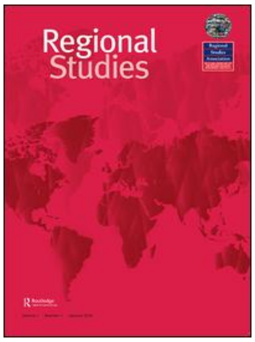

Regional Studies

ISSN: 0034-3404 (Print) 1360-0591 (Online) Journal homepage: http://www.tandfonline.com/loi/cres20

Technology, Growth and Unemployment across European Regions

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Regional Studies, Vol. 31.5, pp. 457–466

Technology, Growth and Unemployment across European Regions

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(Received September 1996; in revised form November 1996)

FAGERBERG J., VERSPAGEN B. and CANIËLS M. (1997) Technology, growth and unemployment across European regions, *Reg. Studies* **31**, 457–466. The process of convergence in GDP per capita levels across European regions came to a halt in the 1980s, although the differences in GDP per capita remain substantial. Moreover, these differences are related to similarly persistent differences in unemployment rates. This paper argues that a perspective which, in addition to other factors, takes into account differences across regions in innovation and diffusion of technology may explain these findings. A simultaneous equation model with GDP per capita growth, employment growth and migration as endogenous variables is proposed and estimated using data for 64 European regions in the 1980s. The results show that innovation and the diffusion of technology are indeed important factors behind European growth in the 1980s. However, due to a lack of own R&D capabilities, most poor regions fail to take advantage of the more advanced technologies available elsewhere. The growth of the poor regions is also hampered by an unfavourable industrial structure (the predominance of agriculture). As a consequence, growth of GDP per capita in the poorer regions is not substantially faster than in the richer ones (where growth is fuelled by much larger R&D efforts and a more advanced industrial structure). Although employment in poor regions actually grows somewhat faster than in the rich ones, so does labour supply, preventing a (relative) reduction in their rates of unemployment.

Convergence Unemployment R&D Innovation Economic growth European regions

FAGERBERG J., VERSPAGEN B. et CANIËLS M. (1997) La technologie, la croissance et le chômage à travers les régions européennes, *Reg. Studies* **31**, 457–466. La convergence du PIB par tête à travers les régions européennes fut interrompue aux années 1980, bien que les écarts du PIB par tête restent non-négligeables. Qui plus est, ces écarts se rapportent aux écarts des taux de chômage qui persistent également. Cet article laissent supposer que ces résultats pourraient s'expliquer à partir d'une approche qui met en considération à travers les régions les écarts d'innovation et de diffusion de la technologie, parmi d'autres facteurs. Un modèle d'équations simultanées comportant des variables endogènes, à savoir l'augmentation du PIB par tête, la montée de l'emploi et la migration, se voit proposer et estimer à partir des données sur soixante-quatre régions européennes aux années 1980. Les résultats laissent voir que l'innovation et la diffusion de la technologie sont d'importants facteurs à l'origine de la croissance européenne aux années 1980. Toujours est-il qu'à défaut de la R et D, la plupart des régions défavorisées ne profitent pas des technologies plus avancées qui sont disponibles ailleurs. Une structure industrielle défavorable empêche aussi les régions défavorisées (vu l'importance du secteur agricole). Par conséquent, le PIB par tête dans les régions défavorisées n'augmente pas sensiblement plus rapidement par rapport à celui des régions plus riches (où la croissance est alimentée par des efforts de R et D beaucoup plus importants et par une structure industrielle plus avancée). Non seulement

FAGERBERG J., VERSPAGEN B. und CANIËLS M. (1997) Technologie, Wachstum und Erwerbslosigkeit in europäischen Regionen, *Reg. Studies* **31**, 457–466. Der Vorgang einer Konvergenz der im eigenen Land pro-Kopf erzielten Bruttosozialprodukthöhen in europäischen Regionen kam in den achtziger Jahren zum Erliegen, obschon weiterhin beträchtliche Unterschiede in den im eigenen Land pro-Kopf erzielten Bruttosoziaprodukten bestehen. Diese Unterschiede stehen außerdem in Bezug zu ebenso beharrlichen Unterschieden in der Erwerbslosenrate. Der vorliegende Aufsatz vertritt die Auffassung, daß diese Befunde sich durch eine Perspekive erklären ließen, die außer anderen Faktoren auch Unterschiede in Innovation und Verbreitung von Technologie in den Regionen in Betracht zieht. Es wird ein Gleichungssystem des Zuwachses des im eigenen Lande erzielten Bruttosozialprodukts, der Zunahme der Erwerbstätigkeit und der Wanderung als endogene Veränderliche vorgeschlagen und berechnet, dem Daten der achtziger Jahre für 64 europäische Regionen zugrunde gelegt wurden. Die Ergebnisse zeigen, daß Innovation und die Verbreitung von Technologie tatsächlich wichtige Faktoren sind, die hinter dem Wachstum der achtziger Jahre standen. Mangels eigener Fähigkeiten in Forschung und Entwicklung gelingt es jedoch den meisten armen Regionen nicht, Vorteile aus höher entwickelten, an anderen Orten zur Verfügung stehenden Technologien zu ziehen. Das Wachstum der armen Regionen wird zudem durch eine ungünstige Industriestruktur (Überwiegen der Landwirtschaft) gehemmt.

l'emploi augmente quelque peu plus rapidement dans les régions défavorisées que dans les régions riches, mais l'offre d'emploi aussi, ce qui empêche une baisse (relative) de leurs taux de chômage.

