determinant of regional performance (Faggian and McCann 2009, pp. 147), yet no automatism exists that would guarantee a transformation of rising productivity into increasing labour demand. As pointed out by Thirlwall (1980), demand for regional exports is ultimately driven by price and demand elasticities. For instance, Mayerhofer et al. (2010) find that Vienna experienced "jobless growth" during the years 1991 to 2008: the Viennese economy was characterised by high productivity growth in connection with no corresponding increase in labour demand. Research in innovation economics also points to the possibility of technologically induced unemployment, which might be especially relevant in the case of traditional industrial regions undergoing a period of disruptive structural change (Pianta 2005).

An associated but less discussed aspect pertains to the complementarity between high-skilled and low-skilled employment. For a positive impact of rising shares of skilled workers on total employment, low-skilled employment has to have a good employment performance, too. Indeed, a positive indirect impact of high-skilled employment on low-skilled employment is emphasised by Glaeser (2013) and documented for the US during the 1990s by Mazzolari and Ragusa (2013). The related question on whether regional human capital endowments diverge is derived in the economic geography literature as the equilibrium outcome of concentration and dispersion forces. In core-periphery relationships as modelled most famously by Myrdal (1957) and Krugman (1991), the presence of human capital makes a region more attractive for physical capital investments, which in turn attracts further human capital.

An influential article by Lucas (1988) posits the existence of localised external effects of human capital. This would provide a strong concentration force with respect to human capital endowments. Econometric results, for instance by Rauch (1993), support the existence of such externalities for the US. Two further mechanisms for increasing concentration are formalised in a general equilibrium model by Berry and Glaeser (2005). Firstly, high-skilled workers innovate increasingly in ways which raise employment predominantly for other high-skilled workers. Secondly, a decrease in housing supply elasticity, which is due to more stringent land-use regulations, may trigger rising house prices which in turn would reduce the incentive for low-skilled workers to co-locate with high-skilled workers who can afford to pay higher rents.

In contrast, dispersion forces can be derived from neoclassical supply-side effects functioning as equilibrating forces: the returns to skills are high where human capital is scarce and vice versa. Human capital accumulation should therefore be faster in human capital poor regions. Additionally, allocation decisions by the public sector, such as the decentralisation of the Austrian university system in the 1970s, might induce catching-up processes of human capital endowments in human capital scarce regions (Wisbauer 2006). Such policies may differ between the EU and the US. For instance, empirical and theoretical research points to important differences between the working of labour, capital and housing markets in the US and Europe (Oswald 1999; Cheshire and Magrini 2009). Moreover, economic and political integration and transformation processes in former centrally planned economies complicate explanations of spatial economic dynamics in Europe compared to the US.

The present paper pays special attention to temporal and spatial heterogeneity of employment growth and spatial human capital distributions. Over the past 40 years, Austria has experienced a number of profound institutional changes. Starting in the 1960s and continuing through the 1970s, a significant process of decentralisation of the secondary and tertiary public education sector took place. During the 1980s, Austrian economic policy shifted from Keynesianism to supply-side oriented concepts. This was accompanied by rising unemployment rates as well as continuous privatisation of state-owned enterprises. During the 1990s, Austria increased its integration with both western and eastern European economies. It accessed the European Economic Area in 1993, the European Union in 1995 and the euro-zone in 1999. During the same period, its eastern neighbouring countries transformed their centrally planned economies to market economies and subsequently joined the EU in 2004. As a result, Austria's trade as well as investment flows increased, accompanied by a substantial surge of market forces and competition. Taking into account the significant

economic implications of these developments, the econometric analysis distinguishes between the periods of pre- and post-European integration.

It should also be mentioned that although the structure of the Austrian economy is comparable to West Germany and both economies are characterized by a high degree of economic openness, for the following reasons the results may deviate from Südekum's (2008) study. Over the past decades the Austrian economy has converged to or even surpassed its Western European peers in terms GDP per capita.[4] During these years, Germany experienced increasing unemployment rates which by the mid-2000s reached over 22 per cent in some NUTS2 regions and over 11 per cent at the national level, while Austria's unemployment rates increased but nevertheless remained steadily among the lowest in Europe.[5] In addition, the disintegration of the Council of Mutual Economic Assistance (Comecon) had strong but different effects on Germany and Austria. Concerning Germany, the two economies of the Federal Republic of Germany and the German Democratic Republic became unified in 1990, i.e. the former's regions (which are identical to Südekum's (2008) observation area except for Berlin) became part of a larger national economy. Concerning Austria – which shared a long border with the Comecon and Yugoslavia – the sudden changes in these countries led to new framework conditions for Austria in general and its respective bordering regions in particular. Finally, Austria represents one of Europe's small countries and for this reason alone may face different conditions.

3 Data

The observation period spans the years 1971-2011. Most data are available only for the years 1971, 1981, 1991, 2001 and 2011, which happen to be the years of population censuses. For these years, data for the Austrian districts and statutory cities have been compiled, which will be referred to as *districts* henceforth (a complete list can be found in Appendix A). Therefore, data are available for 99 spatial units at five different points in time, which makes a total of 495 observations. Following a classification of Austrian regions based on fundamental regional economic drivers of competitiveness developed by Palme (1995), in what follows the paper distinguishes between the *primary city* of Vienna (Wien) and the five *major cities* Graz, Linz, Salzburg, Innsbruck and Klagenfurt. The major cities are of comparable sizes and

[4] Ranked by GDP per capita in US-Dollars at market prices and not counting OPEC member states as well as countries with less than one million inhabitants, in 1971 Austria was found at 15th position, where countries with a higher GDP per capita included France, Germany (in today's borders) and Great Britain. By 1991, Austria had climbed to ninth position, leaving behind France and Great Britain. By 2011, Austria has also surpassed Germany (data source: United Nations, accessed 15-May-2014).

[5] data source: Eurostat, accessed 23-July-2014

function as provincial capitals, endowed with universities and cultural facilities. Furthermore, the following districts are considered as suburbs of the major cities: Mödling, Wien-Umgebung (both Vienna), Graz-Umgebung (Graz), Linz-Land, Urfahr-Umgebung (both Linz), Salzburg-Umgebung (Salzburg), Innsbruck-Land (Innsbruck) and Klagenfurt Land (Klagenfurt).

Concerning skills, the present study's classification follows Berry and Glaeser (2005) and Südekum (2008) by relying on formal degrees. The skill-differentiated employment data refer to the workplace location and are drawn from the Austrian population censuses. Employment (which includes self-employment throughout the paper if not stated otherwise) is classified with respect to skill levels as follows: *low-skilled* employment corresponds to not having earned a university-entrance diploma, *medium-skilled* employment corresponds to having attained a university-entrance diploma with no succeeding university degree, *high-skilled* employment corresponds to tertiary education. This definition takes into account the peculiarities of the Austrian education system. For example, the Austrian higher secondary education offers a university-entrance diploma and a specialised vocational training in technical and managerial skills.

Data on firm size distributions stem from business statistics (Betriebsstättenzählung). A *small firm* is defined as one that occupies nine or less employees, and a *large firm* as one that occupies 100 or more employees. In order to estimate the number of employees, the raw data is reasonably accurate for small firms only, which is why the share of employees in small firms are used, whereas large firms are counted by their total numbers.[6] In addition, the total numbers of colleges and universities per district are counted, which were compiled from data sources provided by the ministry of science. Industry employment data at the two-digit level also stem from the censuses. In order to harmonise the data, all industry data were recoded to the ÖNACE 1995 which corresponds to the NACE Rev.1 classification and comprises 60 sectors at the two-digit level. In addition, data on gross value added as estimated by the Austrian Conference on Spatial Planning (ÖROK) is used.[7]

[6] The raw data correspond to the observation years except for 1971, where values of 1973 are used. The data are classified into groups of numbers of employees and the corresponding number of firms, e.g. in district i at t there were 382 firms with 1 employed person, 682 firms with 2-4 employed persons, etc.

[7] The data for 1971 and 1981 stems from ÖROK (1989), the data for 1991 and 1995 were provided by the Austrian Institute for Economic Research (WIFO). Values for 2001 and 2011 are estimated by the growth rate of the accompanying NUTS3 during the respective periods, with the latter being provided by Statistik Austria.

4 Explorative Analysis

Similar to other OECD countries, Austria has experienced a remarkable increase with respect to high-skilled employment over the last decades. Figure 1 shows the evolution of total employment by skill groups for the observation period. Whereas total employment increased by about 855,000 to 3.9 million, in absolute numbers there were slightly less low-skilled workers in 2011 compared to 1971. The high-skilled segment displays the fastest expansion with an annual average growth rate of 3.9 per cent, while medium-skilled employment increased by 2.4 per cent annually. As a result, in 2011 the share of high-skilled and medium-skilled employment were of comparable sizes (15 and 17 per cent, respectively).

Figure 2 illustrates the association between the initial share of regional high-skilled employment and subsequent long-term regional employment growth. The labelled data points refer to the primary and major cities and their suburban regions. A number of patterns emerge from the data pictured by the scatter plot. Firstly, there exists a significant and positive nexus between human capital and employment growth. Secondly, the suburban regions experienced the strongest employment growth during the observation period. Thirdly, employment in the primary and major cities increased with a rate below the one predicted by the bivariate regression line.

