SPECIALISATION AND LOCAL GROWTH: AN APPLICATION OF CART ANALYSIS TO EUROPEAN REGIONS

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Abstract

Empirical evidence on European regional growth during the last 15-20 years shows that different groups of economies can be identified with the following stylized facts: high level of internal homogeneity and increasing *inter*-groups differentiation. Given this scenario, the aim of this work is to identify and describe groups of regional economies (NUTS2 level) belonging to nine European countries (Belgium, France, Germany, Greece, Italy, United Kingdom, Netherlands, Portugal and Spain), in order to evaluate the role played by specialization in determining regional income growth. The grouping of regions will be carried out taking into account the initial levels of income per capita and productive specialization. The novelty of this work consists in the application of a new methodology, known as *Classification and Regression Tree Analysis*, used to achieve the identification of different groups. This methodology allowed us to generate 4 groups of European regions. The results show that initial specialization in food and beverages, chemical, credit, metal products and machinery and textile activities is important for regional economic growth and may suggest that lower variety would favour local growth. Besides, both descriptive and econometric analyses evidence that regions' behaviour would support the catching-up hypothesis.

Keywords: regional growth, specialization, Classification and Regression Tree Analysis.

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1. Introduction

A large strand of literature has emphasized the role of regions in the global economic system. The suggestion, coming up from the debate, is to analyze global and national economic change as a process depending on regional dynamics. Looking at the uniformity of the economic structure within European countries, different areas than those based on national geographical and political criteria may be obtained. Once the idea of individual countries has disappeared, new core groups may come out exhibiting no links with the old administrative borders, therefore problems' solution becomes pertinent to regional economics. Most of the theoretical contributes (Helg R. *et al.*, 1995) evidence that similarities among countries' industrial structures are crucial in determining both nature and size of responses to external shocks. Particularly, stressing the role of dynamic externalities[1], recent theories (Romer, 1986, Lucas, 1988, Porter, 1990, Jacobs, 1969, Ottaviano and Puga, 1998, Brülhart, 1998) considered the influence of spatial localization and specialization of economic activity on local growth. This stream of the literature is characterized by the effort to explain both the agglomeration process and the spatial distribution of production. Marshall (1980) and Porter (1990), for example, evidence that geographical specialization of industries favours intra-industry knowledge spillovers and therefore would promote innovative activity and economic growth (specialization externalities). On the contrary, Jacobs, suggests that knowledge may be better generated in presence of industries' variety (diversity externalities).

Analyses of the evolution of agglomeration and specialization patterns of economic activity usually privilege the national dimension[2], as a consequence of the lack of data on smaller geographical areas. However, studies at city or district level considered only restricted economic activities, generally the most innovative ones. Glaeser *et al.* (1992) and Feldman and Audretsch (1999), for example, found evidence of considerable support for the diversity thesis against the specialization one, while Paci and Usai (2000) found that both externalities are not necessarily opposed but may work simultaneously. Paci and Pigliaru (1997), in particular, looking at European regions identify the primary sector as the leading one and demonstrate that regions characterized by high specialization in this sector show the highest increases in labour productivity. Another strand of the economic literature analysed particularly the linkages between manufacturing sector growth and labour productivity ("The Third Law" of Kaldor, 1968, is an example) or overall productivity (see Lucas, 1988). The main result of these studies is that, making a comparison with other sectors, manufacturing shows a higher level of R&D expenditure and more intensive international trade with consequent spillover effects across different economies. Finally, Padoan, Parascandolo and Tozzi (Padoan *et al.*, 2000), taking into account the relative importance of productive structure, used a cluster analysis to identify groups of regions with homogeneous specialization model in order to test the presence of regional convergence.

Given this scenario, the aim of this work is the identification and description of groups of regional economies (NUTS2 level[3]) belonging to nine European countries (Belgium, France, Germany, Greece, Italy, United Kingdom, Netherlands, Portugal and Spain) in order to evaluate the role played by initial specialization in determining regional income growth. The regions will be grouped taking into account initial levels of per capita income and productive specialization through the application of a new methodology known as *Classification and Regression Tree Analysis* (CART). Unlike other partitioning methods,

[1] Dynamic externalities are those externalities associated with knowledge spillovers.
[2] Analyses at city or local district level generally concern spatial agglomeration of innovative activities.
[3] Nomenclature of statistical territorial units according to the Eurostat classification of the administrative regions.

