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The impact of convergence in the industrial mix on regional comparative growth: Empirical evidence from the French case

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Abstract. The aim of this article is to explain heterogeneities in French regional labor productivities since the mid-seventies at both aggregate and sectoral level. This paper extends the works of Baumol and of Barro and Sala-i-Martin, firstly by pointing out sources of growth linked to the new growth theories (research effort, size effects) and secondly by emphasizing the impact of cross-sectoral labor reallocations through a shift-share analysis. Our results show the importance of regional asymmetries and the key role played by the dynamic of sectoral composition in the convergence of labor productivities within France.

JEL classification: R11, O4

1. Introduction

Until recently, the empirical studies of growth and convergence initiated by Baumol (1986) and Barro and Sala-i-Martin (1991) paid little attention to structural aspects, and especially to the sectoral dimension of economies, with analyses being based rather on aggregate data. Dollar and Wolff (1994) and Bernard and Jones (1996 a,b) are early exceptions at a national level. Recent papers drawing on regional data have emphasized the importance of a disaggregate analysis at sectoral level (Paci and Pigliaru 1997; Cuadrado-Roura et al 2000; Esteban 2000; Sorenson 2001; De la Fuente 2002; Tumpel-Gugerell and Mooslechner 2003; Carluer 2004). They suggest that to take the continuous process of sectoral reallocation of resources into account could be decisive in understanding growth and convergence.

Moreover, the regional level constitutes an appropriate framework for the study of convergence, from both the empirical and theoretical points of view. Empirically, it is easier to compare data derived from the same sources than to undertake international comparisons. Theoretically, the assumptions such as those regarding the homogeneity of infrastructures, as well as the

institutional framework, preferences and available technologies are directly relevant for highly integrated regional economies.

It is especially interesting to examine the convergence of the French regions since France has the secular feature of a center, the Ile-de-France region (Paris), clearly defined by its size, its localization and above all its widely accepted leadership in technology and industrial commandment. This being so, there is every incentive to analyze polarization phenomena and, more generally, spatio-economic asymmetries.

The paper contributes to the literature on growth and convergence mainly by pointing out non-standard convergence mechanisms that may help discriminate between alternative theoretical models and/or call some of them into question: convergence between French regional productivities is shown to be a consequence of structural change (reallocation of factors) and not of decreasing returns, as in Solow's growth model.

Our approach is a three-stage one. First of all, the results of a descriptive analysis of convergence (Sect. 1) suggest the existence of regional specificities, on the one hand, and of structural effects, on the other hand. We analyze the main sources of regional growth through a conditional convergence equation (Sect. 2) and then through the structural mechanisms leading to convergence (Sect. 3). Thus we measure the impact of innovation and of market size on the regional growth, and we stress the major role played by change in the regional industrial mix in comparison with uniform productivity gaps in explaining the interregional differences.

2. Relative performances and absolute convergence

2.1. Data presentation

This study draws on regional sectoral data provided by the French National Institute of Statistics and Economic Studies (INSEE) for gross value added at 1990 constant prices and total employment for 35 sectors and 21 regions (see the map in Annex 1) and by the Ministries of Industry and of Education (gross fixed investments[1], number of researchers and of graduates). This detailed database had not been exploited until recently despite its advantage of national homogeneity and its ability to account for the efficiency of decentralization policies and the upward influence of the Ile-de-France.

Nevertheless, the data are limited in their time dimension; they are available only from 1975 to 1992 for the secondary sector and from 1982 to 1992 for the primary and tertiary sectors (1982 appears however very relevant since this year marks the beginning of decentralization policy in France). Besides, disaggregate productivity and investment data are characterized by considerable variability in the time dimension (in particular when a sector

[1] The investment data were not used to compute capital stocks because the deflator for investment had neither a sectoral nor a regional dimension, as well as the difficulty of applying the permanent inventory method to a period that was too short.

accounts for only a small share of total activity in a given region). Consequently, a smoothing procedure[2] is used for those time series.

2.2. Relative productivities and sectoral dispersions

First of all, the labor productivities of the twenty-one French regions are examined at the aggregate level (Fig. 1). Regions are ranked according to growing productivities[3] for 1982. Deviations from the national average are relatively large but, if we exclude Ile-de-France and Limousin, they decreased from 1982 to 1992.

At a more disaggregate level, we see that the wider productivity gaps concern the primary sector (degrees of dispersion are measured by the standard errors of logarithms of productivities, Fig. 2). Gaps are moderate in the whole of the secondary sector (but not in all individual industries) and are smaller for the tertiary sector.

The strong agricultural specificities (wine-producing, stock farming or mountain agricultural regions) and the marked regional specializations in manufacturing or energy appear as the main causes of dispersion. As far as services are concerned, each activity is regionally present (absence of or weak specialization; see Kim 1998) and there is no reason for productivities to differ (note, however, the growing advantage of Ile-de-France). Non-market services generate small gaps since productivity norms are common for the public services.

2.3. Beta and sigma-convergence

In order to evaluate more precisely the convergence of productivities we apply the two concepts of (absolute) beta and sigma-convergence.[4] The former refers to the existence of a negative relationship between the initial level of productivity and the subsequent growth (we regress average growth rates for regions over a given period on logarithm of initial productivities and a common intercept). The beta-convergence is a necessary but not sufficient condition for the sigma-convergence to be verified. The latter merely indicates reduction in the cross-sectional variance of productivities between two dates. Note that in the case of strong asymmetric regional shocks, the dispersion of productivities cannot diminish even in the presence of beta-convergence. The

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[2] The smoothing is based on the 'moving average' method, worked out for three years, with weightings of 0.25, 0.5 and 0.25 respectively for the dates $t-1$, t and $t+1$. The initial (1975 or 1982) and final (1992) levels are not modified, so the procedure does not alter cross-sectional regressions.

[3] At an aggregate level, the ranking of regions on the basis of productivities (GDP per worker) does not match the ranking based on *per capita* GDP. The difference results from heterogeneity in participation and unemployment rates. However, the correlation between our productivities and *per capita* GDP taken from Barro and Sala-i-Martin (1995) is 0.97.

[4] These measures cannot sum up the evolution of the inequalities in regional productivities. An extended study, focusing on convergence clubs for example, will require the use of tools developed by Quah (1996 a,b; 1997), Durlauf and Quah (1999), or Fiasci and Lavezzi (2003). In the present case, the small number of regions prevents us from undertaking such an exercise.