A descriptive investigation of human capital convergence is illustrated in Figure 3. It shows the relationship between the initial log of high-skilled employment shares in 1971 on the x-axis and the average annual growth rate of that share from 1971-2011 on the y-axis. The highly significant and strong negative correlation coefficient indicates a catching-up process. The primary and major cities displayed the highest shares of human capital in 1971 and experienced the slowest increase in the following decades. In contrast, the suburban regions started out with relatively low shares and grew fastest.

Figure 1: Total employment by skill groups in Austria (in millions)

Notes: Definitions of skill levels and data sources as documented in the text.

Figure 2: Share of high-skilled employment in 1971 and growth of total employment 1971-2011

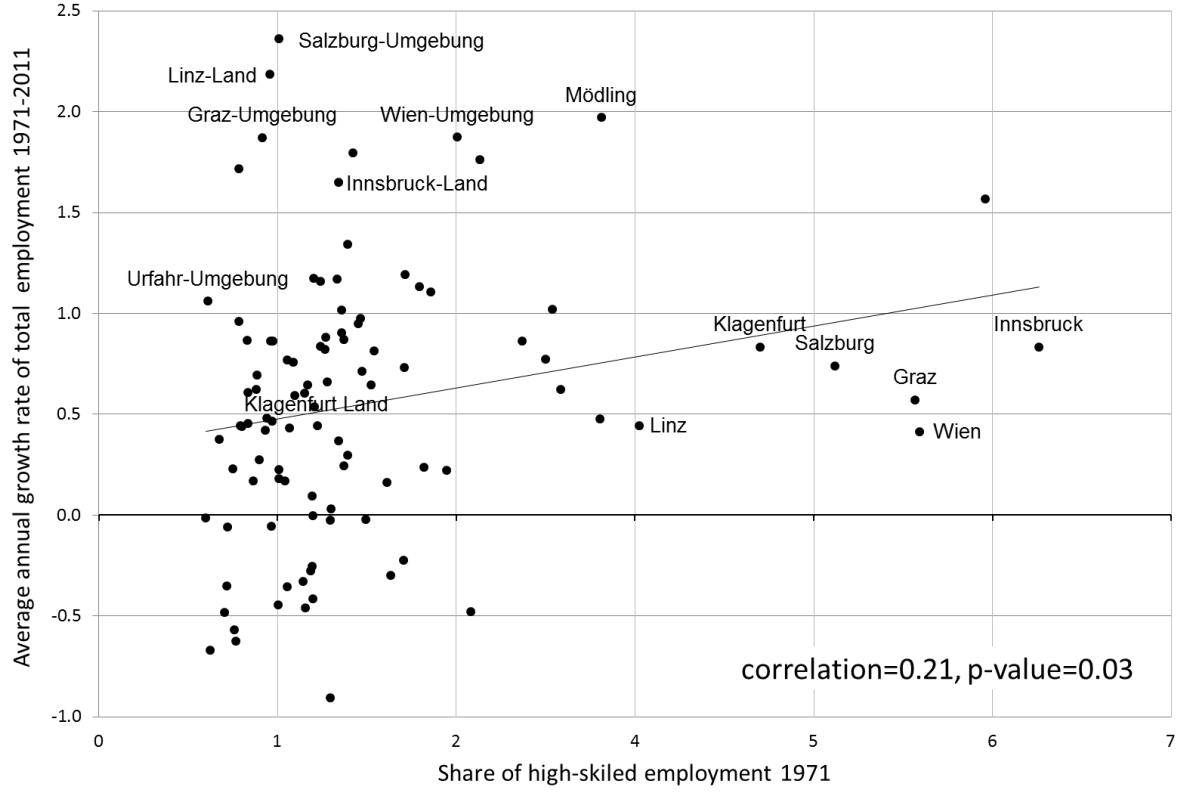


Figure 3: Share of high-skilled employment in 1971 and subsequent growth 1971-2011

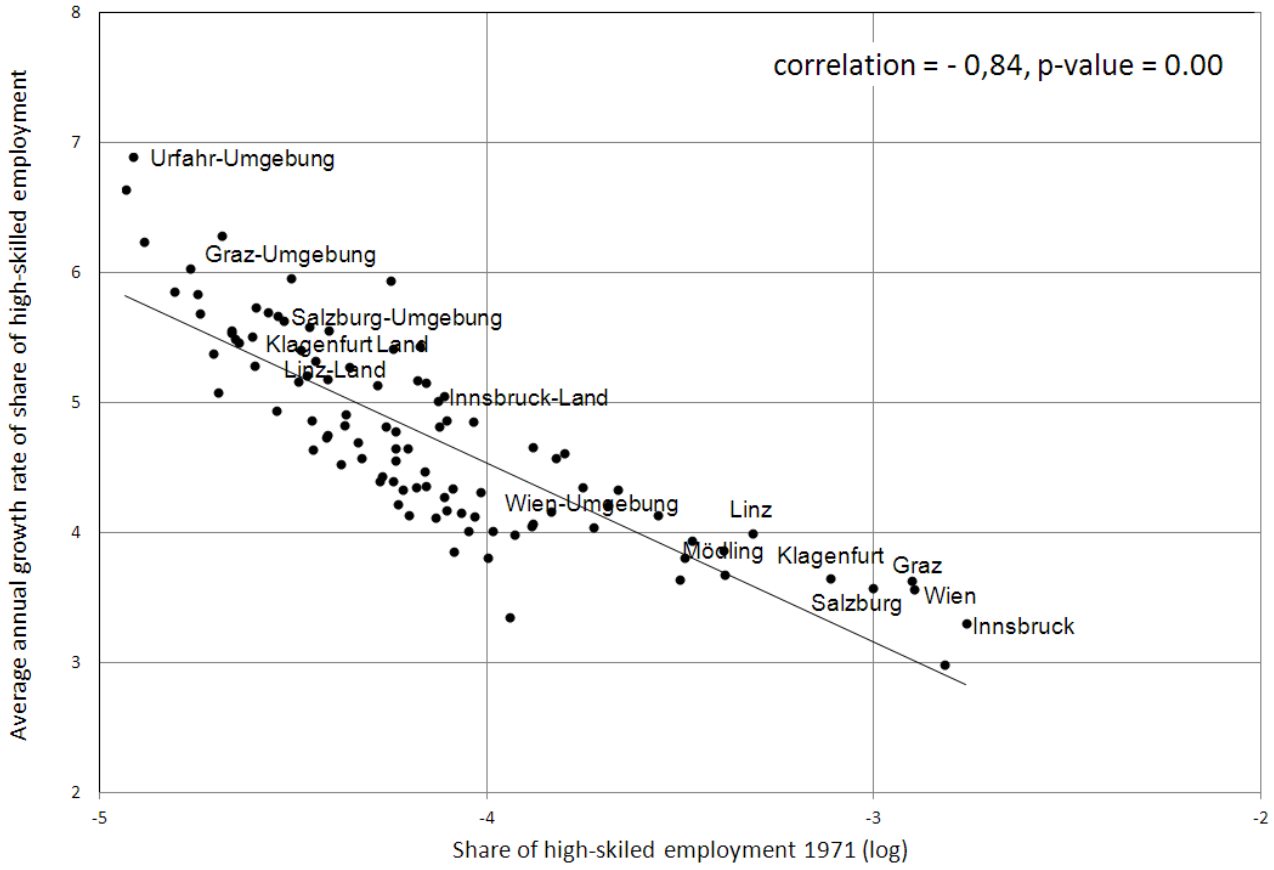


Table 1 displays some measures which quantify the evolution of regional disparities of high-skilled employment, namely the median, the interquartile range, the Gini coefficient and the dissimilarity index.[8] According to the numbers, from 1971-1991 disparities decreased, but rose during the following 20 years. However, the level of disparities in 2011 is far below the one observed for the base year 1971, but similar to 1981. This pattern of a U-shaped evolution of spatial disparities is in contrast to the findings of Berry and Glaeser (2005), who find steady divergence. Interquartile range and dissimilarity index are smaller in the US, e.g. the dissimilarity index for the US data is 0.12 in 1990 compared to 0.18 for Austrian regions in 1991. This could be the consequence of the fact that the data set of the present study comprises all types of regions whereas Berry and Glaeser (2005) restrict their data to metropolitan areas. Furthermore, the findings also differ from West Germany (see Südekum 2008), where no increasing disparities from 1977-2002 are found.

[8] The dissimilarity index as developed by Duncan and Duncan (1955) gives the share of high-skilled employment that has to be reallocated across space so that every region exhibits the same share of high-skilled employment, with $D_t = 0.5\sum_{i=1}^{N}\left|L_{i,t}^{h}\Big/\sum_{i=1}^{N}L_{i,t}^{h} - \left(L_{i,t}^{l}+L_{i,t}^{m}\right)\Big/\sum_{i=1}^{N}\left(L_{i,t}^{l}+L_{i,t}^{m}\right)\right|$, where L^{l}, L^{m} and L^{m} symbolise the total numbers of low-skilled, medium-skilled and high-skilled employment, respectively.