Convergence Chômage R et D Innovation
Croissance économique Régions européennes

Folglich nimmt das im eigenen Lande per Kopf erzielte Bruttosozialprodukt in den ärmeren Regionen nicht wesentlich schneller zu als in den wohlhabenderen (wo das Wachstum von weitaus größeren Anstrengungen in Forschung und Entwicklung, sowie einer höher entwickelten Industriestruktur angeheizt wird). Obwohl Erwerbstätigkeit in armem Gebieten tatsächlich etwas schneller als in reichen zunimmt, trifft das Gleiche auf das Angebot an Arbeitskräften zu, was eine (obschon relative) Senkung der Erwerbslosenrate verhindert.

Konvergenz Erwerbslosigkeit
Forschung und Entwicklung Wirtschaftswachstum
Europäische Regionen

INTRODUCTION

During most of the post-war period, differences in GDP per capita between European regions have been on the decrease. Seemingly, the regions of Europe were on a steady, albeit slow, path towards convergence in GDP per capita. Not any more. Research shows that for the most recent decade (the 1980s) differences in GDP per capita levels were essentially unchanged (NEVEN and GOUYETTE, 1995; FAGERBERG and VERSPAGEN, 1996).[1] This change in trend is not the result of a process through which the differences in GDP per capita across European regions have been reduced to a negligible level. On the contrary, these differences remain rather substantial. In the data set we analyse below, GDP per capita in the poorest region in 1990 was only about one-quarter of that in the richest region. Moreover, as we show in the next section, these differences seem to be related to equally persistent differences in levels of unemployment: regions with a low level of GDP per capita tend to have much higher unemployment and vice-versa.[2] How are these findings to be explained? This is the question we address in the third section of this paper. There are, of course, many possible approaches that could be applied to increase our understanding of this issue. As far as the issue of growth is concerned, the neoclassical model of economic growth (SOLOW, 1956) has been the standard frame of analysis. However, it has been shown that predictions derived from this framework are not consistent with the observed growth pattern of European regions in the post-war period (SALA-I-MARTIN, 1996). Moreover, as argued in more depth elsewhere (FAGERBERG, 1994), the Solow model is based on assumptions that cannot be easily defended. An example is the assumption that technology is a public good. In contrast, we have in previous work (FAGERBERG, 1987; 1988; VERSPAGEN, 1991; CANIËLS, 1996) analysed growth differences from a perspective that acknowledges the joint private–public character of technology. Following this perspective, innovations diffuse through time and space, but diffusion depends on capabilities, efforts and structural factors. In other words diffusion is not an instantaneous and costless process (as suggested by Solow-type models).

In an earlier paper (FAGERBERG and VERSPAGEN, 1996) it was shown that a perspective that takes differences across European regions in innovation and diffusion of technology (and supporting factors) into account has a good deal to offer when analysing growth. What we try to do in this paper is to broaden this perspective by also taking into account differences in employment growth and migration flows. This can only be done in a coherent way if it is acknowledged that variables such as GDP per capita growth, employment growth and migration flows are in fact interdependent. We therefore adopt a framework of analysis that takes this into account. The results confirm that these interdependencies are indeed strong, i.e. that the factors that impact on GDP per capita growth also are important for employment growth, and the other way around.

EUROPEAN REGIONS IN THE 1980s

The sample consists of 64 European regions from four different countries: (West) Germany, France, Italy and Spain. The source is the Eurostat REGIO database.[3] For some variables we have data for other countries as well (Belgium, the Netherlands, Portugal and the UK), but because these countries have missing values for some of the key variables considered here, such as R&D, employment or migration, we exclude them from the analysis. Thus, compared to our previous work (FAGERBERG and VERSPAGEN, 1996), this sample has a more 'southern twist'. The variables employed in this study may be divided into two groups. First, the variables that we wish explain, i.e. those we have chosen to regard as endogenous. There are three of them, and they are all expressed as growth rates or flows: growth of GDP per capita; employment growth; and migration flows. These variables are clearly interdependent: higher growth is likely to lead to more jobs, and job availability is generally recognized as an important impetus to migration. The latter, in turn, should be expected to feed back on GDP per capita.

If inward migrants are relatively productive people, a positive effect may be envisaged. But if they tend to be rather unproductive, their addition to the population may actually lead to a fall in GDP per capita.

The second group consists of variables characterizing the environment in which change is taking place. These variables, normally expressed as levels or shares, are assumed to have an impact on the changes that take place, but not the other way around (i.e. they are exogenous).[4] Typically, these variables change very slowly, so for a period of a decade or so, they can be taken as given. Examples include the industrial breakdown of GDP, the composition of the labour force, population density. In the longer term, of course, many such variables undergo important changes, which would then have to be taken into account. Ideally, one would have wished to test for the assumed stability of such structural factors. But due to lack of annual data this was not possible. However, in the case of the rate of unemployment, which might be considered as one of the more problematic cases, we have at least two observations – one towards the beginning and one towards the end of our period. In Fig. 1 these observations are plotted against each other. The figure confirms that the distribution is essentially stable.