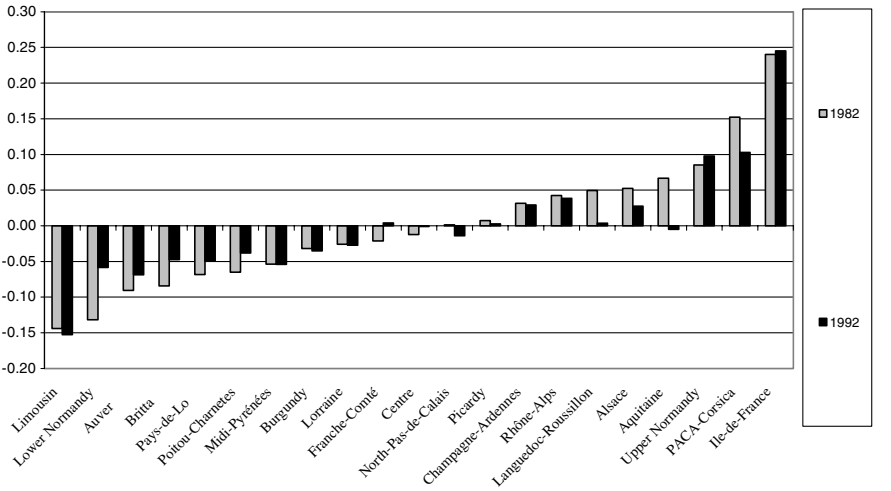

Fig. 1. Aggregate productivities relative to the French average (log differences in 1982 and 1992)

following findings illustrate such situations. Estimates are performed on our cross-section of 21 regions.

For the period 1982–1992, we find a marked convergence of aggregate labor productivities since beta-convergence is present at a speed of 1.8%[5] and there was a 25% decrease in the cross-regional variance in productivities (the variance ratio – final over initial variance – is 0.75). Beta and sigma-convergence are significant at levels of 3 and 4% respectively. Yet, this result hides some important spatial, temporal and especially sectoral heterogeneities.

From a spatial point of view, the observed convergence does not imply that the lagging regions tend to catch up with the leading region. In fact, the Ile-de-France increased its lead between 1982 and 1992 (Fig. 1). The estimated convergence speed grows up to 3% when this region is excluded from the sample and the variance reduction increases to 41% (Table 1). Thus, the performances of the other regions drew closer but the pre-eminence of the Parisian pole remained undisputed (no balancing effect of decentralization policy can be noted).

The time dimension of convergence is also studied. While there was strong convergence in the manufacturing sector between the two oil-shocks, regional productivities tended to diverge during the eighties. Similarly, while the variance ratio for services fell until 1984, it rose considerably from then until the beginning of the 1990s. As far as the primary sector is concerned, the variance ratio fluctuates without exhibiting any trend.

At the sectoral level the main fact, which will repay close analysis, is the paradox of convergence at an aggregate level and its apparent absence at a more detailed level. The presence of sectoral composition effects is con-

[5] This annual speed is very near to the famous '2%' of Barro and Sala-i-Martin (1991), present in numerous samples of regions and countries.

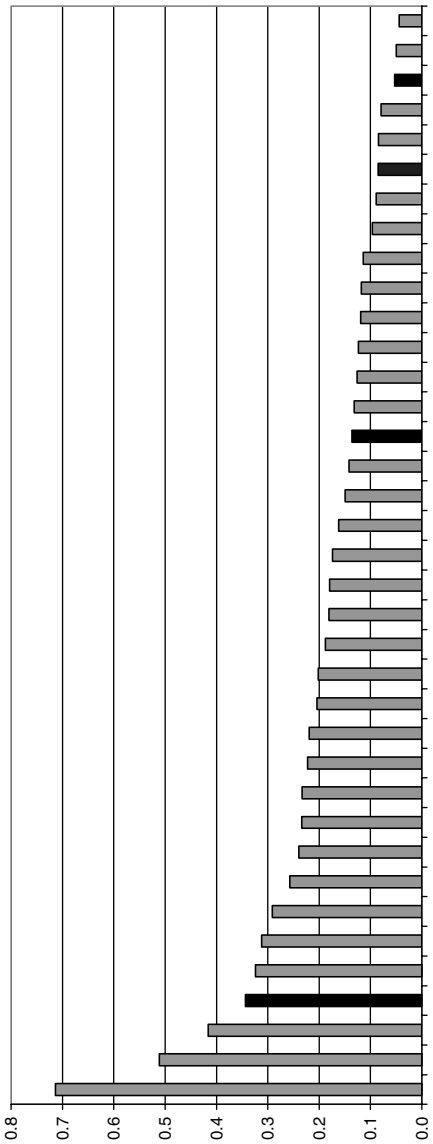

Fig. 2. Dispersion of sectoral productivities: standard errors of logarithms (average 1982–1992)

Table 1. Beta and sigma-convergence of French regional productivities (1982 to 1992)

	With Ile-de-France		Without Ile-de-France	
	Convergence speed (%)	Variance ratio	Convergence speed (%)	Variance ratio
Aggregate	1.8**	0.75**	3.0***	0.6**
Manufacturing	−0.4	1.3*	−0.0	1.3
Services	0.2	1.2	3.7***	0.6**
Farming, forestry, fisheries	0.8	0.9	0.1	1.0
Oil and natural gas	−1.0*	1.9*	−0.9*	1.9
Electricity, gas, water	−21. *	5**	−2.1**	6**
Meat and diary products	1.5	1.5	3.8*	1.2
Other food products	−0.5	2.3**	−0.4	2.4**
Ores and ferrous metal	3.0*	1.0	3.5*	0.9
Ores and non ferrous metals	−0.0	1.1	0.0*	1.2
Building materials	1.1	0.9	1.1	0.9
Glass	−0.5	1.5	−0.5*	1.7*
Basic chemicals, synthetic fibres	3.5*	1.1	3.4*	1.2
Chemicals and pharmaceuticals	7.0***	1.3	7.1***	1.3
Metal works	4.5*	1.5	4.9*	1.4
Mechanical industries	4.0**	1.1	4.2**	1.0
Electric and electronic	3.5***	0.7**	3.5***	0.7**
Motor vehicles	4.1*	1.2	5*	1.2
Transport equipment, arms	2.6**	0.8*	2.5**	0.7**
Textile and clothing	−0.1	1.1	1.0	1.9
Leather and shoes	3	1.7	5*	1.4
Lamber and wood, miscellaneous	−0.8	1.4	−0.9	1.4
Paper, cardboard	7.1***	0.8	7.2***	0.8
Printing and publishing	0.9	1.2	1.2	1.1
Rubber, plastics	5.8***	0.6**	6.0***	0.7**
Building, civil engineering	2	1.0	3.5***	0.7*
Retail trade	−1.0*	3.8*	8.9*	3.2*
Automobile trade and repair	4.1***	1.1	7.5***	0.5*
Hotels, restaurants	5.6***	0.5***	5.2***	0.6**
Transports	2.5**	0.8*	2.5**	0.8*
Telecommunication and mail	1.2	0.9	1.3	1.0
Business services	5**	0.9**	6.8***	0.3**
Personnal services	6.5***	0.8*	6.5***	0.8*
Housing rental and leasing	3.1**	0.7**	3.1***	0.7**
Insurances	7.2***	0.4***	8.1***	0.7***
Financial services	3.5*	1.1	9.5***	1.2
Non market services	5.1***	0.6***	4.9***	0.7***

***, **, * Respectively significant at 1%, 5% and 10%.
Negative convergence speeds mean beta-divergence; above unity variance ratios mean sigma-divergence.

firmed by the stability of the variance ratio of the sum of the secondary and the tertiary sectors, which contrasts with the divergence trend in both manufacturing and services (Fig. 3).