Table 1: The evolution of spatial disparities of high-skilled employment

	Median	Interquartile range	Gini coefficient	Dissimilarity index
1971	1.45	0.69	0.36	0.30
1981	3.16	0.74	0.23	0.20
1991	5.14	1.07	0.20	0.18
2001	7.35	1.69	0.21	0.20
2011	9.25	3.37	0.23	0.22

Notes: Numbers are based on the ratios of high-skilled employment to total employment, where the values for interquartile range are given in percentage points, and the Gini coefficient's sample weights are total population numbers.

5 Cross-Section Analysis

Methodically, the first regressions replicate Südekum's (2008) estimations as faithful as possible with slight variations due to data availability and applicableness. In his study, growth rates are calculated for the period 1985-2002, but control variables refer to 1977 due to issues of reverse causality. Therefore, an analogous cross sectional specification has the form

$$g^{L}_{i,t,t-1} = \alpha + \beta_1 x_{1,i,t-2} + ... + \beta_k x_{k,i,t-2} + \varepsilon_{i,t} \tag{1}$$

where $g^{L}_{i,t,t-1} = \ln\left(L_{i,t} / L_{i,t-1}\right)$ is the growth rate of total employment L in district i between points in time t and $t-1$. The xs represent the k explanatory variables, with the βs representing the corresponding coefficients. α is the intercept, $\varepsilon_{i,t}$ an error term.

The estimations are checked for spatial dependence by testing whether the error terms are spatially autocorrelated. Two districts i and j are considered as neighbours if they share a common border so that $w^{*}_{ij} = 1$. For the construction of a spatial weight matrix its elements are normalised so that the sum of all connectivities in each row equals one, that is $w_{ij} = 1 \Big/ \sum_{j=1}^{N} w^{*}_{ij}$. Spatial autocorrelation is measured by Moran's *I* (see Goodchild 1986), which takes on values between -1 and 1:

$$I_t = \frac{\sum_{i=1}^{N}\sum_{j=1}^{N} w_{ij}\left(\varepsilon_{i,t} - \bar{\varepsilon}_t\right)\left(\varepsilon_{j,t} - \bar{\varepsilon}_t\right)}{\sum_{i=1}^{N}\left(\varepsilon_{i,t} - \bar{\varepsilon}_t\right)^2} \tag{2}$$

Table 2: Cross section analysis with $N = 99$, $t = 2001$, $t - 1 = 1981$, $t - 2 = 1971$

	Total employment growth				Low-skilled employment growth	High-skilled employment growth	High-skilled share growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	0.0886 (0.6452)	0.2017 (0.2166)	0.0911 (0.6457)	-0.4065 (0.0966)	-0.4574 (0.0666)	0.6287 (0.0527)	1.0350 (0.0000)
High-skilled	-0.8778 (0.8037)	4.3270 (0.1547)	4.8120 (0.1214)	5.5429 (0.0837)	4.9274 (0.1300)	-6.0600 (0.1517)	-11.6000 (0.0001)
Medium-skilled	3.2105 (0.1314)	-1.1724 (0.5267)	-1.1790 (0.5266)	-0.8646 (0.6112)	-1.6706 (0.3353)	2.5990 (0.2494)	3.4640 (0.0292)
Density	-0.0126 (0.0936)	-0.0095 (0.1235)	-0.0069 (0.3991)	0.0001 (0.9897)	0.0003 (0.9766)	0.0070 (0.5391)	0.0069 (0.3863)
Productivity	0.0483 (0.6270)	0.0608 (0.4638)	0.0380 (0.6617)	-0.0447 (0.5648)	-0.0577 (0.4649)	0.0393 (0.7019)	0.0839 (0.2420)
East		-0.1088 (0.0019)	-0.1150 (0.0013)	-0.0766 (0.0211)	-0.0873 (0.0101)	-0.0139 (0.7472)	0.0626 (0.0401)
Suburbia		0.2958 (0.0000)	0.2969 (0.0000)	0.2811 (0.0000)	0.2564 (0.0000)	0.2402 (0.0000)	-0.0409 (0.2990)
Small firms			0.1415 (0.316)	0.2730 (0.0668)	0.3172 (0.0369)	0.0952 (0.6255)	-0.1777 (0.1931)
Large firms			0.0000 (0.7677)	0.0003 (0.3918)	0.0003 (0.3709)	0.0000 (0.9491)	-0.0003 (0.3079)
Specialisation				-0.3532 (0.0013)	-0.3895 (0.0005)	-0.2477 (0.082)	0.1054 (0.2856)
Universities				-0.0598 (0.1491)	-0.0699 (0.0977)	-0.0136 (0.8032)	0.0462 (0.2255)
Old industries				0.0749 (0.0246)	0.0712 (0.0354)	0.0794 (0.0701)	0.0045 (0.8808)
New industries				0.1076 (0.0053)	0.1009 (0.0100)	0.1133 (0.0254)	0.0057 (0.8702)
Moran's I	0.2589 (0.0000)	0.2266 (0.0000)	0.2216 (0.0013)	0.1225 (0.0316)	0.1641 (0.0079)	0.1028 (0.0514)	0.1711 (0.0050)
***F*-statistic**	1.6100 (0.1781)	9.8820 (0.0000)	7.4660 (0.0000)	9.7940 (0.0000)	9.2590 (0.0000)	4.2660 (0.0000)	3.7810 (0.0001)
R^2	0.0243	0.3522	0.3455	0.5185	0.5028	0.2857	0.254
LIK	50.4739	71.8153	72.3879	89.8346	88.1234	62.1587	97.9008
BIC	-73.3770	-106.8697	-98.82451	-115.3375	-111.9150	-59.98571	-131.4700
BP	13.0501 (0.0110)	9.4560 (0.1495)	11.0460 (0.1991)	18.0719 (0.1135)	17.5129 (0.1313)	19.5221 (0.0767)	21.8285 (0.0395)

Notes: The columns correspond to the regressions as specified in the text, the estimations have been carried out with *R* by application of the packages *lmtest* and *spdep*. *p*-values are in parentheses, adjusted R^2 values are given. *Moran's I* refers to the Moran's *I* values of the residuals, where *p*-values are based on 10,000 sampled raw parameter estimates. *LIK* and *BIC* refer to the values of the maximised log-likelihood and Schwarz's Bayesian criterion, respectively. *BP* is the Breusch-Pagan test for heteroskedasticity, using studentised values.

Column (1) in Table 2 displays the result for the most basic specification, with $t = 2001$, $t - 1 = 1981$ and $t - 2 = 1971$. High-skilled and medium-skilled refer to the respective employment shares, formally expressed as $L^h_{i,t-2} / L_{i,t-2}$ and $L^m_{i,t-2} / L_{i,t-2}$, where L^h and L^m symbolise the total numbers of high-skilled and medium-skilled employment, respectively. Furthermore, employment *density* is defined as $L_{i,t-2} / \mathrm{km}^2_i$, and productivity defined as $\ln\left(Y_{i,t-2} / L_{i,t-2}\right)$, where Y symbolises total gross value added (in Austrian

schillings).[9] In contrast to Südekum's (2008) study, there is no significant relationship, with the *F*-test being non-significant. Spatial autocorrelation is positive and significant. Replacing high-skilled and medium-skilled by a variable that includes the sums of both does not change this result.[10]

In column (2), dummy variables are included which control for geographical location and regional characteristics: *east* equals one if a district bordered a member state of the Comecon, *suburbia* equals one if a district is considered a suburb of one of the primary and major cities as defined above. Now the *F*-test as well as the two dummies are highly significant: *east* is negative, which is probably due to the unfavourable geographical location during era of economic bloc formation. *Suburbia* is positive, which is probably due to the relocations of production facilities as well as people that occurred in the second half of the 20th century (Dicken and Lloyd 1999). In order to control for urbanity, regressions that additionally include dummies for the primary and major cities were also carried out. However, the results do not further improve and for this reason are not printed.[10]

Column (3) additionally includes the share of employees in *small firms* as well as the total number of *large firms*, column (4) adds four other variables that control for economic structure. The Krugman index as a measure of regional *specialisation* is negative and highly significant.[11] Perhaps surprisingly, *universities*, which equals the number of colleges and universities, is negative, although not significant at the ten per cent level.[12] The importance of *old* and *new industries*, as measured by the logarithmised relative shares of gross value added, are both positive and significant.[13] The inclusion of variables which control for economic

[9] This study applies productivity in contrast to Südekum's (2008) application of market potential as Austria is much smaller in total size, therefore its regions are relatively less dependent on demand from other Austrian regions.

[10] The results are available upon request.

[11] The index is calculated as $K_{i,t} = \sum_{k=1}^{n} \left| Y_{i,p,t} \Big/ \sum_{k=1}^{n} Y_{i,p,t} - \sum_{i=1}^{N} Y_{i,p,t} \Big/ \sum_{i=1}^{N}\sum_{k=1}^{n} Y_{i,p,t} \right|$, where $Y_{i,p,t}$ is gross value added of district i in sector p at t.

[12] Due to the relatively small sample size, type II errors (not rejecting the hypothesis that a coefficient equals zero although it does not) are relatively likely, which is why *p*-values slightly above 0.1 also get a mention (for a discussion see Verbeek (2009)).