The definitions of the variables are as follows: *GQ* stands for the average annual compound growth rate of GDP per capita (in 1990 PPPs – Purchasing Power Parities – to the Ecu) over the period 1980–1990; *Q* is the level of GDP per capita in 1980;[5] *GE* is the average annual compound growth rate of employment (in persons) over 1983-89, and *GN* the average annual compound growth rate of the labour force (in persons);

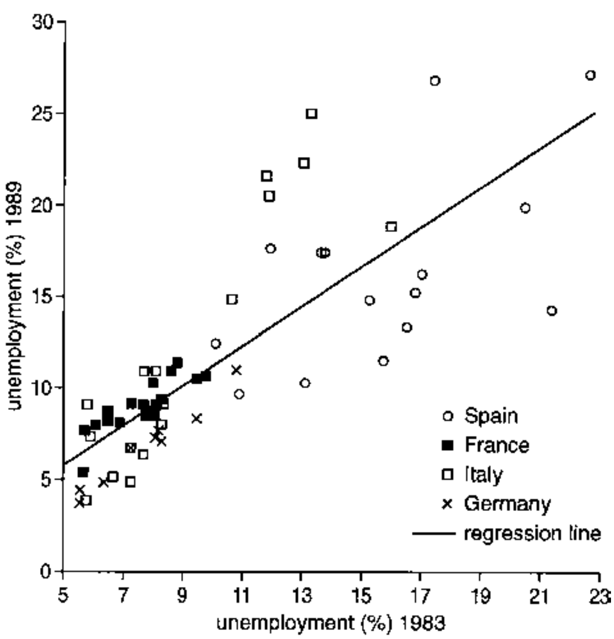

Fig. 1. *The persistence of unemployment levels across European regions*

Wage is the sum of wages divided by employment, 1989 (in 1990 PPPs to the Ecu); *RDE* is R&D employment in business enterprises in 1985 as a percentage of the labour force; *PA* is population density in 1985 (in thousands of persons per km^2); *UE* is the unemployment rate in 1983;[6] *MIR* is the mean net inward migration per thousand persons in the labour force over 1983–89; and *AGR*, *IND* and *SER* are the shares of agriculture, industry and services in total 1983 employment, respectively.

One of the novelties of this data set compared to the one we used in previous work is the inclusion of data for employment and net migration. Note, however, that the migration data used in this paper only counts migration within countries, not across. This implies an underestimation of total migration, but perhaps not a very serious one, since cross-border migration flows in Europe are known to be small. However, the data also include persons that are not in the labour force. Hence, the data may in fact overestimate the actual flows of economically active migrants. Still, migration flows appear small (see Table 1). In fact, in most regions, migration adds/subtracts far less than 0·5% per year to/from the labour force. It has to be stressed, though, that the relatively low migration rates do not necessarily imply a small impact of migration on, for example, economic growth. It may be the case, as suggested by BLANCHARD and KATZ, 1992, that the qualitative effects of migration (for example, in terms of the quality of the labour force, or spillover effects) may still be quite substantial.

Table 1 gives summary statistics for the variables employed in the study. In addition to the sample means, the table includes means for four groups of regions ranked from high to low depending on the level of GDP per capita. As is evident from the table, there are important differences between these groupings. At the high end we find many heavily urbanized regions, characterized by low unemployment, high levels of R&D and relatively high wages. At the opposite extreme – those with low GDP per capita – we find a number of agricultural regions with low population density, high unemployment and relatively low wages. Hence, as shown in Fig. 2, the 'poor' regions – those with low GDP per capita – also face the most serious unemployment problems, and vice versa. Another 'stylized fact' that comes out very clearly in the data is the positive relationship between GDP per capita and R&D (Fig. 3). Indeed, R&D efforts in the poor regions are very close to zero while, in some advanced regions, up to 2·5% of the business labour force is made up of R&D personnel.

The evidence considered so far indicates a strong polarization between regions with high and low levels of GDP per capita (or rich and poor regions). There are, however, some tendencies that qualify this pattern, and these are worth briefly mentioning. First, it should be noted that GDP per capita actually grows faster in

Table 1. Summary statistics for 64 European regions

Variable	Regional group (quartiles) means				Total sample	
	1st (high) quartile	2nd quartile	3rd quartile	4th (low) quartile	Mean	Standard deviation
GQ	0·0186	0·0182	0·020	0·022	0·0196	0·0066
GE	0·0079	0·0051	0·008	0·012	0·0082	0·0097
GN	0·0072	0·0056	0·010	0·016	0·0098	0·0093
Q	15·510	12·685	10·871	7·953	11·755	3·089
Wage[1]	23·993	23·066	20·871	19·669	21·713	2·441
RDE	1·013	0·548	0·338	0·081	0·495	0·588
PA	0·571	0·162	0·116	0·150	0·250	0·408
UE	0·070	0·075	0·107	0·144	0·099	0·042
MIR	−0·00053	0·00084	0·00096	−0·00187	−0·00015	0·0039
AGR	0·057	0·094	0·129	0·227	0·127	0·086
IND	0·361	0·361	0·334	0·267	0·331	0·073
SER	0·582	0·545	0·537	0·505	0·542	0·076

Note: 1. Results for the *Wage* variable exclude observations for France, as French wage data was unavailable.