At a disaggregate level, productivities converge quite strongly in sectors such as paper-pasteboard, rubber-plastic materials or electric and electronic materials as well as personal market services, insurances, hotels and restaurants, and transports. On the other hand, heterogeneities increased for sectors such as food industry, non-ferrous minerals-metals, construction materials,

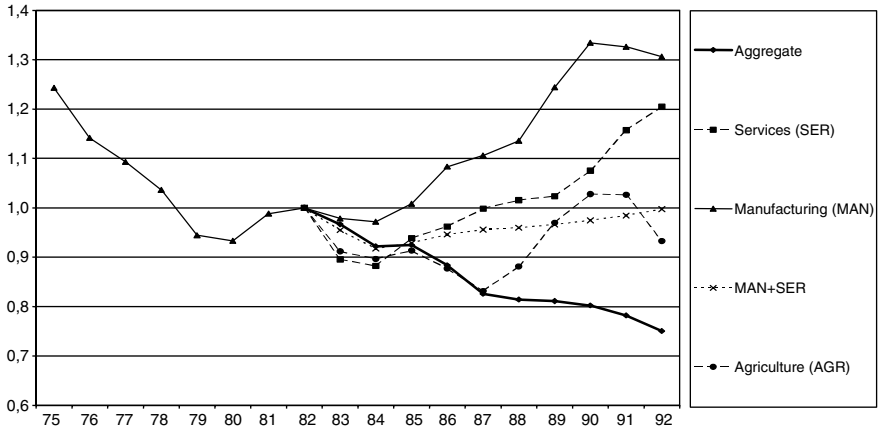

Fig. 3. Evolution of the dispersion of productivities: variance ratios (variance of logarithms of productivities, 1982 = 1)

glass, textile, wood, leather, press-publishing, electricity-gas-water or retailing (Table 1). For chemistry-pharmacy, as well as some other cases, strong beta-convergence (high and significant convergence speed) did not prevent an increase in the variance ratio (sigma-divergence): the regions tended to swap positions but dispersion was not reduced. Convergence in electric and electronic or transport equipment and arms may denote the ease of technology diffusion in high-tech industries. Service industries, in which ICTs are widely used, may also benefit from diffusion while the retail trade exhibits divergence.

Moreover, the exclusion of the Ile-de-France (IDF) regions considerably increases convergence for some service sectors. Convergence appears for building, repairing and trade of automobiles and increases for business services. When the IDF is excluded, we also observe cases such as retail trade or financial services, where beta-convergence becomes evident even if sigma-divergence remains.

The manufacturing sector (excluding energy). A temporal and spatial decomposition remains essential for the manufacturing sector (Table 2). Indeed, there is no significant convergence during the period 1975–1992 whereas a 20% decrease in dispersion (p-value of 5%) is identified with a convergence speed of 2.7% (p-value of 4%) during the sub-period 1975–1982. During this first period, convergence is even more marked when the IDF, the Provence-Alps-French Riviera-Corsica (PACAC) and the Languedoc-Roussillon (LR) are excluded. During the second period, the IDF and Mediterranean regions hinder convergence, since convergence becomes significant when those regions are excluded.

The IDF, the PACAC and the LR are the regions where manufacturing productivities are highest, but also where this sector represents the smallest share of total employment (about 8% in 1992 compared with a French

Table 2. Convergence in the manufacturing sector: influence of the regions Ile-De-France (IDF), Provence-Alps-French Riviera-Corsica (PACAC) and Languedoc-Roussillon (LR)

Regions	All			Without IDF			Without PACAC-LR			Without IDF-PACAC-LR		
Years	1975–1982	82–92	75–92	1975–1982	82–92	75–92	1975–1982	82–92	75–92	1975–1982	82–92	75–92
Convergence speed (%)	2.7**	−0.4	1.0	3.1***	−0.0	1.3*	3.5***	1.8	2.6**	5.0***	4.6**	3.8***
Variance ratio	0.8**	1.31*	1.05	0.72***	1.27	0.91	0.8**	1.15	0.93	0.6***	0.92	0.5*

***, **, * Respectively significant at 1%, 5% and 10%.
Variance ratio are measured in 1982 for the 1975–1982 period and 1992 for the other two periods.
Negative convergence speeds mean beta-divergence; above unity variance ratios mean sigma-divergence.

average of 19%). It can be assumed that only a few overcompetitive firms[6] subsist in the two Mediterranean regions, which are strongly specialized in services.

Services. With regard to services, the strong specificity of the IDF hinders the attainment of convergence. The IDF, which was the most productive region in 1982, experienced the strongest growth thereafter but, when it is excluded, the weak dispersion of productivities continues to decrease (Table 1).

3. Analysis of regional specificities: Conditional convergence

A study of absolute convergence gives little insight into the main determinants of regional specificities. The study must be extended by means of a multivariate analysis in which a set of variables, together with initial productivity level (conditional beta-convergence), are intended to explain heterogeneities in the growth performances of regions and the persistence of productivity gaps. The following estimated equations confirm the presence of a conditional convergence process: controlling for a given set of covariates, lagging regions grow faster. This finding is *a priori* consistent with various theoretical models:

– Solow's model (Mankiw et al. 1992), in which a progressive convergence towards parallel growth paths depending on national characteristics (especially the accumulation effort) stems from decreasing marginal productivity of capital. This convergence is encouraged and potentially strongly accelerated at the regional level because of the perfect mobility of capital (Blanchard and Hall 1991). However, the existence of immobile factors such as human capital or public infrastructures slows down the convergence process.
– The models with endogenous technical progress (Aghion and Howitt 1998) and with a mechanism of technological diffusion[7] (Fagerberg 1995), where a regional social capability is crucial. In such models, imitation is costly and catching-up is gradual and conditional on a set of technical, institutional or human factors (incentives, training etc.).

Here, the evidence of conditional convergence and the role of research and development are consistent with Jones's 'semi-endogenous' model (Jones 1995). In this model, growth is generated in the R&D sector with decreasing returns.