[13] The following industries are counted as "old": agriculture, hunting and forestry (NACE codes 01 and 02), manufacture of textiles and textile products (17 and 18), manufacture of leather and leather products (19). The following industries are counted as "new": manufacture of chemicals, chemical products and man-made fibres (24), manufacture of machinery and equipment n.e.c. (29), manufacture of office machinery and computers (30), manufacture of radio, television and communication equipment and apparatus (32), manufacture of medical, precision and optical instruments, watches and clocks (33), manufacture of transport equipment (34 and 35), post and telecommunications (64), financial intermediation, except insurance and pension funding (65),

Table 3: Cross section analysis with $N = 91$, $t = 2001$, $t - 1 = 1981$, $t - 2 = 1971$

	Total employment growth				Low-skilled employment growth	High-skilled employment growth	High-skilled share growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Intercept	0.0506 (0.7680)	0.1872 (0.2712)	-0.0848 (0.6945)	-0.3550 (0.1405)	-0.3922 (0.1076)	0.8408 (0.0180)	1.1960 (0.0000)
High-skilled	6.0442 (0.0636)	5.1844 (0.0961)	7.7159 (0.0183)	8.0773 (0.0120)	7.8267 (0.0159)	-6.3830 (0.1680)	-14.4600 (0.0000)
Medium-skilled	-1.6443 (0.4107)	-1.4260 (0.4547)	-1.7484 (0.3541)	-1.9813 (0.2294)	-2.8432 (0.0893)	2.8730 (0.2325)	4.8550 (0.0030)
Density	-0.0004 (0.9695)	-0.0021 (0.8449)	0.0094 (0.4218)	0.0257 (0.0569)	0.0283 (0.0385)	0.0307 (0.1188)	0.0049 (0.7038)
Productivity	-0.0026 (0.9776)	0.0568 (0.5266)	-0.0050 (0.9577)	-0.0918 (0.2586)	-0.0982 (0.2320)	0.0841 (0.4771)	0.1759 (0.0274)
East		-0.1016 (0.0027)	-0.1030 (0.0020)	-0.0835 (0.0049)	-0.0960 (0.0015)	-0.0348 (0.4112)	0.0487 (0.0862)
Small firms			0.2988 (0.0497)	0.3623 (0.0117)	0.4039 (0.0056)	0.0334 (0.8710)	-0.3289 (0.0181)
Large firms			-0.0002 (0.1764)	0.0002 (0.4845)	0.0002 (0.5040)	0.0000 (0.9757)	-0.0002 (0.4436)
Specialisation				-0.4819 (0.0000)	-0.5201 (0.0000)	-0.3709 (0.0205)	0.1110 (0.2900)
Universities				-0.0561 (0.1106)	-0.0637 (0.0736)	-0.0144 (0.7779)	0.0417 (0.2197)
Old industries				0.0761 (0.0162)	0.0741 (0.0204)	0.0932 (0.0425)	0.0171 (0.5708)
New industries				0.0545 (0.1551)	0.0437 (0.2580)	0.0708 (0.2050)	0.0163 (0.6584)
Moran's *I*	0.3803 (0.0000)	0.3222 (0.0000)	0.3252 (0.0000)	0.1922 (0.0069)	0.2227 (0.0028)	0.1215 (0.0603)	0.1374 (0.0373)
***F*-statistic**	2.0700 (0.0917)	3.725 (0.0043)	3.559 (0.0022)	7.293 (0.0000)	7.2790 (0.0000)	1.9630 (0.04343)	5.0380 (0.0000)
***R*²**	0.0917	0.1315	0.1660	0.4348	0.4342	0.1053	0.3304
LIK	64.0149	68.8468	71.7753	91.7224	90.7664	57.2769	94.4679
BIC	-100.9646	-106.1176	-102.9529	-124.8036	-122.8916	-55.9126	-130.2946
BP	1.8498 (0.7634)	5.3739 (0.3720)	6.5744 (0.4745)	14.4762 (0.2078)	12.8045 (0.3063)	20.1546 (0.04326)	23.3125 (0.01596)

Notes: See Table 2.

structure in columns (3) and (4) has two interesting effects. Firstly, high-skilled is positive and becomes weakly significant on the ten per cent level in column (4). Secondly, spatial autocorrelation becomes weaker and is now not significant at the one per cent level. An additional inclusion of location quotients for seven groups of industries has brought no improvement on results.[14]

In columns (5) and (6), the dependent variables are growth of low-skilled labour $g^{l}_{i,t,t-1} = \ln\left(L^{l}_{i,t} / L^{l}_{i,t-1}\right)$, and growth of high-skilled labour $g^{h}_{i,t,t-1} = \ln\left(L^{h}_{i,t} / L^{h}_{i,t-1}\right)$, respectively, where L^{l} symbolises total low-skilled employment. While the results of column (5) are

insurance and pension funding, except compulsory social security (66), computer and related activities (72), research and development (73), other business activities (74).

[14] If the Krugman index is replaced by location quotients, the latter are negative and weakly significant or non-significant, which confirms the negative effect of specialisation. The results are available upon request.

roughly comparable to column (4), the results in column (6) display some remarkable differences. Firstly, the coefficient for the existing stock of human capital has turned negative. Despite not being significant at the ten per cent level, given the small sample size the estimation hints at convergence of high-skilled employment.[12] Furthermore, neither employment density, geographical location, nor the number of colleges and high-schools seem to have an impact. Variables of economic structure as well as the dummy for a suburban district, however, remain significant and keep their signs.

In column (7), the dependent variable is growth of share of high-skilled employment $g^{h*}_{i,t,t-1} = \ln\left(L^h_{i,t} / L_{i,t} / L^h_{i,t-1} / L_{i,t-1}\right)$. The evidence for convergence of high-skilled employment now becomes even more pronounced, with a highly significant, negative coefficient. Eastern location switches its sign to positive, which hints at a catch-up of peripheral East Austrian districts.

Empirical research suggests that the growth processes in suburban regions are heavily dependent upon economic dynamics in the core city and the relocation of activities from the core to the urban fringe (Niedercorn and Kain 1963; Palme 1995). Because of the strong effect of suburban districts, Table 3 reproduces the results of Table 2 with the only difference that the primary and major cities have been merged with their respective suburbs.[15] As columns (1), (2) and (3) in Table 3 show, the positive effect of *high-skilled* on employment growth is now more pronounced, while the negative effect of eastern districts remain and spatial autocorrelation increases. In columns (4) and (5), the introduction of structural control variables improves the results, with a preference of the test statistics for the sample with merged districts. As columns (6) and (7) show, the convergence effect is more pronounced, but test statistics prefer the sample with non-merged districts. Therefore, in what follows, the text will focus on results based on the full set of 99 districts, while analogous estimations with merged cities and suburbs can be found in the Appendix.

Table 4 reproduces the results of columns (4) and (7) of Table 2 for three different periods: firstly, the time span 1981-1991 is considered, during which Austria was economically considerably less integrated than today, by neither being a member of the European Economic Community as most of its western neighbours, nor a member of the

[15] One outcome of the suburbanisation dynamics and the interconnections between core city and suburban regions is also the practice of the US census bureau to increase the size of metropolitan areas over time (Glaeser 2000).

Table 4: Cross section analysis with $N = 99$ for different observation periods

	Total employment growth			High-skilled share growth		
t	**1991**	**2011**	**2011**	**1991**	**2011**	**2011**
***t* – 1**	**1981**	**2001**	**1981**	**1981**	**2001**	**1981**
***t* – 2**	**1971**	**1991**	**1971**	**1971**	**1991**	**1971**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept	-0.0832 (0.5826)	-0.2678 (0.0283)	-0.6813 (0.0309)	0.3473 (0.0761)	-0.0386 (0.8331)	1.2950 (0.0001)
High-skilled	2.5605 (0.1981)	-0.6330 (0.3990)	3.0693 (0.4521)	-9.1141 (0.0005)	-3.3998 (0.0036)	-17.5800 (0.0000)
Medium-skilled	-0.2298 (0.8283)	0.6195 (0.2050)	0.9125 (0.6757)	3.1068 (0.0243)	3.6538 (0.0000)	8.5890 (0.0001)
Density	0.0065 (0.2230)	0.0022 (0.5999)	0.0039 (0.7228)	0.0029 (0.6678)	0.0137 (0.0323)	0.0158 (0.1500)
Productivity	0.0343 (0.4788)	-0.0853 (0.0122)	-0.0435 (0.6620)	0.0087 (0.8882)	-0.0075 (0.8825)	0.1410 (0.1542)
East	-0.0464 (0.0248)	-0.0105 (0.5525)	-0.0974 (0.0223)	0.0411 (0.1183)	-0.0022 (0.9358)	0.0735 (0.0795)
Suburbia	0.1430 (0.0000)	0.0758 (0.0024)	0.3689 (0.0000)	-0.0428 (0.2110)	0.0210 (0.5696)	0.0087 (0.8720)
Small firms	0.1060 (0.2506)	0.0255 (0.7668)	0.3096 (0.1043)	-0.0703 (0.5515)	0.2016 (0.1245)	-0.4265 (0.0248)
Large firms	0.0000 (0.8615)	-0.0001 (0.5564)	0.0001 (0.7684)	-0.0003 (0.2531)	-0.0003 (0.2956)	-0.0006 (0.1462)
Specialisation	-0.3233 (0.0000)	-0.0293 (0.6743)	-0.3583 (0.0103)	0.2228 (0.0105)	-0.0381 (0.7198)	0.0521 (0.7009)
Universities	-0.0267 (0.2994)	0.0161 (0.4492)	-0.0405 (0.4442)	0.0428 (0.1958)	0.0025 (0.9383)	0.0606 (0.2481)
Old industries	0.0453 (0.0291)	0.0303 (0.0546)	0.1280 (0.0030)	0.0237 (0.3675)	0.0044 (0.8528)	0.0197 (0.6370)
New industries	0.0618 (0.0100)	0.0333 (0.1703)	0.1690 (0.0007)	0.0006 (0.9850)	0.0504 (0.1710)	0.0402 (0.4026)
Moran's *I*	0.0870 (0.0882)	-0.0463 (0.6918)	0.0608 (0.1542)	0.0566 (0.1647)	0.1454 (0.0184)	0.2147 (0.0016)
***F*-statistic**	10.6700 (0.0000)	3.9250 (0.0001)	9.5090 (0.0000)	6.0290 (0.0000)	5.8300 (0.0000)	3.0030 (0.0015)
R^2	0.5421	0.2089	0.5103	0.3811	0.3716	0.1969
LIK	136.6600	152.5356	65.1779	111.9674	111.1421	66.2142
BIC	-208.9883	-240.7396	-66.02416	-159.6031	-157.9526	-68.0968
BP	18.6780 (0.0966)	11.5302 (0.4841)	11.2974 (0.5036)	22.0915 (0.0365)	15.9770 (0.1923)	12.1248 (0.4357)

Notes: See Table 2.