CART allows a regression to be performed together with a classification analysis on the same "learning" dataset, without requiring particular specification of the functional form for the predictor variables which are selected endogenously. This potentialities confers on the CART analysis higher explanatory power, if compared to cluster methodology, for example. This methodology allowed us to identify 4 groups of European regions showing high *intra*-group homogeneity of per capita GDP growth rate and productive specialization. The analysis of *intra*-group characteristics highlights that initial specialization in food and beverages, chemical, credit, metal products and machinery and textile activities is important for regional economic growth and may suggest that lower variety would favour local growth. Besides, both descriptive and econometric analyses evidence that regions' behaviour would support the catching-up hypothesis.

The paper is organised as follows: section 2 displays the dataset, section 3 presents the results of descriptive analysis on income and specialization dynamics, section 4 introduces the methodology, section 5 shows the results of econometric analysis, section 6 concludes. In addition, Appendix I lists the groups of regions identified by the CART analysis.

2. Data description

This section presents the dataset used both for the descriptive analysis of the GDP regional growth patterns and geographic specialization, and for econometric analysis aimed to group the sample regions. Data for GDP and employment are from the Eurostat New Cronos Regio database at NUTS2 level according to the Regulation (EC) No.1059/2003 of the European Parliament and of the Council. We use annual values for GDP per inhabitant in terms of Purchasing Power Parity (PPP) and the number of employees in the NACE92 productive branches from 1981 to 2000. The branches we considered are the following: Agricultural-forestry and fishery products (*agri*), Manufactured products (*manu*), Fuel and power products (*ener*), Non-metallic minerals and mineral products (*min*), Food-beverages-tobacco (*food*), Textiles and clothing-leather and footwear (*tex*), Chemical products (*chem*), Metal products, Machinery-equipment and electrical goods (*mach*), Products of various industries (*other*), Building and construction (*constr*), Transport and communication services (*transp*), Services of credit and insurance institutions (*cred*). The specific choice of branches has been determined by the current limitation of data availability. The sample consists of 123 regions belonging to nine countries: 11 Belgian, 8 Dutch, 29 German, 22 French, 20 Italian, 18 Spanish, 5 Portuguese, 2 Greek[4], 8 British[5]. The analysis of German and Greek regions starts from 1984 because of the lack of data in the respective regional labour statistics.

For each region we built initial productive specialization indexes (SP) for all the considered branches and an initial diversity index (PD) based on employment data. The indicator of specialisation, commonly used as a measure of the revealed comparative advantage, is given by the fraction of region's employment that a branch represents in the region, relative to the share of the whole branch (all regions) in total European employment. For a region *i* the specialisation index in branch *j* is expressed as follows:

[4] During the period 1983-1987 there has been a different aggregation of Greek regions at NUTS2 level. Kriti and Thessalia are the only regions which presents data for the whole sample period.

[5] The geographic units for UK are at NUTS1 level of Eurostat classification because of the lack of data for NUTS2 units.

$$SP_{ij} = \frac{E_{ij}}{\sum_{j=1}^{n} E_{ij}} \Bigg/ \frac{\sum_{i=1}^{m} E_{ij}}{\sum_{j=1}^{n}\sum_{i=1}^{m} E_{ij}} \qquad (1)$$

where E indicates the number of employees. The minimum value of the index is zero if the region does not presents employees in a specific branch and it is positively correlated with the regional specialization.
The variety of productive activities of each region is measured by the reciprocal of Gini coefficient:

$$PD_i = \left(\frac{2}{(n-1)Q_n} \sum_{j=1}^{n-1} Q_j \right) \qquad (2)$$

where Q_j is the cumulative sum of specialization indexes values listed in increasing order. The index assumes values within the interval (0,1) and increases with variety.
All the indexes mentioned above will be used in the econometric analysis.