[6] This explanation is consistent with the results of Abd-El-Rahman (1991), who emphasizes the role of overcompetitive firms maintaining a profitable (and export) activity within an undercompetitive sector (national comparative disadvantage – regional in the present case).

[7] However, several endogenous growth models do not present the conditional convergence property: the scale of the externalities could even lead to a positive relation between growth and initial level of productivity (first mover advantage, strong specialization...).

The manufacturing sector (energy excepted). For the manufacturing sector, the investment rate (average 1975–1992) and, even more clearly, R&D both have a positive impact (average 1975–1992). These results (Table 3) confirm the findings of several previous studies. The R&D coefficient gives the marginal effect of R&D on output (Barro and Sala-i-Martin 1995, p.351) and the rate of social return as well (greater than the private return because of the existence of externalities). The figure of 40% estimated for the coefficient appears rather high compared to that obtained by Coe and Helpman (1995) but remains lower than the estimate by Frantzen (2000) for 21 OECD countries (social return on domestic R&D of 59%). Fixed effects and estimated GMM using panel data produce similar results in terms of the R&D sign and significance (Annex 2). All regions benefit from the local externalities associated with R&D, but in a very unequal way. Effects are strong in IDF due to the importance of research in this region (5.4% of manufacturing employment in 1992 relative to the 1.1% French average).

Table 3. Conditional convergence for manufacturing

21 regions	Initial productivity	Investment rate (average)	Share of research workers in total employment (average)	Constant
Coefficient	−0.020	0.212	0.409	−0.037
T-stat (P-value)	−3.06 (0.007)	3.54 (0.003)	5.07 (0.000)	−2.59 (0.019)
Corrected for het.	−2.58 (0.020)	4.14 (0.001)	5.67 (0.000)	−2.29 (0.035)

R^2 = 0.69 (adjusted R^2 = 0.63). *Heteroscedasticity test LM: 1.91 (0.167). Jarque-Berra normality test: 0.26 (0.876). Ramsey test (RESET2): 1.39 (0.255). p-values are in brackets.*

$$\frac{\Delta y^r_{1975-92}}{17} = \beta \cdot y^r_{1975} + \alpha_0 + \alpha_1 \cdot inv^r_{moy} + \alpha_2 \cdot R\&D^r_{moy} + \varepsilon^r \quad (1)$$

where y^r stands for logarithm of labor productivity.

Services. For services, a size variable is included among the explicative variables (Eq. 2) in order to explain the productivity dynamic in terms of the sector's specificities: activity is mainly urban, i.e. concentrated in places with a critical mass (Table 4). Then we find that the larger[8] the regional service sector is, the higher the productivity growth is. This effect can be explained by the strong competition in a large market (pro-competitive effect) and more generally by the positive externalities due to geographic agglomeration. The region is the relevant level for the analysis of externalities in services because services are relatively closed activities. As for the secondary sector, the externalities surely extend to the interregional level, and even to the international level.

[8] The size of the service sector in each region is measured by the logarithm of employment or value added, and the results are robust to this choice. Results were less conclusive with population.

Table 4. Conditional convergence for services

21 regions	Initial productivity	Size (employment)	Ile-de-France dummy	Constant
Coefficient	−0.057	0.003	0.009	−0.138
T-stat (P-value)	−5.64 (0.000)	3.96 (0.001)	4.22 (0.001)	−5.42 (0.000)
Corrected for het.	−9.29 (0.000)	4.25 (0.001)	5.94 (0.001)	−8.36 (0.000)

$R^2 = 0.74$ (adjusted $R^2 = 0.69$). *Heteroscedasticity test LM: 0.90 (0.342). Jarque-Berra normality test: 0.05 (0.975). Ramsey test (RESET2): 0.53 (0.478). p-values are in brackets.*

$$\frac{\Delta y^r_{1982-92}}{10} = \beta \cdot y^r_{1982} + \alpha_0 + \alpha_1 \cdot E^r_{1982} + \alpha_2 \cdot IDF + \varepsilon^r \quad (2)$$

Despite the presence of a size effect, a dummy 'Ile-de-France' is necessary to account for the specific dynamics of the leading region in this sector. This dummy can be considered as a polarization variable, i.e. it shows the importance of the unbalanced densification of activities in the French space. Alternatively, polarization can be taken into account by using distance from Paris as a variable, but the results are less convincing. The immediate periphery of the IDF does not benefit from the region's dynamism in the service sector.

The aggregate level. At a global level, the effects of the variables R&D (logarithm of the ratio between number of research workers and total employment) and distance from Paris (logarithm of the distance in kilometres between Paris and the regional capitals) are highlighted (Table 5). Their impacts, respectively positive and negative, stress the importance of innovation and of the role of proximity to Paris in the diffusion of technologies developed in IDF (the firms of the Parisian basin very often work as subcontractors). However, this second effect is not consistent with the absence of such an impact in the manufacturing and services sectors (the correlation between distance from Paris and the rate of productivity growth is respectively 0.31, −0.30, −0.37 and 0.52 for primary, secondary, tertiary and all sectors; and −0.75 for the sum of non-agricultural sectors). In fact, the nearest regions of the IDF are more industrialized on average, and so their productivity growth rates are more affected by the growth of the manufacturing

Table 5. Conditional convergence at the aggregate level

21 regions	Initial productivity	Share of research workers in total employment (average)	Distance from Paris	Constant
Coefficient	−0.033	0.941	−0.002	−0.035
T-stat (P-value)	−4.45 (0.000)	1.78 (0.093)	−3.07 (0.007)	−2.23 (0.040)
Corrected for het.	−3.92 (0.001)	2.87 (0.011)	−3.30 (0.004)	−2.13 (0.048)

$R^2 = 0.64$ (adjusted $R^2 = 0.57$). *Heteroscedasticity test LM: 1.95 (0.163). Jarque-Berra normality test: 0.83 (0.660). Ramsey test (RESET2): 0.01 (0.962). p-values are in brackets.*

sector, which is always greater than the growth in services. The higher proportion of industrial activities in the regions of the Parisian basin can be explained by economic geography (Krugman 1991; Krugman and Venables 1995): research and managerial activities are concentrated around Paris, while industrial activities are located in the peripheral regions. Regions outside the Parisian sphere of influence do not benefit, that much, from the relocation of mature industrial activities.

$$\frac{\Delta y^r_{1982-92}}{10} = \beta \cdot y^r_{1982} + \alpha_0 + \alpha_1 \cdot R\&D^r_{moy} + \alpha_2 . Dist^r + \varepsilon^r \quad (3)$$

Lastly, we find a positive but insignificant impact of educational level (education is measured by number of regional graduates relative to total population) in all sectors.[9] Even if human capital has a positive influence on regional productivity growth, it is not obvious that the benefits accrue to the training region. This is likely to be an important issue in France, where interregional migration flows, occurring during the training period and after, are considerable (a better and/or well-paid job can be obtained in IDF or in the great metropolis). Regional inequalities in training supply (diversity or merely existence of various programs) especially for higher degrees (IDF accounts for more than 40% of all MBA programs, for example) also explain these migrations. Moreover, we note a convergence of regional educational efforts after 1982 (Fig. 4). That date corresponds to the beginning of the French decentralization policy, and in particular to the greater responsibilities given to regions in education and training management. The difficulties small regions with fewer job opportunities experience in keeping their graduates calls into question the adequacy and effectiveness of public policies promoting equality across regions in the supply of education and training.