Comecon as most of its eastern neighbours. Secondly, the time span 2001-2011 is considered during which Austria was a fully integrated member state of the European Union as well as the euro-zone, and in addition all of its eastern neighbouring countries accessed the EU. Thirdly, the time-span 1981-2011 is considered to see which effects prevail over both periods.

While estimations for change in total employment 1981-1991 (column (1) of Table 4) are similar to 1981-2001 (column (4) of Table 2), the differences to 2001-2011 are remarkable. In particular and somewhat surprisingly, in column (2) *productivity* has a negative effect, while *old industries* remains positive. In addition, *high-skilled* switches from positive and significant to negative and non-significant. While eastern regions lose their

disadvantage, *suburbia* remains positive but decreases in value and significance over time. Variables of economic structure are also much less pronounced in column (2) than in column (1). Concerning the complete time span as reported in column (3), *high-skilled* is non-significant, too. In contrast, some variables which control for economic structure are very pronounced: *small firms*, *old industries* and *new industries* are positive, while *specialisation* is negative. It is also worth mentioning that almost no spatial autocorrelation can be detected.

The estimations where the share of high-skilled employment acts as dependent variable are reported in columns (4), (5) and (6). They do not show much difference across observation periods at first sight. A closer look, however, reveals that the convergence process was much more pronounced during the years when Austria was economically less integrated with Europe, with the respective coefficient being more than three times higher. *Density* becomes positive and significant for 2001-2011, and *medium-skilled* is positive and significant for each period. As in Table 2, spatial autocorrelation is more pronounced if growth of high-skilled employment share is the dependent variable.

6 Panel Analyses

As a next step, the results are complemented by panel regressions. The first step is a fixed-effects regression, where the change of total employment is the dependent variable:

$$g^{L}_{i,t,t-1} - \bar{g}^{L}_{i} = \beta_1 \left(x_{1,i,t-1} - \bar{x}_{1,i} \right) + ... + \beta_k \left(x_{k,i,t-1} - \bar{x}_{k,i} \right) + ... + \varepsilon_{i,t} - \bar{\varepsilon}_{i} \qquad (3)$$

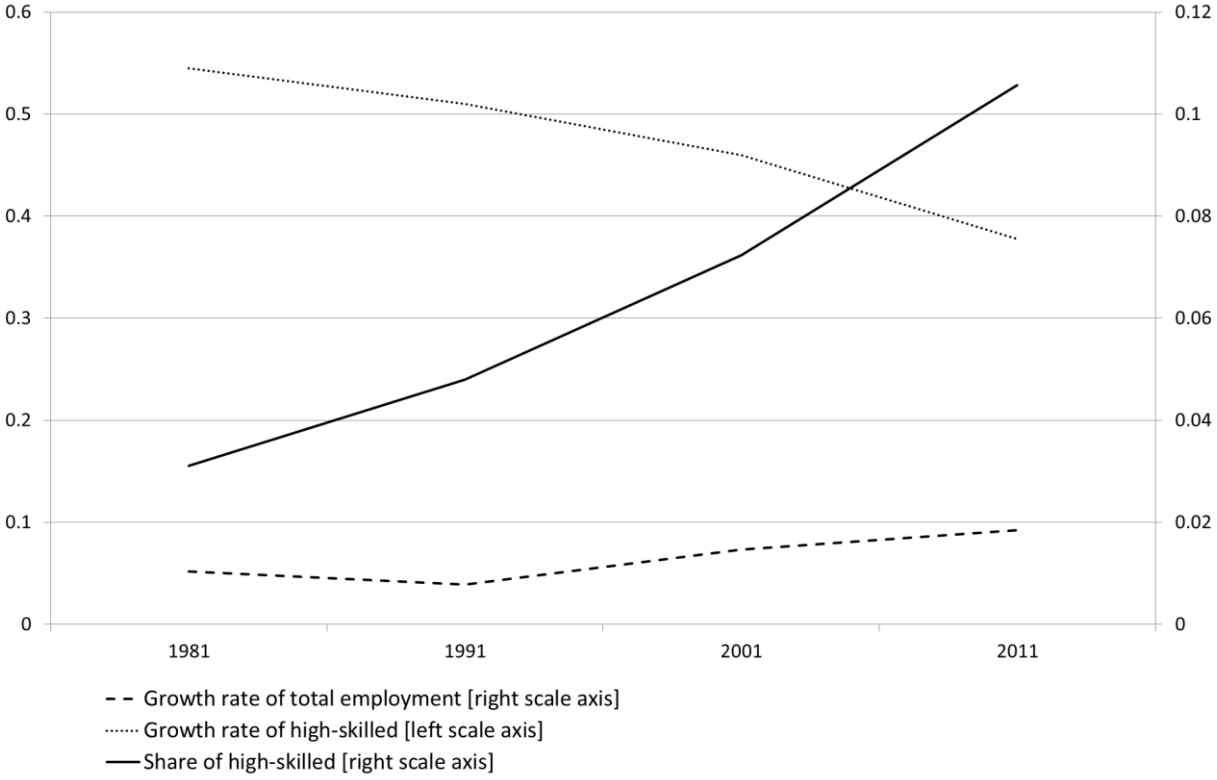
where $\bar{g}^{L}_{i} = (1/4) \sum_{t=2}^{5} g^{L}_{i,t,t-1}$ and $\bar{x}_{q} = (1/4) \sum_{t=2}^{5} x_{q,i,t-1}$, and x_q representing the qth of the k explanatory variables. The explanatory variables are the same as in the cross sectional specifications apart from *density*, as the latter's change over time is identical to the change of total employment over time. Also note that as a consequence of fixed-effects regression, the dummy variables which do not change over time are not included. The corresponding results as displayed in column (1) of Table 5 are roughly comparable to column (4) of Table 2.[16] In particular, the signs for *high-skilled* and *medium-skilled* are both positive and significant. The error terms are spatially uncorrelated in each period. In addition, a dummy variable *integration* is introduced. It equals one for each region in the years 2001 and 2011 to test whether Austria' EU membership as well as its eastern neighbours' integration and subsequent succession to the EU had an effect. The dummy is, however, non-significant.