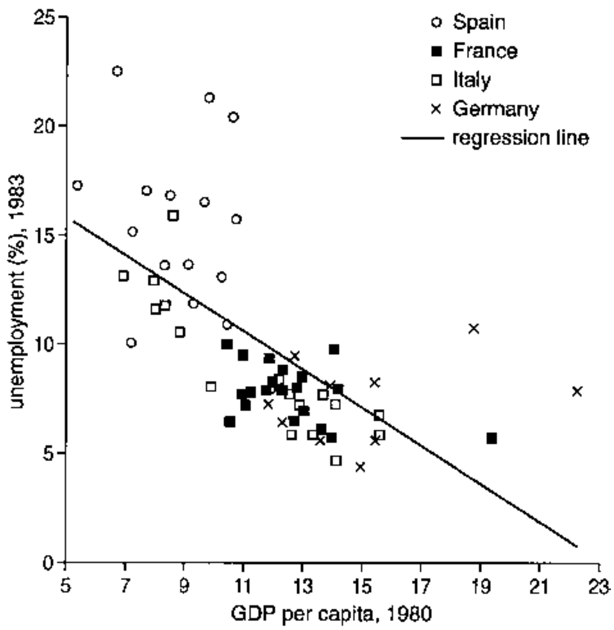

Fig. 2. Unemployment and GDP per capita across European regions

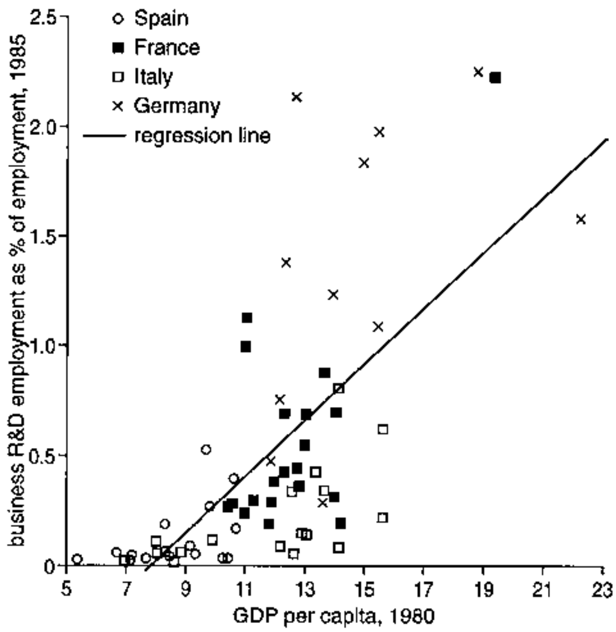

Fig. 3. Innovation and GDP per capita across European regions

the poor regions than in the others, although the difference is not large. Employment grows faster too, but so does the labour supply, so on balance unemployment in the poor regions is on the increase. Second, migration flows are not mainly from poor regions to rich ones, as one might expect. Rather it is the regions in the middle – those with close to average GDP per capita – that attract most migration.

EXPLORING THE RELATIONSHIP BETWEEN TECHNOLOGY, GROWTH AND EMPLOYMENT

Regions may benefit from technology in two different ways. First, regions may benefit from innovation, proxied by R&D efforts, which is assumed to lead to higher growth in the region of origin. Hence, technology is not regarded as a pure 'public good', as in the traditional neoclassical perspective. Second, regions may benefit from diffusion; backward regions have a lot to learn by imitating the more advanced technologies already in use elsewhere. As in most of the literature on technology gaps, we use the distance in GDP per capita between the region in question and that of the frontier region as a proxy for the potential for imitation (i.e. we include the log of initial GDP per capita in the equation for growth).

Whether this potential is exploited or not depends on a number of factors. Although R&D is taken here as a measure of innovative efforts, it is also important for imitation, since a certain level of R&D is a precondition for successful imitation in many cases (COHEN and LEVINTHAL, 1989). Another factor that has been identified in the literature is investment in physical capital. However, recent theoretical work (ROMER, 1990; GROSSMAN and HELPMAN, 1991) has disputed the explanatory value of investment on the grounds that it is an effect, and not a cause, of economic growth. In a previous paper (FAGERBERG and VERSPAGEN, 1996) we showed that differences across European regions in investment activity did not contribute to the explanation of differences in growth of GDP per capita. The same was shown to be the case for regional support from the European Union.[7] We do not repeat these exercises here, partly because this would not add much to existing knowledge in this area, and partly because doing so would have implied a considerable reduction in the size of the sample (since these additional variables are not available for all regions).

We extend our previous analysis in two ways. First, we take into account the suggestion from the literature on regional economics that migration may be a source of convergence in GDP per capita in its own right (BARRO and SALA-I-MARTIN, 1991). Assume, for the purpose of illustration, that migrants are not economically active. Then, if people leave regions with low levels of GDP per capita and join those with high levels, GDP per capita will increase in the former and decrease in the latter, i.e. convergence in GDP per capita will occur. However, if migrants are very productive people, perhaps because they are better educated and/or more innovative than others, this might be different. Evidence from the USA and Japan seems to indicate that the latter may be closer to the truth than the former (BARRO and SALA-I-MARTIN, 1991, 1992).