The role played by reallocation in the convergence should be borne in mind. Such a role suggests that the estimated equation for the whole productive system should be treated with caution: productivities at the aggregate level are the weighted average of sectoral productivities.

4. Impacts of cross-sectoral labor reallocations

At this point, it appears that aggregate convergence has something to do with structural effects. Convergence is rarely found at a disaggregate level. From a theoretical point of view, such structural effects are not often highlighted as convergence or divergence factors in the literature (Paci and Pigliaru 1999; Cuadrado et al. 1999; Esteban 2000; Landesmann and Stehrer 2001). However, Echevarria (1997) shows that a modified version of the Solowian framework can generate such phenomena and more generally can link growth and structural change.[10] Given that technical progress is greater in the

[9] In the same way, for European regions, Martin (1998) shows that the educational effect is not robust when country effects are introduced.

[10] Using numerical simulations, he evaluates the contribution of structural effects to growth at 2% (the importance of this phenomenon is evident from the fact that very few countries have a long-run growth rate greater than 4%)

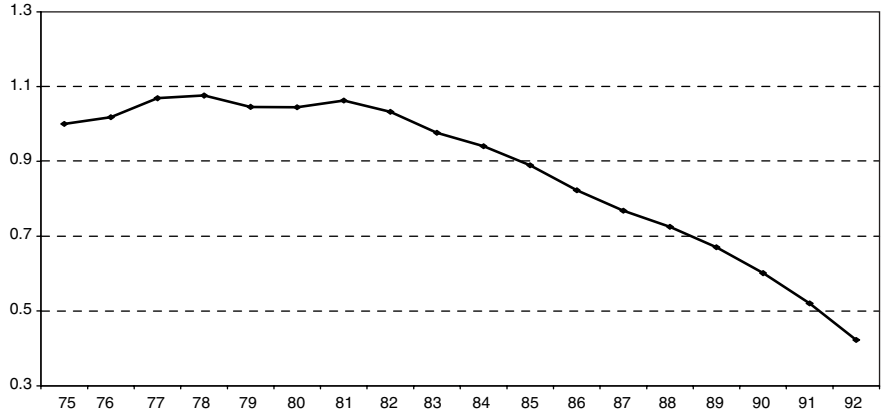

Fig. 4. Regional disparities in education (dispersion of education variable, 1975 = 1)

manufacturing sector, the development process starts with an initial, dynamic industrialization phase, which is followed by a less dynamic second stage characterized by de-industrialization.

4.1. Underlying structural effects

In order to evaluate the importance of changes in the sectoral allocation of resources,[11] fictive productivities series are computed using two alternative hypotheses. In the first one, the initial sectoral mix is assumed to be fixed in all regions. For each region, the aggregate productivities growths are then due only to within-sector dynamics. The opposite assumption consists in taking the average productivity growth rate for each industry in each region and the actual sectoral mix. As a consequence, regional within-industry differences in growth rates are neutralized, and the remaining growth differences are due only to labor shifts (Annex 3).

First of all, structural effects in the 19 manufacturing industries are analyzed. At this level of disaggregation, effects can more easily be considered as driven by specialization. Compositional effects taking place between large sectors (agriculture-manufacturing-services) are likely to be long-run structural ones rather than the results of trade relations. In Fig. 5, we plot together the variance ratios for manufacturing productivities, investment rates, R&D and structural effects, which is the series reconstructed by removing within-sector growth rate differences (labelled 'structural effect' in the legend). Before 1982–1984, the convergence for manufacturing is consistent with the convergence of its main determinants: investment and R&D rates. A stage of divergence starts after 1984; it corresponds to the divergence of the investment rate (from 1982 onwards) and to a an unfavourable structural effect from 1986–1987 onwards. Nevertheless the structural effect had at best a

[11] Without reliable data on the stocks of physical capital we only examine cross sectoral factor allocation change *via* labor allocation.

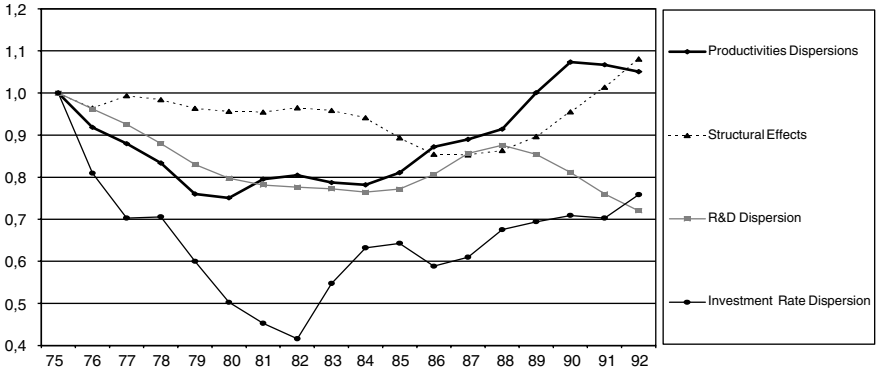

Fig. 5. Determinants of convergence in manufacturing

small impact, even if it may have contributed to the divergence of manufacturing industry productivities in the second half of the 1980s.

In contrast, when the productive system is considered as a whole, the structural effect is obvious and extremely pro-convergence (Fig. 6). Without labor reallocation (labor shares taken in 1982) the variance ratio rises: from convergence (observed productivities), we shift to divergence. When only the structural effect is taken into account, the variance ratio decreases continually. It reached 0.6 in 1992, which corresponds to a very fast sigma-convergence (p-value less than 1%).

These results are confirmed by a beta-convergence analysis of the reconstructed productivities (Table 6). A significant structural effect is found at the aggregate level between 1982 and 1992 but no such effect is found either in manufacturing nor in services. This suggests that the relevant labor-reallocation effects take place not at an inter-industry but rather at an inter-sectoral level. It seems to be the labor shifts from agriculture to manufacturing and then to services that drive the structural effect and convergence.