Table 5: Panel analyses with $N = 99$ for different specifications

	Fixed effects, total employment growth		First difference, total employment growth		Fixed effects, high-skilled share growth	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept			0.0785 (0.0011)	0.0862 (0.0006)		
High-skilled	1.7478 (0.0424)	-1.1734 (0.2623)	-1.7728 (0.0003)	-3.2146 (0.0001)	-5.6734 (0.0158)	-19.7070 (0.0000)
Medium-skilled	0.9658 (0.0584)	1.2201 (0.0865)	0.4617 (0.4639)	0.3827 (0.5808)	8.0400 (0.0000)	3.1919 (0.0160)
Productivity	0.0145 (0.5300)	-0.0073 (0.7239)	-0.0943 (0.0000)	-0.0752 (0.0058)	-0.2579 (0.0000)	0.0839 (0.0532)
Small firms	-0.4052 (0.0001)	-0.1930 (0.3697)	-0.0517 (0.2934)	-0.1257 (0.1471)	0.2091 (0.4118)	0.2923 (0.166.)
Large firms	-0.0011 (0.1595)	-0.0002 (0.7139)	0.0015 (0.0417)	0.0011 (0.134)	-0.0017 (0.3232)	-0.0026 (0.0677)
Specialisation	-0.3312 (0.0005)	-0.3978 (0.0000)	0.2522 (0.0487)	0.3331 (0.0159)	0.4969 (0.0006)	0.4346 (0.0019)
Universities	-0.0019 (0.8918)	0.0193 (0.2283)	-0.0317 (0.0008)	0.0290 (0.0529)	0.0904 (0.0102)	0.0897 (0.0130)
Old industries	0.1086 (0.0001)	0.0413 (0.0801)	-0.1281 (0.0000)	-0.1547 (0.0000)	-0.0982 (0.1196)	0.0069 (0.8775)
New industries	-0.0185 (0.4318)	-0.0134 (0.5975)	0.0373 (0.051)	0.0325 (0.2044)	-0.1709 (0.0003)	-0.1123 (0.0103)
Integration	-0.0173 (0.3438)	-0.3161 (0.0084)	0.0008 (0.9439)	-0.1139 (0.3659)	-0.1631 (0.0000)	0.1100 (0.6215)
Integration * High-skilled		1.3673 (0.0955)		1.6477 (0.0078)		8.9993 (0.0000)
Integration * Medium-skilled		-0.1931 (0.7432)		0.2322 (0.6025)		0.7891 (0.3807)
Integration * Productivity		-0.0396 (0.3418)		0.0433 (0.4465)		0.0645 (0.2993)
Integration * Small firms		0.2373 (0.0105)		-0.0126 (0.9039)		-0.3038 (0.0521)
Integration * Large firms		0.0000 (0.7421)		0.0004 (0.0073)		-0.0004 (0.0898)
Integration * Specialisation		0.1534 (0.0084)		-0.2609 (0.0006)		-0.4256 (0.0004)
Integration * Universities		-0.0037 (0.7890)		-0.0592 (0.0000)		0.0103 (0.7277)
Integration * Old industries		0.0404 (0.0012)		0.0417 (0.0089)		-0.0425 (0.0769)
Integration * New industries		0.0091 (0.6774)		0.0186 (0.4752)		0.0217 (0.6078)
Moran's *I* 1971, 1981	0.0441 (0.2043)	0.0307 (0.2742)	0.1714 (0.0070)	0.1856 (0.0028)	-0.0250 (0.5755)	-0.0252 (0.5783)
Moran's *I* 1981, 1991	0.0162 (0.3427)	0.0453 (0.2086)	0.1083 (0.0463)	0.0748 (0.1177)	-0.0740 (0.8181)	-0.0354 (0.6296)
Moran's *I* 1991, 2001	-0.0386 (0.6489)	0.0453 (0.2086)	0.1875 (0.0027)	0.1217 (0.0311)	0.0878 (0.0793)	0.0012 (0.4210)
Moran's *I* 2001, 2011	-0.0726 (0.8103)	-0.0209 (0.5564)	0.3737 (0.0000)	0.3024 (0.0000)	-0.0167 (0.5228)	-0.0261 (0.5756)
***F*-statistic**	12.0927 (0.0000)	12.0353 (0.0000)	14.1399 (0.0000)	9.1110 (0.0000)	98.5875 (0.0000)	81.4288 (0.0000)
R^2	0.2149	0.3168	0.2612	0.2993	0.5613	0.5951

Notes: The columns correspond to the regressions as specified in the text, the estimations have been carried out with *R* using the *plm* and *spdep* packages Moran*'s I* refers to the Moran's *I* values of the residuals for the respective periods. White homoskedastic *p*-values are in parentheses. R^2 is adjusted for the number of variables.

Figure 4: Stocks and growth rates of high-skilled employment in comparison to total employment



Note: Growth rates refer to the respective ten-year intervals.

The picture changes in column (2) of Table 5, where the dummy integration interacts with each explanatory variable and shows some remarkable effects. Perhaps the most interesting result is how *high-skilled* interacts with *integration*: while *integration* as such keeps its negative sign but is now highly significant, *high-skilled* interacts positively with *integration* and is negative when non-interacting, with the former being non-significant and the latter significant at the ten per cent level only. In addition, *medium-skilled* seems to have a positive effect for the years before accession only, and *specialisation* keeps its negative sign before the accession and turns positive afterwards. *Large firms* seem to have no effect at all, while *small firms* has a positive effect when interacting. It should also be mentioned that spatial autocorrelation cannot be detected for any period.

In columns (3) and (4), a first difference estimation is applied:

$$g^{L}_{i,t,t-1} = \alpha_0 + \beta_1 \Delta x_{1,i,t,t-1} + ... + \beta_k \Delta x_{k,i,t,t-1} + ... + \Delta \varepsilon_{i,t} \quad (4)$$

where $\Delta x_{q,i,t,t-1} = x_{q,i,t} - x_{q,i,t-1}$. Note that the results cannot be directly compared to columns (1) and (2) of Table 5, as eq. (4) estimates the effect of a *change of a change* of explanatory variables on employment growth. Perhaps the most striking result is that growth of *high-skilled* employment share has a negative effect on total employment growth, which seems counterintuitive. One may think of highly qualified personnel replacing labour in the short run which may lead to this effect. Figure 4, however, tells a different story: while total employment has increased over the observation period, high-skilled employment and medium-skilled employment have increased way faster, which explains their negative signs. Interestingly, however, by interacting with *integration* in column (4), *high-skilled* has a positive and highly significant effect. It should also be mentioned that large firms and universities display positive effects: the former when interacting, the latter when non-interacting. In addition, most error terms are spatially autocorrelated, indicating that some additional, unobserved spatial effects are at work.

Growth of high-skilled employment is the dependent variable in the next regressions. The estimation corresponds to a fixed-effects regression as in eq. (3), with growth of high-skilled employment share as the dependent variable:

$$g^{h^*}_{i,t,t-1} - \bar{g}^{h^*}_{i,t,t-1} = \beta_1 \left(x_{1,i,t-1} - \bar{x}_{1,i} \right) + ... + \beta_k \left(x_{k,i,t-1} - \bar{x}_{k,i} \right) + ... + \varepsilon_{i,t} - \bar{\varepsilon}_i \qquad (5)$$

The accompanying results in column (5) of Table 5 confirm the convergence by the negative and highly significant sign of *high-skilled*. The impact of *medium-skilled* employment on growth of high-skilled employment share is positive an highly significant, However, in column (6) the interaction of *high-skilled* with *integration* is positive and highly significant, indicating that the years of EU membership slowed down the human capital convergence process. In contrast, the interaction of *medium-skilled* is non-significant. As with columns (1) and (2), no spatial effects seem to be at work.

7 Conclusions and Comparative Perspectives

As the importance of human capital endowments for developed economies increases, the issue of distribution and growth effects of these endowments within one economy gains importance. This paper adds to the evidence on the smart city hypothesis by testing for Austria whether regions with higher initial human capital endowments experienced higher employment growth and whether human capital endowments across regions diverged or

converged. To this end, explorative as well as explanatory analyses are applied, using data for Austrian districts for the observation period 1971-2011. The main results of the present study are as follows.

Firstly, positive effects of high-skilled employment share on total employment growth are only weak, with the effect depending on the inclusion of other variables and disappearing for the period during which Austria was a member of the European Union. The relatively low unemployment rates in Austria, which were close to zero during the 1970s and still rank among the lowest within the European Union, may explain the weak effects in comparison to Südekum's (2008) study for West Germany. If unemployment is considered a push factor regarding migration decisions, it becomes more difficult for firms or regions to attract internal migrants if unemployment is low. In this context it is also worth mentioning that the weak positive effect of high-skilled employment on total employment growth disappears during the 1990s and 2000s, i.e. when market forces became more important: during these decades, state influence on the economy was reduced and immigration became freer in the wake of Austria's accession to the European Union.

Secondly, the findings from descriptive and regression analyses strongly support the interregional convergence of human capital endowments which has also been found in previous studies of European economies such as West Germany (Südekum 2008) and Norway (Rattsø and Stokke 2013). Austria's primary and major cities started out with high levels of human capital and were able to increase their endowments, but other regions' human capital growth was even higher. This convergence is highly significant and robust with respect to various periods if the dependent variable is the growth of the share of high-skilled employment. A potential explanation for the observed convergence is high marginal productivity of human capital if relatively high productivity levels coincide with low human capital endowments. Furthermore, during the observation period, Austria experienced a development from an industrialised country with relatively low innovation activities to an innovation-led economy (Aiginger et al. 2009), which has probably increased demand for high-skilled personnel in companies' facilities outside the primary and major cities. Moreover, urban firms have relocated some of their activities into regions with a relatively low-skilled labour force. In contrast to Südekum's (2008) study, however, the convergence effect is statistically significant only for the *share* of high-skilled employment, but non-significant for total high-skilled employment growth. Furthermore, the effect gets weaker during the era when Austria was a member of the European Union.

Thirdly, the results show strong effects of regional characteristics and geographical location on total employment growth, which were not investigated in previous studies. Suburban regions experienced an increase in total employment during the whole observation period, although this effect becomes weaker after 2001. In contrast, suburban location has no measurable effect on the growth of high-skilled employment share. Population density and urbanisation seem to play no role in addition to the effects of suburbanisation. Concerning geographical location, the results clearly show that bordering the Eastern Bloc had a negative impact on total employment growth. This negative effect disappears over time, which is possibly due to Austria's integration with its eastern neighbours. Within Austria, however, spatial neighbourhood effects are only weak.

Fourthly, economic structure plays an important role with some surprising results. In contrast to Südekum's (2008) study, data on sector-specific skills are not available. However, whereas Südekum's (2008) application of such data is mainly interpreted as confirming the positive effect of high-skilled employment on total employment growth, this study finds that the effect of high-skilled employment on total employment growth is significant only by inclusion of variables that control for economic structure, and only for some periods. With respect to economic structure, the effect of new industries on both total employment growth as well as high-skilled employment growth is either negative or not significant. Furthermore, the size of the industrial sector as measured by location quotients seems to have no effect. In contrast, however, regional specialisation as such, as measured by the Krugman index, is consistently negative with respect to total employment growth, and ambiguous with respect to high-skilled employment growth. The presence of large firms as well as colleges and universities seems to have no effect at all.