Second, following some of the recent literature on economic geography (KRUGMAN, 1991, among others), we allow for the possibility that scale economies may result in higher growth in areas with high population density (so-called agglomeration). Some preliminary work on US data seems to support this suggestion (CICCONE and HALL, 1996). As in our previous work, we also include a structural variable, the share of agriculture in GDP, which is assumed to act as a constraint on productivity growth (because of the limited scope for technological progress and growth in agriculture). We also considered other structural variables: the shares of industry and services in GDP (*IND*, *SER*); and the *STRUC* variable suggested by BARRO and SALA-I-MARTIN (1991, 1992).[8] Basically, the latter is a synthetic measure of the economic structure of the region, with the relative size of each sector weighted by the average growth of that sector for the EU as a whole. If we apply a small open economy perspective to European regions, then this variable may be interpreted as reflecting the growth of external demand for a region's products. However, since – as might be expected – these structural variables turned out to be closely correlated, we chose to include only one of them (*AGR*). The equation for growth, then, is the following:

$$GQ_i = c_1 + \alpha_1 \log(Q_i) + \alpha_2 RDE_i + \alpha_3 PA_i + \alpha_4 AGR_i + \beta_1 MIR_i \quad (1)$$

Although migration may play a role in the growth process, there is also ample evidence of a feedback from growth on migration. For instance, potential migrants take job availability into account when they make their decisions, and job growth depends on economic growth. Other variables that have been identified in the literature as important for migration flows include unemployment, wage-levels and population density (BARRO and SALA-I-MARTIN, 1991, 1992; BLANCHARD and KATZ, 1992; NEVEN and GOUYETTE, 1995). In short, people are assumed to migrate from areas with high unemployment, low wages and high population density (congestion problems) to areas where job opportunities and pay are better and living conditions more pleasant. The evidence concerning the impact of these factors is somewhat contradictory, though. BLANCHARD and KATZ, 1992, in a very thorough study based on US data, point to differences in unemployment, rather than wages, as the main impetus to migration. NEVEN and GOUYETTE, 1995, reach the opposite conclusion in the case of Europe, but their sample was limited to two countries only (UK and Italy). BARRO and SALA-I-MARTIN (1991, 1992) do not include unemployment as a possible source of migration. They conclude that 'the main results for Japan and the United States are similar: people move away from highly populated areas and into high-income areas' (1992, p. 339).

This leads us to use the following equation for migration:

$$MIR_i = c_2 + \gamma_1 PA_i + \gamma_2 RW_i + \gamma_3 UE_i + \beta_2 GE_i \quad (2)$$

RW – relative wages – is the (log of) the wage level in the region divided by the average wage level in the country to which the region belongs.[9] Since cross-country migration flows are not included in our migration figures, it was deemed natural to adjust the wage variable by taking out the part of the total variance that refers to cross-country differences in wage levels.

However, we are interested not only in the relationship between growth of GDP per capita and migration behaviour, but also in the outcome for employment. We therefore include a separate equation for employment growth. While it seems reasonable to model migration behaviour from the standpoint of the individual job-seeker, employment growth is, to a much larger extent, the result of decisions by firms. From this perspective, low wages should, *ceteris paribus*, be considered advantageous for job creation. Unemployment, on the other hand, may have a dual impact. On the one hand it signals availability of labour; on the other it suggests a state of economic depression that may not be so good for business after all (BLANCHARD and KATZ, 1992). A high population density may be good for employment growth, since it attracts firms and industries for whom proximity is an important competitive factor, and allows for a deeper specialization of labour. Higher overall growth (GDP per capita) should, *ceteris paribus*, be expected to be good for employment. Finally, we take into account the fact that European agriculture was under severe pressure during the 1980s, and that this may have affected employment growth in agricultural regions negatively. The equation we use is:

$$GE_i = c_3 + \delta_1 UE_i + \delta_2 RW_i + \delta_3 AGR_i + \delta_4 PA_i + \beta_3 GQ_i \qquad (3)$$

As is customary in work on pooled samples, we estimate the above regressions including country-dummies.[10] This implies that we do not try to explain why, say, all Spanish regions grow faster than all German ones, but focus on growth differences between regions within countries. Thus, to the extent that there are important differences between these countries at the country level (such as growth of overall demand, for instance), these will be accounted for by the dummies. To avoid simultaneous equation bias, we estimate equations (1)–(2) using a 2SLS (instrumental variables) procedure, using all the exogenous variables included in the three equations, plus *IND* and *STRUC* as instruments.[11] The results of the estimations of these equations are reported in Table 2. Basically, the results confirm many of our priors. Both the scope for imitation and R&D turn up as important for growth. Migration is found to have a strong, positive impact on GDP per capita growth, consistent with previous findings. A high share of agriculture in GDP acts as a constraint on growth, as expected. However, there is not much support in these data for the agglomeration hypothesis. In fact, population density has a negative sign (although it is not significant).