3. Descriptive analysis

Dynamics of Regional GDP

The aim of this section is the dynamic analysis of per capita GDP of European regions during the period 1981-2000[6]. The mean value of European per capita GDP (in terms of PPP) increased from 7637.25 in 1981 to 21264.65 in 2000, displaying a mean growth rate equal to 103.77%. This value emphasises the considerable economic growth of the European area as a whole, in spite of two recessions (1981-1983; 1991-1994). The relationship between the initial level of per capita GDP and its growth rate (fig. 4.1) seems to support the catching-up hypothesis.

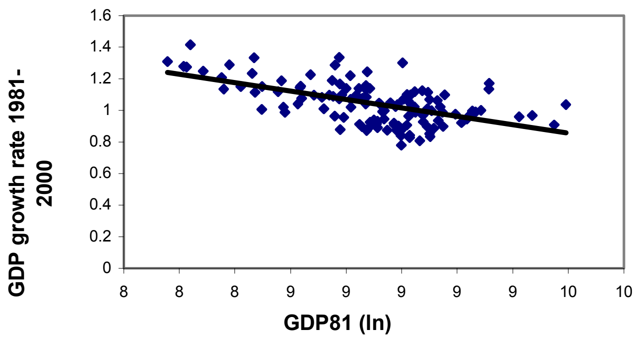

Figure 4.1

In particular, some regions of Spain (Ceuta-y-Melilla, Comunidad de Madrid, Extremadura, Canarias, Cataluña) and Portugal (Norte, Centro, Algarve, Alentejo), despite an initial low level of per capita GDP, show the highest growth rate of the period while Bremen, Region de Bruxelles, Île de France, Düsseldorf and Valle D'Aosta, initially among the richest, display sluggish growth.

The usual investigation of economic growth related to the explicative variables (schooling, investment, government spending, initial income level, etc.) is a standard

6 Data relative to UK regions cover the period 1981-1999.

approach for cross-section analyses (Barro and Sala-i-Martin, 1992). Nevertheless, Quah (1993) asserted that this methodology may be informative only when income permanent movements are well described by smooth time trends, unaffected by current economic disturbances. He suggested that, in the case of economic shocks, in order to correctly verify the effects of the time trend on economic growth it was necessary to analyze separately the periods prior to and after the shock. By the same token, we divided the whole period into two sub-periods, with 1992 as the breaking year, and regressed the log of per capita income of each region on a linear time trend in order to evaluate the impact of the latter on GDP growth rate. The results show that all coefficients are statistically significant and robust to diagnostic tests[7]. Figure 4.2 graphs the slope of each economy's time trend after 1992 against that before. The graph displays that 98% of the regions are above an imaginary 45° line indicating a speeding up of economic growth in the second period. On the contrary, Picardie and Lorraine show a considerable slowdown after the break.

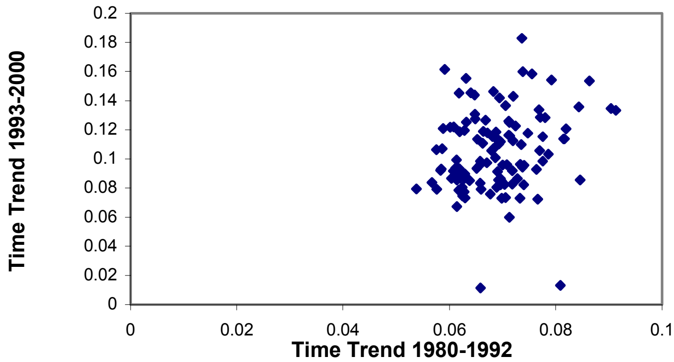

Figure 4.2

Figure 4.3, similarly, graphs the standard deviation of the fitted growth rate of the second period against the first. All the regions have data points below an imaginary 45° line, indicating a decrease in income growth rate variability in the second period, as a consequence of important changes occurring in each economy.