To summarise, the present study provides further evidence that factors and processes as emphasised by the smart city hypothesis work differently in developed European economies and in the US. In particular, the findings suggest that human capital endowments converge rather than diverge. Additionally, this study confirms the importance of temporal heterogeneity, as the impact of high-skilled employment on total employment growth varies over time. Concerning the latter, the results show that in Austria an intensification of market forces coincided with a slower convergence speed. Furthermore, as regional specialisation affects changes in the share of high-skilled employment (see Foray et al. 2009 for a discussion), it should be underlined that the degree of regional specialisation can to some extent be managed by industrial policy. However, the results in this paper do not indicate self-enforcing growth to be caused by agglomeration effects or by human capital externalities.

This is in line with empirical studies in labour economics which found no evidence for regional human capital externalities in Austria (Winter-Ebmer 1994).

Understanding the contribution of skilled workers to total employment is crucial if the European Union's aims on creating a knowledge-based economy and reduction in unemployment are to be achieved. This study's results appear all the more interesting if it is considered that Austria's population share with tertiary education is among the lowest within the European Union.[16] Considering this, one would perhaps expect strong effects of high-skilled employment share on total employment growth, which are, however, not present. The absence of such strong effects makes the most important result of the study. Instead, the results indicate that industry mix, perhaps based on dynamic comparative advantages, is important for regions to thrive. Industries demand skilled but not necessarily tertiary educated workers, which is underlined by the positive effect of medium-skilled employment on total as well as high-skilled employment growth. These findings echo recent research which points to a revival of the importance of industrial policy in the aftermath of the Great Recession which set in in 2008. For example, Aghion et al. (2011) show how European economies with active industrial policies proved to be more resilient with respect to the current economic crisis. It follows that focusing exclusively on tertiary education may not be sufficient in meeting industry needs for qualified labour. Understanding this relationship requires further research if targets for lowering unemployment at the regional level are to be met.

References

Aghion P, Boulanger J, Cohen E (2011) Rethinking industrial policy, *Bruegel Policy Brief* 4

Aiginger K, Falk R, Reinstaller A (2009) *Evaluation of government funding in RTDI from a systems perspective in Austria – synthesis report*, Vienna, WIFO

Bade FJ, Niebuhr A, Schönert M (2000) Spatial structural change – evidence and prospects, *HWWA Discussion Paper* 87

Barro R (2001) Human capital and growth, *American Economic Review* 91: 12-17

Berry CR, Glaeser EL (2005) The divergence of human capital levels across cities, *Papers in Regional Science* 84: 407-444

[16] In 2011, Austria ranked 13th within the EU15 and 20th within the EU27 member states when considering the share of inhabitants 15-64 years old who attained ISCED levels 5 or 6 (data source: Eurostat, accessed 21-July-2014).

Caragliu A, Del Bo C, Nijkamp P (2011) Smart cities in Europe, *Journal of Urban Technology* 18: 65-82

Cheshire P, Magrini S (2009) Urban growth drivers and spatial inequalities: Europe – a case study with geographically sticky people, *LEQS Paper* 11

Dicken P, Lloyd PE (1990) *Location in space: theoretical perspectives in economic geography* [German print of 3rd ed. 1999], Stuttgart, Verlag Eugen Ulmer

Duncan O, Duncan B (1955) A methodological analysis of segregation indexes, *American Journal Sociology* 20: 210-217

Faggian A, McCann P (2009) Human capital and regional development. In: Capello R, Nijkamp P (eds) *Handbook of regional growth and development theories*, Cheltenham and Northampton [MA], Edward Elgar: 133-151

Florida R (2002) *The Rise of the creative class and how it's transforming work, leisure and everyday life*, New York, Basic Books

Foray D, David PA, Hall B (2009) Smart specialisation – the concept, *Knowledge Economists Policy Brief* 9

Ganong P, Shoag D (2012): Why has regional convergence in the US stopped?, *Harvard Kennedy School Faculty Research Working Paper Series* 12-028

Gennaioli N, La Porta R, Lopez-de-Silanes F, Shleifer A (2013) Human capital and regional development, *Quarterly Journal of Economics* 128:105-164

Glaeser E (2000) The new economics of urban end regional growth. In: Clark GL, Feldman MP, Gertler MS (eds) *The Oxford handbook of economic geography*, Oxford [NY], The Oxford University Press: 83-98

Glaeser E (2013): A review of Enrico Moretti's 'The new geography of jobs', *Journal of Economic Literature* 51: 825-37

Goodchild MF (1986): Spatial autocorrelation, *Catmog* 47

Krugman, P (1991) *Geography and trade* [reprint 1992], Leuven, Leuven University Press and Cambridge (MA) and London, MIT Press

LeSage J, Pace RK (2009) *Introduction to spatial econometrics*, Boca Raton, London and New York, CRC Press

Lucas R (1988) On the mechanics of economic development, *Journal of Monetary Economics* 22: 3-4

Myrdal, G (1957) *Economic theory and under-developed regions* [reprint 1964], London, Duckworth

Mayerhofer P, Fritz O, Pennerstorfer D (2010): *Dritter Bericht zur internationalen Wettbewerbsfähigkeit Wiens*, Vienna, WIFO

Mazzolari F, Ragusa G (2013): Spillovers from high-skill consumption to low-skill labor markets, *Review of Economics and Statistics* 95: 74-86

Moretti E (2004) Human capital externalities in cities. In: Henderson JV, Thisse JF (eds) *Handbook of regional and urban economics*, Amsterdam, Lausanne, New York, Oxford, Shannon and Tokyo, Elsevier: 2243-2291

Niedercorn JH, Kain JF (1963) An econometric model of metropolitan development, *Papers in Regional Science* 11, 121-143

O'Sullivan A (2009) *Urban economics*, New York, McGraw-Hill

ÖROK (1989) *Volkswirtschaftliche Gesamtrechnung nach Bezirken*, Vienna, ÖROK

Oswald AJ (1999) The housing market and Europe's unemployment: a non-technical paper, *University of Warwick*, available at: http://individual.utoronto.ca/helderman/Oswald.pdf, accessed 14-February-2014

Palme G (1995) Struktur und Entwicklung österreichischer Wirtschaftsregionen, *Mitteilungen der Österreichischen Geographischen Gesellschaft* 137: 393-416

Pianta M (2005) Innovation and employment. In: Fagerberg J, Mowery DC, Nelson RR (eds) *The Oxford handbook of innovation*, Oxford [NY], The Oxford University Press: 568-598

Prager JC, Thisse JF (2012) *Economic geography and the unequal development of regions*, Abingdon, Routledge

Rattsø J, Stokke H (forthcoming): Regional convergence and education: investigation of distribution dynamics, *Urban Studies*, available at: http://usj.sagepub.com/content/early/2013/08/16/0042098013498625.full.pdf+html, accessed 31-January-2014

Rauch JE (1993): Productivity gains from geographic concentration of human capital: Evidence from the cities, *Journal of Urban Economics* 34: 380-400

Romer D (1996) *Advanced macroeconomics,* New York, McGraw-Hill

Shapiro JM (2006) Smart cities: quality of life, productivity, and the growth effects of human capital, *Review of Economics and Statistics* 88: 324-335

Südekum J (2008) Convergence of the skill composition across German regions, *Regional Science and Urban Economics* 38:148-159

Thirlwall AP (1980): Regional problems are "balance of payments" problems, *Regional Studies* 14: 419-425

Vandenbussche J, Aghion P, Meghir C (2006): Growth, distance to frontier and composition of human capital, *Journal of Economic Growth* 11: 97-127

Verbeek M (2008) *A guide to modern econometrics* [3rd ed.], Chichester, John Wiley & Sons

Winter-Ebmer R (1994) Endogenous growth, human capital and industry wages, *Bulletin of Economic Research* 46: 289-314

Wisbauer A (2006) *Bildungschancen in Österreich am Beginn des 21. Jahrhunderts – Beiträge zur Bevölkerungs- und Sozialgeographie 10*, Vienna, Universität Wien

Appendix A: List of Districs

The official names of the 99 districts considered in this study are, as ordered by their superior federal state:

Burgenland: Eisenstadt (Stadt); Rust (Stadt); Eisenstadt-Umgebung; Güssing; Jennersdorf; Mattersburg; Neusiedl am See; Oberpullendorf; Oberwart

Carinthia: Klagenfurt (Stadt); Villach(Stadt); Hermagor; Klagenfurt Land; Sankt Veit an der Glan; Spittal an der Drau; Villach Land; Völkermarkt; Wolfsberg; Feldkirchen

Lower Austria: Krems an der Donau (Stadt); Sankt Pölten (Stadt); Waidhofen an der Ybbs (Stadt); Wiener Neustadt (Stadt); Amstetten; Baden; Bruck an der Leitha; Gänserndorf; Gmünd; Hollabrunn; Horn; Korneuburg; Krems (Land); Lilienfeld; Melk; Mistelbach; Mödling; Neunkirchen; Sankt Pölten (Land); Scheibbs; Tulln; Waidhofen an der Thaya; Wiener Neustadt(Land); Wien-Umgebung; Zwettl