The estimates for the migration equation confirm the hypothesis that people migrate from regions with high unemployment to areas where job opportunities are better (employment growth). The other two variables, relative wages and population density, both have the expected signs, but neither of them is significant. Hence, as in the study by BLANCHARD and KATZ, 1992, on US data, unemployment appears to be more important than relative wages in stimulating migration. Thus, our results do not confirm those reported by NEVEN and GOUYETTE, 1995, for a smaller sample (two EU countries).

Employment growth responds positively to growth in demand (GDP per capita), and negatively to high relative wages. The assumed negative effect on employment of agriculture is also confirmed. Population density has a positive effect, as suggested, but this effect is not very significant. Also unemployment failed to have a significant impact on employment growth, perhaps because the two mechanisms mentioned above counteract one another.

By solving the equations (1)–(3) for the endogenous variables, using the estimates from Table 2 above, we may get a better grasp of what explains the differences in growth and employment across European regions. These reduced-form equations may then be used to decompose predicted growth in GDP per capita and employment into its various components (i.e. our exogenous variables). The reduced form equations are reported in Table 3, while Table 4 gives the decomposition of the growth rates into the different effects.[12] The first column (mean) in Table 4 shows how the model explains the growth of GDP per capita for an 'average' European region (defined as having mean values of all variables). Both the potential for catch-up and R&D efforts emerge as important for growth, as do the economic structure (share of agriculture in GDP) and the level of unemployment. There is also a sizeable constant term (including country dummies) which we will have more to say about below.

More interesting, perhaps, is how this model explains the differences in GDP per capita growth between

Table 2. Estimation results[1]

Dependent variable	Adjusted R^2	*n*	Endogenous variables: *GQ*	*MIR*	*GE*	Exogenous variables: log(Q)	*RDE*	*AGR*	*UE*	*PA*	*RW*
GQ	0·31	64		0·96		−0·015	0·008	−0·027		−0·0014	
t-values				2·51**[2]		2·39**	2·80***	2·06**		0·28	
MIR	0·38	64			0·388				−0·07	−0·0014	0·0024
t-values					5·15***				5·17***	0·56	0·44
GE	0·71	64	0·624					−0·060	−0·03	0·0031	−0·057
t-values			3·49***					4·00***	0·83	1·19	4·00***

Notes: 1. Estimated by instrument variables (2*SLS*) with all exogenous variables and *IND* and *STRUC* as instruments.
2. Two and three stars denote significance at a 5% or 1% level in a two-tailed *t*-test, respectively, using heteroscedasticity consistent standard errors. Country dummies are not explicitly documented.

Table 3. Reduced form equations for growth of GDP per capita and growth of employment

Dependent variable	Exogenous variables log(Q)	*RDE*	*AGR*	*UE*	*PA*	*RW*	*DIT*	*DFR*	*DES*	constant
GQ	−0·0195	0·0102	−0·0643	−0·10	−0·0021	−0·0247	0·0165	0·0044	0·0231	0·0707
GE	−0·0122	0·0063	−0·1001	−0·09	0·0018	−0·0724	0·0081	−0·0015	0·0284	0·0487

Table 4. Why growth rates of GDP per capita and employment differ (%)

	GDP per capita		Employment	
	Mean (1)	Low–high (2)	Mean (1)	Low–high (2)
Catch-up	1·3	1·3	0·8	0·8
R&D	0·5	−0·9	0·3	−0·6
Population density	−0·1	0·1	0·0	−0·1
Structure	−0·8	−1·1	−1·3	−1·7
Unemployment	−1·0	−0·7	−0·9	−0·7
Wages	0·0	0·3	0·0	0·9
Constant	1·0		1·1	
Country specific	1·1	1·4	0·8	1·9
Total of above	*2·1*	*0·3*	*0·9*	*0·5*
Actual	2·0	0·3	0·8	0·4

Notes: 1. Decomposition of the growth rates of an 'average' region in our sample (point of gravity of the regression).
2. Decomposition of the difference in growth rates between 'rich' and 'poor' regions in our sample.

rich and poor regions. This is illustrated in the second column of Table 4 (low–high). Catch-up emerges as the most important factor for the poor regions, but this advantage is to a large extent eroded by the much higher R&D efforts in the rich regions. The performance of the poor regions is also significantly negatively affected by their industrial structure (characterized by a large agricultural sector) and high levels of unemployment. Finally, the growth of the poor regions is positively affected by country specific factors.

Regarding the latter, it can be shown that the country-specific factors partly responsible for the difference in GDP per capita growth between poor and rich regions all relate to one country (or dummy variable), i.e. Spain. This is not necessarily so surprising, since most of the poor regions in our sample are Spanish. It should be noted, also, that the very inclusion of country-specific factors in the regressions implies that the differences in, say, growth of GDP per capita between Spain and other countries will be explained by these dummies and not by the other variables included in the regressions. Thus, what this result tells us is simply that, on average, all Spanish regions grew faster than regions from other countries. Why this is so we do not know. But is tempting to suggest that catching up (between Spain and more advanced countries such as Germany) during the 1980s, as well as the entry of Spain into the European Community, may have been factors in this. At least, the potential for catch-up was substantial. In fact, in 1980 GDP per capita in Spain was only 60% of that in Germany.