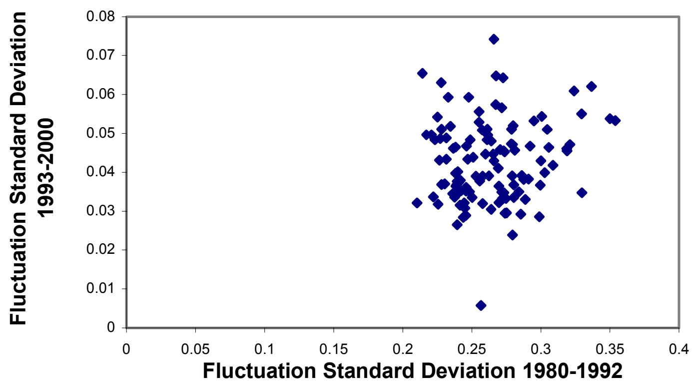

Figure 4.3

The analysis shows that the instability could generate heavy distortions in the empirical analyses of regional economic growth if, regardless of what is highlighted by the data, a stable time trend for each economy is considered.

[7] Econometric results are available on request.

Dynamic of regional specialization

In this section we describe the evolution of regional productive specialization of all the European regions included in our sample during the period 1981-2000. This analysis will be carried out using the productive specialisation indexes presented in section 2. Considering initial level of these indexes Calabria (I), Basilicata (I), Extremadura (ES), Puglia (I), Sicilia (I) and Andalucia (ES) appear to be the regions most specialised in agriculture (*SPagri* between 9.49 and 6.48); Namur (B), Saarland (D), Oberpfalz (D), Gießen (D) in non-metallic, minerals and mineral products (*SPmin* between 4.2 and 3.2); Ceuta y Melilla (ES), Zeeland (NL), Friesland (NL), Algarve (PT), La Rioja (ES), Canarias (ES) in food-beverage and tobacco (*SPfood* between 3.4 to 2.6); Limburg (NL), Köln (D), Antwerpen (B), Darmstadt (D), Düsseldorf (D), Sardegna (I), Zuid-Holland (NL) in chemical products (*SPchem* between 3.6 to 2.01); Drenthe (NL), Zeeland (NL), Ceuta y Melilla (ES), Algarve (PT), Luxembourg (B), Kriti (GR), Basilicata (I) in construction (*SPconstr* between 5.2 to 2.5); Région Bruxelles-capitale (B), Hamburg (D), Darmstadt (D), Noord-Holland (NL), Utrecht (NL) in credit (*SPcred* between 5.2 to 2.4); Principado de Asturias (ES), Münster (D), Limburg (B), Wales (UK), Saarland (D), Yorkshire and The Humber (UK) in fuel and power products (*SPener* between 6.6 to 3.1); Brabant Wallon (B), Valle d'Aosta (I), West Midlands (UK), Pais Vasco (ES), Hainaut (B), Lombardia (I), Piemonte (I) in manufacturing branch (*SPmanu* between 1.3 to 1.2); Braunschweig (D), Arnsberg (D), Mittelfranken (D), Stuttgart (D), Unterfranken (D), Oberbayern (D), Karlsruhe (D) in Metal products, Machinery-equipment and electrical goods (*SPmach* between 1.9 to 1.6); Hamburg (D), Kriti (GR), Bremen (D), Franche-Comté (FR), Trier (D) in transport services (*SPtransp* between 4.04 to 2.5); Norte (PT), Marche (I), Toscana (I), Oost-Vlaanderen (B), Veneto (I) in textile products (*SPtex* between 3.9 to 2.5).

In the table 1 we report the average and the standard deviation values of all the specialisation indexes in the years 1981, 1985, 1990, 1995, 2000. In particular, results evidence that the sample appears to be mainly specialised in agriculture sector and in non-metallic minerals and mineral products and food-beverage-tobacco branches. Except for construction, manufacturing and fuel and power branches, average values generally increase between 1981 and 1985, decrease slightly from 1985 until 1990 and finally increase up to year 2000. On the contrary, activity in the construction branch decreases in the whole period, manufacturing decreases from 1981 to 1985 while increases during the remaining period and, finally, fuel and power specialisation increases from 1981 to 1990 and decreases from 1990 to 2000.