4.2. The agriculture-industry-services sequence

Despite its low share in total value added or total labor (5 and 9% in 1982), it seems that the structural effects are mediated mainly through the agricultural sector. The agricultural labor force is known to go first to manufacturing and then to services. This intuitive sequence is confirmed by the high correlation (−0.82) between the changes (from 1982 to 1992) in the shares of agriculture and manufacturing in total employment. The correlation with changes in the service sector's share is only about −0.23 and is not significant.

We can distinguish two steps in the pro-convergence structural change:

– The first step of this sequence is related to industrialization:[12]

[12] There is not necessarily an absolute increase in manufacturing's share in total employment but more frequently a relative increase (on average the manufacturing sector lost 4% of total employment between 1982 and 1992, with its share decreasing from 23% to 19%).

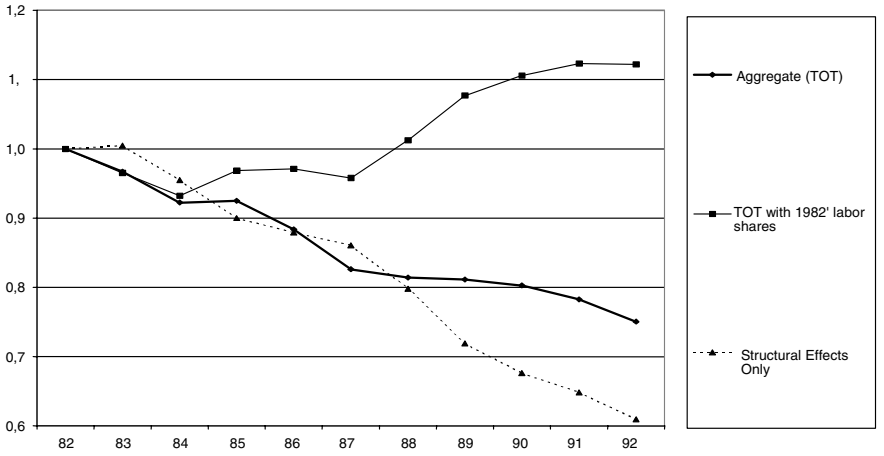

Fig. 6. Aggregate convergence and labor reallocations (Variance Ratios)

The least productive regions in 1982 were the most agricultural (at this date the correlation between relative productivities and agriculture share is −0.74). These lagging regions benefited from higher productivity growth in agriculture than in the other sectors (the average productivity growth rates between 1982 and 1992 for agriculture, manufacturing and services are respectively 4.7%, 3% and 1%). Meanwhile, the agricultural share tends to decrease in the places where it was abnormally high.

This shift was strongly pro-convergence since the mean productivity level is higher in the manufacturing sector (on a basis of 100 for aggregate productivity in 1982, agriculture was at the index 66, manufacturing at 108 and services at 102).

However, if we know that "*the chance for gain by better allocating labor is greater among laggards because their agriculture and petty trade sectors, in which productivity is very low, are larger*" (Abramovitz 1994), it may be wondered whether the agriculture share change is the sole determinant of aggregate convergence.

Table 6. Impact of labor reallocations on the convergence of productivities: beta and sigma-convergence

	Aggregate			Manufacturing			Services		
	Series	With 1982 sectoral structure	Structural effect only	Series	1975 SS	SE Only	Series	1982 SS	SE Only
Convergence speed (%)	1.8**	0.3	2.3***	0.9	0.8	0.1	0.2	0.9	0.4
Variance ratio	0.75**	1.12	0.61***	1.05	1.12	1.08	1.2	1.2	1.05

***, **, * Respectively significant at 1%, 5% and 10%.

– The second shift, from industry to services, is *a priori* more ambiguous as concerns convergence, since growth rates are relatively low in services and productivity levels are similar.

Here, it is useful to go back to the cross-country productivity variance corresponding to the sum of manufacturing and services. Despite the observation of a divergence in both manufacturing and services, this variance remained roughly constant between 1982 and 1992 (Fig. 3). Thus there seems to be pro-convergent structural effects between those two sectors. Manufacturing regions were the least productive ones (at the aggregate level) in 1982 (the correlation between manufacturing shares and productivities of the two sectors is −0.52), that is to say that the leading regions were service economies. Lagging regions benefit from better growth performances relative to their manufacturing shares. Contrary to what happened in some other regions, manufacturing shares did not fall because of the shift from agriculture to manufacturing.

The agricultural regions (especially the most productive ones, i.e. the western regions) managed to preserve manufacturing jobs. Labor moved to more productive sectors and the aggregate productivities of the lagging regions did not decrease very much because of de-industrialization.

On the other hand, the larger the increase in the service sector's share is, the more favourable the pro-growth structural effect is (the correlation is about 0.55). This is due partly to the fact that backward regions benefit from the structural effect and thus have an increasing share of services.[13] When this effect is neutralized,[14] we obtain a 0.30 residual correlation, which is significant only at the 10% level.

Finally, we can see that the transfer of manufacturing labor towards service activities is in favour of (sigma-) convergence, since the cross-country productivity variance is much lower in services (Fig. 2). Thus the agriculture-manufacturing-services sequence was strongly pro-convergence.

The apparent aggregate convergence is due to the factor distribution at regional and sectoral levels. If structural effects are ignored, no convergence remains. Such a result has already been obtained for Spain (Cuadrado et al. 1999; De la Fuente 2002) and more clearly for Italy (Paci and Pigliaru 1997), even if these studies do not exhibit such a strong and double impact. As far as the United States are concerned, it seems that the structural effects have been a key component of the episodes of convergence (divergence) between states for more than a century (Kim 1998; Caselli and Coleman 1999). On the contrary, regional specialization plays a very minor role and interregional differences are essentially explained by uniform productivity gaps in the case of regions at the European level (Esteban 2000). For France, even if the phenomenon is mainly explained by the shift of agricultural labor to manufacturing industries, it seems that the labor shift from manufacturing to services also encouraged

[13] The strong convergence of structures is highlighted by the correlation of −0.73 between the changes in the manufacturing sector's shares (1982–1992) and the starting values of these shares (1982).

[14] By regressing changes in the service sector's share on this share in 1982 (convergence effect) and a constant we obtain a residual series which, in our view, equates to changes in the service sector's share in total employment after controlling for changes due to the convergence of structures.

convergence. Moreover, the pro-convergent structural effect is not limited to the 1970s, as in Italy, but is clearly present in the 1980s as well.