The third and fourth columns in Table 4 give similar predictions for employment growth. In general, the estimation results show that what is good for GDP per capita growth tends to be good for employment growth as well. However, catch-up and R&D have a smaller impact on differences in employment growth than on differences in growth of GDP per capita. Moreover, although relative wages do not matter much for growth, this variable has a sizeable impact on employment. This favours employment growth in the poorer regions. Also, an unfavourable industrial structure (i.e. a large agricultural sector) is even more damaging for employment growth than for growth of GDP per capita. The table also reveals that employment actually grows faster in poor regions. However, this is more than outweighed by more rapid growth of the labour supply there (see Table 1). As a result, differences in unemployment levels between poor and rich regions tend to increase, rather than the other way around.

CONCLUSIONS

This paper has tried to explore the relationship between technology, growth and employment growth across European regions. We have been motivated by the fact, laid out in the second section of this paper, that levels of GDP per capita and unemployment seem to be inversely related, i.e. that poor regions also tend to have high unemployment, and vice versa. Another source of inspiration has been our previous finding (FAGERBERG and VERSPAGEN, 1996) that unemployment seems to affect economic growth negatively. Taken together these findings suggest the possibility of a 'high unemployment–low GDP per capita trap' in Europe. Arguably, this may have strong implications for European 'cohesion'.

The explanation offered by the model for the negative correlation between growth and unemployment, is that unemployment affects growth negatively through its negative impact on inward migration (and positive impact on outward migration). In fact, net inward migration was found to have a strong, positive impact on growth. Unemployment acts as a factor that limits net inward migration and, hence, growth.

Regarding the persistence of high rates of unemployment in regions with low GDP per capita, the explanation seems to be that although employment grows somewhat faster in poorer regions (a fact attributed by our model mainly to a large scope for catch-up and relatively low wages, in combination with country specific factors), it does not grow rapidly enough to keep up with the growth of labour supply, which is also higher in more backward regions. Hence, unemployment rates in backward regions tend to increase rather than the other way around.

What are the policy implications of this study? First, note that some of the traditional policy recipes, such as encouraging migration and reducing wages in areas with high unemployment, do not necessarily alleviate the problem of a 'high unemployment–low GDP per capita trap'. In our model, migration flows are assumed to have a symmetrical impact on growth, i.e. inward migration increases growth, while outward migration decreases it. The estimated impact is quite large, although the flows are rather small (compared, for instance, to the number of unemployed in high unemployment areas). Hence, increased migration would be likely to increase the differences in GDP per capita between rich and poor regions, while having only a relatively modest impact on the recorded levels of unemployment in poor regions.[13] A reduction in wages, on the other hand, might have a more substantial effect on unemployment. But, in our model, this reduction in unemployment in the poor regions (due to a lowering of wages there) will occur at the expense of the workers in rich regions. The explanation is again one of symmetry, reduced relative wages – and more jobs – in the poor regions *cœteris paribus* transmits itself into increased relative wages in rich regions and, hence, fewer jobs in the latter. Thus, increased inequality between workers in poor and rich regions – through a widening of the difference in wage levels – will not cure the present high level of unemployment in the European Union, but it may contribute to a different regional distribution of unemployment. Whether this is an acceptable policy option or not is not for us to decide. However, it may be difficult to combine such a policy with the current aim in the EU to create a truly common European labour market.

Fortunately, our analysis indicates that there are other policy options that may have a more promising impact. First, encouraging R&D in backward regions appears crucial. Today, R&D is very unevenly distributed across Europe, with little or no R&D in most poor regions. However, without well-developed R&D capabilities, backward regions will find it increasingly difficult to exploit the potential for learning offered by more advanced technology developed elsewhere. Moreover, in contrast to migration or relative wages, this is not a zero-sum game. Hence, an increase in R&D in, say, the poor regions will – according to our model (and much recent theorizing in this area) – lead to higher growth in poor areas without necessarily decreasing growth elsewhere. However, it needs to be stressed that encouraging R&D in backward regions is not simply a matter of subsidizing these activities. R&D is typically an activity that can only be undertaken in the context of an adequate infrastructure, i.e. when sufficient high quality labour and supporting institutions such as higher education institutions are available. Policies aimed at R&D thus have an essential long-run and structural character, both in terms of implementation and effect.

Second, the findings presented here point to economic structure, i.e. the dominant role played by agriculture in many poor regions, as an important barrier to growth of employment and GDP per capita in backward regions. Thus, rather than conserve the existing economic structure by such means as the Common Agricultural Policy, policy should be aimed at changing it.

It is, however, pertinent to stress that these conclusions rest on a number of assumptions which, although defendable, are not always tested (or even testable). One main reason for this is lack of data. For instance, if (for some variable) data is available for a single year only, econometric testing is necessarily limited. Rather than following the common practice of ignoring important variables for which data are scarce, we have in this paper tried to do much with little. Without denying the limitations that this places on the generality of the analysis, we nevertheless hope that this paper may provide some useful inputs to the debate about EU policy and regional policy in particular.

Acknowledgements – Financial support from European Union's Targeted Socio-economic Research Programme is gratefully acknowledged, as is support from the Norwegian Research Council. Bart Verspagen's research has been made possible by a fellowship of the Royal Netherlands Academy of Arts and Sciences.