Table1: Specialization indexes, period 1981-2000

	SPagri	SPmin	SPfood	SPchem	SPconstr	SPcred	SPener	SPmanu	SPmach	SPtransp	SPtex
Average 1981	1.388	1.072	1.190	0.872	1.318	0.986	0.965	0.925	0.821	0.929	0.848
Average 1985	1.433	1.352	1.298	1.029	1.166	1.161	0.989	0.853	0.910	1.243	0.908
Average 1990	1.347	1.217	1.108	0.995	1.124	0.989	1.125	0.931	0.883	1.094	0.870
Average 1995	1.381				1.077	0.901	1.027	0.921		1.005	
Average 2000	1.130	1.162	1.681	1.068	0.878	1.020	0.944	1.148	1.002	0.862	0.969
Std Dev 1981	2.224	0.631	0.689	0.683	0.960	0.594	0.767	0.302	0.358	0.636	0.958
Std Dev 1985	1.825	1.169	0.809	0.870	0.603	0.992	1.010	0.344	0.594	0.809	0.952
Std Dev 1990	1.745	0.966	0.671	0.832	0.439	0.622	1.081	0.341	0.535	0.629	0.903
Std Dev 1995	1.510				0.507	0.354	0.416	0.321		0.346	
Std Dev 2000	1.181	1.800	3.350	0.476	0.611	0.460	0.448	1.850	0.380	2.295	0.399

Source: elaboration on Eurostat data

Allocation of agriculture and manufacturing activities evidences a specific geographical distribution, in fact, regions of Mediterranean areas are the most specialised in the primary sector (mainly Spanish, Portuguese and Italian ones) while Continental regions (mainly German and Belgian ones) are the less specialised in the latter. As regards manufacturing branch, Northern-Italian, German and Belgian regions appear to be the most specialised.

4. The methodology

The empirical analysis will be carried out through the CART methodology, first described by Breiman *et al*. (1984), which provides binary recursive partitioning using non-parametric approaches. The main result of this procedure is the construction of homogeneous groups of individuals using splitting variables which minimize the *intra*-group "impurity" (heterogeneity) as predictors. The term "binary" implies that the algorithm used by this technique always splits the dataset into two subsets based on a single best predictor variable. This procedure may be applied over and over again in a "recursive" way. The final outcome is a tree with branches and "terminal nodes", as much homogeneous as possible, where the average value of the node represents the predicted value of the dependent variable. Tree building starts from a "root node" containing the individuals of the whole sample (learning dataset). The first step is to find the splitter (the best among the splitting variables available) that seeks to maximize the average "purity" of the two child nodes, that is to minimize the variance explained in each node. Different measures of purity, called "splitting criteria", can be chosen to group the individuals[8]. In our analysis the regression is carried out using regional GDP growth rate as dependent variable and initial GDP and some specialisation indexes as explicative variables. The use of the least squares method allowed us to minimize the *intra*-group variability of the dependent variable in each group. In order to chose the best tree, we selected the Standard Error rule which enabled us to generate the smallest tree within a single standard error of the minimal cost tree.

There are several key advantages to apply this methodology. First of all, unlike other methodologies, CART allows a regression to be performed together with a classification analyses on the same "learning" dataset. Moreover, CART does not require an *a priori* selection of the splitting variables and proves to be extremely robust to the effects of occurring outliers. Finally, it allows to classify individuals without any information on the underlying distribution of the predictor variables. In other words, there is no need to determine whether these variables are normally distributed or make any transformation if they are not.

In order to support the results of CART analysis we estimated a cross-section regression using all the sample regions. The equation is formalized as follows:

$$\dot{y}_i = \alpha + \beta GDP81_i + \sum_{j=1}^{11} \chi_j SP_{ij} + \varepsilon_i \qquad (3)$$

[8] The most common are Gini, Twoing and Power-modified Twoing splitting rules where the first, performing typically best, is generally preferred in dealing with quantitative variables. The heterogeneity index of Gini is given by the following expression:

$$G = 1 - \sum_{i=1}^{r} f_i^2$$

where f_i^2 is the relative frequency of the *i*-th modality of a phenomenon which may assume *r* modality. The range of G is the interval [0,1] where G=0 denotes maximum homogeneity and G=1 maximum heterogeneity. Gini tries to divide classes of modality by focusing on one class at a time: separating the most "important" class in each node (with a higher frequency) until the final tree contains only pure child nodes.

where $\dot{y}_i = \ln GDP_i^{2000} - \ln GDP_i^{1981}$ indicates regional growth rate in the period 1981-2000, $GDP81_i$ is the initial level of per capita GDP (in terms of logarithm) and SP_{ij} is the specialisation index; i=1, 2,…,123 and j=1, 2, …,11 indicate, respectively, the region and the branch.