Upper Austria: Linz (Stadt); Steyr (Stadt); Wels (Stadt); Braunau am Inn; Eferding; Freistadt; Gmunden; Grieskirchen; Kirchdorf an der Krems; Linz-Land; Perg; Ried im Innkreis; Rohrbach; Schärding; Steyr-Land; Urfahr-Umgebung; Vöcklabruck; Wels-Land

Salzburg: Salzburg (Stadt); Hallein; Salzburg-Umgebung; Sankt Johann im Pongau; Tamsweg; Zell am See

Styria: Graz (Stadt); Bruck an der Mur; Deutschlandsberg; Feldbach; Fürstenfeld; Graz-Umgebung; Hartberg; Judenburg; Knittelfeld; Leibnitz; Leoben; Liezen; Mürzzuschlag; Murau; Radkersburg; Voitsberg; Weiz

Tyrol: Innsbruck-Stadt; Imst; Innsbruck-Land; Kitzbühel; Kufstein; Landeck; Lienz; Reutte; Schwaz

Vorarlberg: Bludenz; Bregenz; Dornbirn; Feldkirch

Vienna: Wien

Appendix B: Accompanying Results

Table 6: Cross section analysis with $N = 91$ for different observation periods

	Total employment growth			**High-skilled share growth**		
t	**1991**	**2011**	**2011**	**1991**	**2011**	**2011**
***t* – 1**	**1981**	**2001**	**1981**	**1981**	**2001**	**1981**
***t* – 2**	**1971**	**1991**	**1971**	**1971**	**1991**	**1971**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept	-0.0127 (0.9343)	-0.3226 (0.0113)	-0.5899 (0.0674)	0.4936 (0.0143)	-0.0919 (0.6229)	1.5640 (0.0000)
High-skilled	3.4570 (0.0910)	-0.7211 (0.3680)	4.9330 (0.2428)	-11.6500 (0.0000)	-3.5898 (0.0039)	-21.0600 (0.0000)
Medium-skilled	-0.6014 (0.5691)	0.5742 (0.2806)	0.0729 (0.9734)	4.2900 (0.0021)	4.5221 (0.0000)	10.8400 (0.0000)
Density	0.0213 (0.0148)	0.0070 (0.2434)	0.0324 (0.0722)	-0.0052 (0.6387)	0.0261 (0.0043)	0.0250 (0.1646)
Productivity	0.0312 (0.5491)	-0.1079 (0.0025)	-0.0927 (0.3916)	0.0860 (0.2004)	0.0212 (0.6828)	0.3016 (0.0065)
East	-0.0479 (0.0117)	-0.0043 (0.7987)	-0.0965 (0.0143)	0.0310 (0.1970)	-0.0031 (0.9042)	0.0584 (0.1346)
Small firms	0.1507 (0.0990)	0.0930 (0.3018)	0.3943 (0.0384)	-0.2226 (0.0586)	0.2774 (0.0421)	-0.6020 (0.0019)
Large firms	0.0000 (0.7938)	-0.0001 (0.4347)	0.0000 (0.9122)	-0.0002 (0.3346)	-0.0004 (0.1136)	-0.0006 (0.1169)
Specialisation	-0.3912 (0.0000)	-0.0751 (0.2741)	-0.5444 (0.0003)	0.2245 (0.0134)	-0.0800 (0.4368)	0.0489 (0.7343)
Universities	-0.0229 (0.3089)	0.0234 (0.2485)	-0.0307 (0.5105)	0.0404 (0.1632)	0.0273 (0.3403)	0.0746 (0.1129)
Old industries	0.0457 (0.0244)	0.0298 (0.0554)	0.1295 (0.0024)	0.0327 (0.2052)	0.0178 (0.4415)	0.0405 (0.3311)
New industries	0.0316 (0.1985)	0.0371 (0.1302)	0.1105 (0.0319)	0.0151 (0.6307)	0.0561 (0.1268)	0.0415 (0.4156)
Moran*'s I*	0.1255 (0.0565)	-0.0050 (0.5505)	0.1443 (0.0330)	0.0085 (0.4689)	0.1015 (0.0927)	0.2142 (0.0030)
***F*-statistic**	9.2950 (0.0000)	2.0310 (0.0359)	5.9140 (0.0000)	7.1410 (0.0000)	6.8700 (0.0000)	0.3834 (0.0000)
R^2	0.5034	0.1120	0.3753	0.4287	0.4177	0.2975
LIK	131.9054	143.2010	65.4983	109.1105	106.6587	65.2504
BIC	-205.1697	-227.7609	-72.35549	-159.5798	-154.6761	-71.8596
BP	16.9134 (0.1529)	11.4323 (0.4923)	10.6642 (0.5579)	18.8583 (0.0920)	23.7201 (0.0222)	11.6035 (0.4780)

Notes: See Table 2.

Table 7: Panel analyses with $N = 91$ for different specifications

	Fixed effects, total employment growth		First difference, total employment growth		Fixed effects, high-skilled share growth	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Intercept			0.0799 (0.0006)	0.0961 (0.0001)		
High-skilled	2.0500 (0.0249)	-1.3707 (0.2052)	-1.3800 (0.0271)	-3.3101 (0.0002)	-7.7385 (0.0004)	-18.5460 (0.0000)
Medium-skilled	1.4515 (0.0229)	1.5468 (0.0369)	-0.3476 (0.5224)	-0.2408 (0.7405)	8.6487 (0.0000)	1.8464 (0.1888)
Productivity	-0.0042 (0.8674)	-0.0097 (0.6028)	-0.0852 (0.0001)	-0.0675 (0.0117)	-0.2133 (0.0001)	0.0804 (0.0744)
Small firms	-0.4098 (0.0000)	-0.1894 (0.3937)	0.0190 (0.6689)	-0.0501 (0.5532)	0.2356 (0.3749)	0.2630 (0.2016)
Large firms	-0.0009 (0.1874)	-0.0001 (0.7715)	0.0012 (0.0325)	0.0011 (0.0640)	0.0004 (0.8234)	-0.0019 (0.1896)
Specialisation	-0.3323 (0.0004)	-0.3736 (0.0000)	0.3390 (0.0102)	0.3738 (0.0070)	0.4747 (0.0030)	0.3582 (0.0209)
Universities	-0.0068 (0.6903)	0.0149 (0.3538)	-0.0212 (0.0023)	0.0064 (0.6177)	0.0805 (0.0432)	0.0872 (0.0076)
Old industries	0.1036 (0.0005)	0.0420 (0.0961)	-0.1122 (0.0002)	-0.1299 (0.0000)	-0.0813 (0.2413)	0.0054 (0.9136)
New industries	-0.0262 (0.2545)	-0.0160 (0.4949)	0.0320 (0.0955)	0.0244 (0.3564)	-0.1523 (0.0026)	-0.1151 (0.0074)
Integration	-0.0327 (0.0799)	-0.3207 (0.0138)	0.0123 (0.2705)	-0.1198 (0.3400)	-0.1395 (0.0003)	0.1296 (0.5887)
Integration * High-skilled		1.6388 (0.0993)		2.1459 (0.0013)		6.9611 (0.0004)
Integration * Medium-skilled		-0.2169 (0.7628)		-0.1488 (0.7909)		2.0174 (0.0416)
Integration * Productivity		-0.0848 (0.0296)		0.0396 (0.4782)		0.1096 (0.0791)
Integration * Small firms		0.2317 (0.0224)		-0.0172 (0.8747)		-0.3029 (0.0648)
Integration * Large firms		0.0001 (0.4513)		0.0001 (0.3583)		-0.0003 (0.0574)
Integration * Specialisation		0.1304 (0.0249)		-0.1571 (0.0080)		-0.4287 (0.0002)
Integration * Universities		-0.0079 (0.5229)		-0.0292 (0.0127)		0.0162 (0.5331)
Integration * Old industries		0.0340 (0.0052)		0.0301 (0.0509)		-0.0341 (0.1736)
Integration * New industries		0.0067 (0.7657)		0.0157 (0.5369)		0.0282 (0.5224)
Moran's *I* 1971, 1981	0.0058 (0.4824)	0.0131 (0.4515)	0.0123 (0.4427)	0.0377 (0.3014)	-0.0290 (0.6740)	-0.0420 (0.7346)
Moran's *I* 1981, 1991	0.0464 (0.2689)	-0.0200 (0.6183)	0.0471 (0.2718)	0.0591 (0.2235)	0.0241 (0.3847)	0.0181 (0.4123)
Moran's *I* 1991, 2001	-0.0298 (0.6714)	-0.0257 (0.6515)	0.1126 (0.0727)	0.0821 (0.1448)	-0.0246 (0.6435)	-0.0456 (0.7533)
Moran's *I* 2001, 2011	0.0934 (0.1120)	0.0424 (0.2908)	0.2053 (0.0037)	0.2005 (0.0044)	-0.1094 (0.9465)	-0.2069 (0.9990)
***F*-statistic**	12.1894 (0.0000)	11.9805 (0.0000)	13.2005 (0.0000)	8.0577 (0.0000)	93.1004 (0.0000)	77.4477 (0.0000)
R^2	0.2288	0.3298	0.2640	0.2911	0.5634	0.5951

Notes: See Table 5.