NOTES

1. Note that a similar, though not identical, process can be shown to have taken place in the US and Japan (Barro and Sala-i-Martin, 1992). This suggests that the factors responsible for these developments may be rather general in nature, rather than country or region specific. This is not inconsistent with the perspective we apply here, but we do not attempt to explain developments outside Europe.
2. Dunford, 1996, provides additional evidence on the relationship between GDP per capita and unemployment across European regions.
3. In the REGIO database, regions are identified in the NUTS-scheme. We use both NUTS 2-digit and 3-digit level regions, depending on data availability and the country. A listing of regions is in the Appendix table.
4. The only variable in this latter group that reflects change is the growth of labour supply (*GN*). This variable, it may be noted, is not included in any of the models/regressions presented later, but used to illustrate the joint

impact of growth in the demand for and supply of labour on unemployment.

5. GDP per capita is closely related to income per head. This is why we sometimes denote regions with low GDP per capita as 'poor' and regions with high GDP per capita as 'rich'. We use national price indices and purchasing power parities to the Ecu, because region-specific data for these variables are lacking.
6. Unemployment, employment and the labour force data in the EUROSTAT REGIO database generally are not available for years before 1983, so we are forced to use the 1983 value as the initial year.
7. This applies to support through the so-called European Regional Development Fund, which is the main source for regional support at the EU level. Loans from the European Investment Bank (and supporting schemes), though much smaller in size, were found to have a more positive impact, however.
8. This is defined as $\Sigma_j \sigma_{ij} y_j$, where y_j is the European wide growth rate of GDP in sector j (agriculture, industry or services), and σ_{ij} is the share of sector j in GDP in region i.
9. Since we lacked wage data for France, we estimated these data on the basis of a linear regression of *RW* on a similarly constructed variable for GDP per capita for the other countries in our sample.
10. Technically speaking, we have three country dummies and a common constant term, which amounts to the same thing.
11. We cannot include *SER*, since *SER*, *IND* and *AGR* sum to one.
12. In order to quantify the effect of catching-up, we substituted the log of GDP per capita by a similar variable, but expressed relative to GDP per capita in the 'richest' region in the sample. At the same time, we add the log of GDP per capita in the 'richest' region in the sample multiplied by the catching-up coefficient to the constant term, thus leaving the statistical and arithmetical characteristics of the equation unchanged.
13. If the impact is not symmetrical, for instance because inward migration has a larger quantitative effect than outward migration, migration may also have an impact on the average growth rate of GDP per capita. However, as long as this does not change the qualitative impact of migration flows, one would still expect migration to drag down growth in poor regions (although less than in the case of symmetrical effects).

APPENDIX

Regions used in the regression analysis

Number	NUTS code	Country	Region
1	r11	Germany	Baden-Wuerttemberg
2	r12	Germany	Bayern
3	r13	Germany	Berlin
4	r15	Germany	Bremen
5	r16	Germany	Hamburg
6	r17	Germany	Hessen
7	r19	Germany	Niedersachsen
8	r1a	Germany	Nordrhein-Westfalen
9	r1b	Germany	Rheinland-Pfalz
10	r1c	Germany	Saarland
11	r1f	Germany	Schleswig-Holstein
12	r311	Italy	Piemonte
13	r313	Italy	Liguria
14	r32	Italy	Lombardia
15	r331	Italy	Trentino-Alto Adige
16	r332	Italy	Veneto
17	r333	Italy	Friuli-Venez. Giulia
18	r34	Italy	Emilia-Romagna
19	r351	Italy	Toscana
20	r352	Italy	Umbria
21	r353	Italy	Marche
22	r36	Italy	Lazio
23	r37	Italy	Abruzzo-Molise
24	r38	Italy	Campania
25	r391	Italy	Puglia
26	r392	Italy	Basilicata
27	r393	Italy	Calabria
28	r3a	Italy	Sicilia
29	r3b	Italy	Sardegna
30	r21	France	Ile de France
31	r221	France	Champagne
32	r222	France	Picardie
33	r223	France	Haute Normandie
34	r224	France	Centre
35	r225	France	Basse Normandie
36	r226	France	Bourgogne
37	r23	France	Nord-Pas-de Calais
38	r241	France	Lorraine
39	r242	France	Alsace
40	r243	France	Franche-Comté
41	r251	France	Pays de la Loire
42	r252	France	Bretagne
43	r253	France	Poitou-Charentes
44	r261	France	Aquitaine
45	r262	France	Midi-Pyrénées
46	r263	France	Limousin
47	r271	France	Rhône-Alpes
48	r272	France	Auvergne
49	r281	France	Languedoc-Roussillon
50	rb11	Spain	Galicia
51	rb12	Spain	Principado de Asturias
52	rb13	Spain	Cantabria
53	rb21	Spain	Pais Vasco
54	rb22	Spain	Comunidad Foral de Navarra
55	rb23	Spain	La Rioja
56	rb3	Spain	Comunidad de Madrid
57	rb41	Spain	Castilla y León
58	rb42	Spain	Castilla-la Mancha
59	rb43	Spain	Extremadura
60	rb51	Spain	Cataluña
61	rb52	Spain	Comunidad Valenciana
62	rb53	Spain	Islas Baleares
63	rb61	Spain	Andalucia
64	rb62	Spain	Región de Murcia

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