On the theoretical side, the place taken by structural change argues in favour of multisectoral growth models and, as pointed out by Cuadrado et al. (1999), may modify some of the conclusions drawn in the literature regarding the mechanisms that generate convergence: Solow's model is called into question. Among competing models, the technological gap approach is particularly suited to revealing inter-regional and inter-sectoral growth differences. The impact of structural effects can legitimate structural public policies, especially for the manufacturing sector, and their efficiency may be improved if the specializations are supervised at the European level.

5. Conclusion

The main conclusion stemming from this study is the need to take into account geographical and sectoral dimensions in order to have a better understanding of the causes and mechanisms of growth and convergence. Indeed, as it is the case for France, global analysis can be misleading.

If the descriptive analysis reveals convergence of productivities in the last two decades at regional (Paris region excepted) and sectoral levels (especially for services), it remains the case that strong spatial, sectoral and temporal disparities persist. This is why the (endogenous) sources of regional convergence (R&D, size and more generally polarization) responsible for these specificities are included and prove to be quite significant. However, it is above all the differences in the sectoral composition of activities (structural effects), rather than uniform productivity gaps, that explain the interregional inequality in aggregate per worker productivities. Thus in the French case, as for the Italian or Spanish regions, these effects are the key element in the existing convergence, even if their magnitude and temporality are typical. The shift of agricultural employment to the manufacturing sector and then to the tertiary sector explains the largest part of the decrease in the observed disparities in productivities at the aggregate level.

This study suggests a large number of new lines of enquiry. Thus it would seem interesting to analyze polarization at a more detailed level in order to appraise the strength of the agglomeration phenomenon, the interdependences and the externalities between regions and sectors,[15] as well as to measure more precisely the role of regional policies, especially that of investment and infrastructure programs.

Annex 1. Regional nomenclature and French regional map

The spatial decomposition (France) distinguishes 21 regions divided into 6 groups:

[15] From this perspective, the studies by Goicolea et al. (1997) for Spain, Terrasi (1999) for Italy and Neven and Gouyette (1994), Armstrong and Vickerman (1995), Brülhart and Torstensson (1996), Lopez-Baso et al. (1999) for Europe and Carluer (2004) for Eastern Europe are very interesting.

– Ile-de-France [IDF];
– the Parisian Basin or the first circle around Paris: Upper Normandy (UN), Picardy, Champagne-Ardenne (CA), Burgundy and Centre;
– the West: Brittany, Lower Normandy (LN), Pays-de-Loire (PDL) and Poitou-Charentes (PC);
– the South-West: Aquitaine, Limousin, Auvergne and Midi-Pyrenees (MP);
– the North-East: North-Pas-de-Calais (NPDC), Lorraine, Alsace and Franche-Comte (FC);
– and the South-East: Rhone-Alps, Languedoc-Roussillon (LR) and Provence-Alps-French Riviera (PACA) – Corsica.

Annex 2: Panel data estimate

Conditional convergence equations in this paper are estimated using cross-sectional data. The time series dimension of the data set is thus used only in order to obtain productivity growth rates between initial and final date.

Fig. 7.

Nevertheless this dimension can be useful in providing more flexible estimates by means of panel data methods. Islam (1995) emphasizes the gains of a fixed effect panel data estimate of a growth model. By greatly increasing the degrees of freedom, the panel analysis allows more precise estimates. *Via* fixed effects, it allows the modelling of country (region) specificities which are usually unmeasurable.[16]

The data base used in this study has a relatively short time span. In most cases, it is difficult to build panels with time dimensions relevant for a growth (long-term) study (De la Fuente 1998). However, we performed a panel data

[16] The unmeasured differences are likely to be much smaller between regions (common preferences and institutions) that they are between countries. Consequently, the question of fixed effects is less crucial. Other problems (specification and estimator choice) may be minimized in regional studies, as pointed out by Caselli et al. (1996).

Table 7. R&D coefficient: panel estimate

	"1 year"		"3 year"	
OLS	1.02	5.39	0.67	3.07
Within	0.88	2.48	0.80	2.48
GMM			1.71	4.28

Estimated coefficient and associated T-stat. Standard errors are heteroscedastic-robust.

estimate for the manufacturing sector, since we have 18 years in that case. In order to abstract from business frequency fluctuations we propose two methods: the first one (labelled *'1 year'* in Table 7) uses smoothed data instead of raw data, the second one (*'3 year*s'*)* uses three-year averages (6 points for each regions in time dimension).

We use three estimators: Ordinary Least Squares on pooled data (« OLS »), Fixed-effect estimator ('Within') and Generalized Method of Moments ('GMM'). The latter provides an adequate treatment of both fixed effects and right-hand variables endogeneity. In order to take possible common shocks (affecting all regions) into account, we work on centred variables: we subtract the 21-region average from each variable, at each time period.[17]

Only results concerning the R&D variable are presented in Table 7. Indeed, this is the less common variable in that kind of model and it is therefore important to evaluate its robustness.[18] However, let us note that conditional convergence is always accepted. By contrast, the investment rate coefficient is quite sensitive to the smoothing method and to the estimator. The impact of R&D is much more satisfactory and is sufficiently robust in all cases. It is highly significant. The value of 0.67 given by the cross-sectional estimate appears to be a lower-bound. On the other hand, the coefficient 1.71 given by GMM is surprisingly high.

Annex 3: Fictive productivities formulae

$$y_t^{ri} = \frac{VA_t^{ri}}{E_t^{ri}} \quad \text{labor productivity in region } r, \text{industry } i, \text{time } t,$$
$$s_t^{ri} = \frac{E_t^{ri}}{E_t^{r}} \quad \text{industry } i \text{ labor share for region } r \text{ at time } t. \tag{1}$$

$$y_t^r = \sum_i s_t^{ri} \cdot y_t^{ri} \quad \text{actual aggregate productivity.} \tag{2}$$

$$\hat{y}_t^r = \sum_i s_0^{ri} \cdot y_t^{ri} \quad \text{productivity computed with sectoral labor shares at year 0.} \tag{3}$$

[17] This is equivalent to introducing time effects *via* dummy variables.

[18] The study of Levine and Renelt (1992) shows that very few variables, among those introduced in conditional convergence equations, have a significant impact standing up to the specification changes. However the positive impact of the investment rate is usually quite robust.

$$y_t^i = N^{-1} \sum_r y_t^{ri} \quad \text{N regions average productivity for industry } i. \tag{4}$$

$$\tilde{y}_t^{ri} = \tilde{y}_{t-1}^{ri} \cdot \frac{y_t^i}{y_{t-1}^i} \quad \text{with} \quad \tilde{y}_0^{ri} = y_0^{ri} \tag{5}$$

$$\tilde{y}_t^r = \sum_i s_t^{ri} \cdot \tilde{y}_t^{ri} \quad \text{productivity computed with true labor shares but national average sectoral productivity growth rates.} \tag{6}$$

References

Abd-El-Rahman K (1991) Firms' competitive and national comparative advantage as joint determinants of trade composition. Weltwirtschaftliches Archiv 127(1): 83–97

Abramovitz M (1994) Catch up and convergence in the post-war growth boom and after. In: Baumol WJ, Nelson RR, Wolf EN (eds), Convergence and productivity. Oxford University Press, Oxford

Aghion P, Howitt P (1998) Endogeneous growth theory. The MIT Press, Cambridge, Massachusetts

Armstrong MW, Vickerman RW (1995) Convergence and divergence among European regions. ERRS, Plon, London

Barro RJ (1991) Economic growth in a cross section of countries, Quarterly Journal of Economics 106: 407–443

Barro RJ, Sala-I-Martin XX (1991) Convergence across states and regions. Brookings papers on economic activity (1): 107–158

Barro RJ, Sala-I-Martin XX (1995) Economic growth. McGraw-hill, New York

Baumol WJ (1986) Productivity growth, convergence, and welfare: what the long-run data show. American Economic Review 76(5): 1072–1085

Bernard AB, Jones CI (1996a) Comparing apples to oranges: productivity convergence across industries and countries. American Economic Review 86(5): 1216–1238

Bernard AB, Jones CI (1996b) Productivity across industries and countries: time series theory and evidence. Review of Economics and Statistics 78(1): 135–146

Blanchard OJ, Hall RE (1991) Comments and discussion about Barro & Sala-i-Martin. Brookings papers on economic activity (1): 159–182

Brülhart M, Torstensson J (1996) Regional integration, scale economies and industrial location in the European union. CEPR dicussion paper 1435

Carluer F (2001) The convergence of European regions: a specific catching up. Research Ph.D. Grenoble

Carluer F (2004) Regional disparities and convergence at national and regional level in the candidate countries. In: Ward T, Third Report on economic and social cohesion: needs of regions in candidate countries eligible for structural fund assistance. DG Regio, European Commission

Caselli F, Coleman WJ (1999) How Regions Converge. CEPR 2191

Caselli F, Esquivel G, Lefort F (1996) Reopening the convergence debate: a new look at cross-country growth empirics. Journal of Economic Growth (1): 363–389

Coe DT, Helpman E (1995) International R&D spillovers. European Economic Review 39(5): 859–897

Coe DT, Helpman H, Hoffmaister AW (1995) North-South R&D spillovers, NBER working paper 5048

Cuadrado-Roura JR, Garcia-Greciano B, Raymond JL (1999) Regional convergence in productivity and productive structure : the Spanish case 22(1): 35–53

Cuadrado-Roura JR, Mancha-Navarro T, Garrido-Yserte R (2000) Regional productivity patterns in Europe: an alternative approach. The Annals of Regional Science 34(3): 365–384

De la Fuente (1998) What kind of regional convergence? CEPR discussion paper 1924

De la Fuente A (2002) On the sources of convergence: a close look at the Spanish regions. European Economic Review 46(2): 569–599

Dollar D, Wolff EN (1994) Capital intensity and TFP convergence by industry in manufacturing: 1963–1985. In: Baumol WJ, Nelson RR, Wolff EN, convergence of productivity: cross national studies and historical evidence. Oxford university press, Oxford
Durlauf SN, Quah DT (1999) The new empirics of economic growth. In: Taylor JB, Woodford M, Handbook of Macroeconomics, Amsterdam, North-Holland
Echevarria C (1997) Changes in sectoral composition associated with economic growth. International Economic Review, 38(2): 431–452
Esteban J (2000) Regional convergence in Europe and the industry mix : a shift-share analysis. Regional Science and Urban Economics 30(3): 353–364
Fagerberg J (1995) Convergence or divergence? The impact of technology or why growth rates differ. Journal of Evolutionary Economics 5: 269–284
Fiaschi D, Lavezzi AM (2003) Distribution dynamics and nonlinear growth. Journal of Economic Growth 4: 379–402
Frantzen D (2000) Innovation, International Technological Diffusion and the Changing Influence of R&D on Productivity. Cambridge Journal of Economics, 24(2): 193–210
Goicolea A, Herce JA, De Lucio JJ (1997) Externalities and industrial growth: Spain 1978–1992. European Economic Association Congress
Islam N (1995) Growth empirics: a panel data approach. Quarterly Journal of Economics 110: 1127–1170
Jones CI (1995) R&D-based models of economic growth. Journal of Political Economy 103: 759–784
Kim S (1998) Economic Integration and Convergence: US regions, 1840–1987. Journal of Economic History 58(3): 659–683
Krugman P (1991) Increasing returns and economlic geography, Journal of Political Economy, 99, 3: 483–499
Krugman P, Venables AJ (1995) Globalization and the inequality of nations. Quarterly Journal of Economics 110(4): 857–880
Landesmann MA, Steher R (2001) Convergence patterns and switchovers in comparative advantage. Structural Change and Economic Dynamics 12(4): 399–423
Levine R, Renelt D (1992) A sensitivity analysis of cross-country regressions. American Economic Review 82(4): 942–963
Lopez-Bazo E, Vaya E, Mora AJ, Surinach J (1999) Regional economic dynamics and convergence in the European union. The Annals of Regional Science 33: 343–370
Mankiw NG, Romer D, Weil DN (1992) A contribution to the empirics of economic growth. Quarterly Journal of Economics (3): 407–437
Martin P (1998) Can regional policies affect growth and geography in Europe ? The World Economy 21(6): 757–773
Neven DJ, Gouyette C (1994) Regional convergence in the European community. Revue Economique 45(3): 703–713
Paci R, Pigliaru F (1997) Structural change and convergence: an Italian regional perspective. Structural Change and Economic Dynamics 8: 297–318
Paci R, Pigliaru F (1999) European regional growth: do sectors matter? In: Pigliaru R, Adams, Economic growth and change: a comparative analysis. Elgar
Quah DT (1996a) Empirics for economic growth and convergence. European Economic Review 40: 1353–1375
Quah DT(1996b) Twin peaks: growth and convergence in models of distribution dynamics. Economic Journal 106: 1045–1055
Quah DT (1997) Empirics for growth and distribution: stratification, polarization, and convergence debate. Journal of Economic Growth 2(1): 27–59
Sorenson A (2001) Comparing apples and oranges: productivity convergence and measurement across industries and countries: comment. American Economic Review 91(4): 1161–1167
Stehrer R, Wörz J (2003) Technological convergence and trade patterns. Review of World Economics 139(2): 191–219
Terrasi M (1999) Convergence and divergence across Italian regions. The Annals of Regional Science 33(4): 491–510
Tumpel-Gugerell G, Mooslechner P (2003) Economic convergence and divergence in Europe. Hardback, Elgar