A negative and statistically significant coefficient of initial level for GDP would indicate the presence of a catching up process. A higher value of the specialisation index indicates a greater share of regional employment in a branch. Therefore, a positive and statistically significant coefficient of the index would indicate that increasing specialisation of the region in that particular branch would support local economic growth. On the contrary, a negative coefficient would indicate that greater specialisation in that branch would have a negative impact on economic growth.

5. Econometric results

In this section we perform the econometric analysis through CART methodology in order to build a tree with terminal nodes including regions showing a more homogeneous behaviour of per capita GDP growth rate and productive specialisation. In our investigation income per inhabitant growth rate will be used as dependent variable and the initial level of GDP and eleven[9] out of twelve specialisations indicators as explicative variables. The purpose is to evaluate the relative importance of the initial regional economical characteristics on growth. The analysis shows that specialization in food and beverages, chemical, credit, metal products and machinery and textile activities are very important for economic growth (tab.2). These results are confirmed by the outcome of the cross-section regression presented in section 4 (eq. 3).

Table 2. Cross-section estimations results

Const	GDP81	SPagri	SPmin	SPfood	SPchem	SPconstr	SPcred	SPener	SPmach	SPtrans	SPtex
3.65	-0.328	0.001	-0.083	0.0626	0.054	-0.0228	0.0165	-0.005	0.106	0.0191	0.035
(7.960)	(-6.57)	(0.161)	(-0.621)	(2.894)	(3.055)	(1.072)	(1.861)	(-0.044)	(2.033)	(1.122)	(1.663)

Note: the t-values of the coefficients are listed in parentheses

Besides, the estimates show the presence of a catching-up process in the considered period, in the sense that initially backward regions grow faster than the richer ones (negative and highly statistically significant coefficient for GDP81).

The tree grown by the CART methodology displays four terminal nodes whose regions are listed in Appendix I. Groups and their characteristics are listed according to a decreasing order of the estimated GDP growth rate.

- *Group 1*. This group includes 11 regions belonging to Spain, Greece and Portugal. These economies show the highest estimated mean value of GDP growth rate (126.08%) despite their lowest initial income level (average equal to 4144.3). Regions are characterized by strong specialization in the agriculture sector (*SPagri* equal to 3.75) and construction branch (*SPconstr*=2,09[10]) and in the food and beverages compartment (*SPfood*=1.93). In particular, Castilla-la Mancha, Extremadura, Andalucia, Canarias, Alentejo and Algarve present the highest values of agriculture

[9] We excluded the "other industries" specialisation index in order to avoid correlation problems among the regressors.

[10] The specialisation indexes, presented in parentheses, are the mean value of the group.

specialisation of the whole sample (together with Campania, Puglia, Basilicata, Calabria, and Sicilia belonging to the second group). Making a comparison with the other terminal nodes, this group presents the minimum specialization in chemical, energetic, and machinery branches and the highest in agriculture, food-beverages-tobacco, mineral and construction. This evidence, in accordance with the results of our descriptive analysis, refutes the idea that specialization in the primary sector is not crucial for economic growth (as showed in Paci and Pigliaru, 1997). Since these regions have the highest employment share in the food and beverages compartment we presume that it is due to the transformation of primary sector products. This group, among all the groups, shows the lowest variety of economic activities (*PD* mean vale equal to 0.113).

- *Group 2*. This group include 23 regions from Belgium, Spain, Italy, and United Kingdom except for Lüneburg (D) and Lisboa e Vale do Tejo (PT). Their estimation for the average GDP growth rate is 111.36% while the initial income level is the second highest (average *GDP81*=5788,78). Regions are characterized by strong specialisation in agriculture (*SPagri*=2.68), food and beverage (*SPfood*=1.26), in construction (*SPconstr*=1.52) and energy (*SPener*=1.20) compartments. In comparison with the other groups these regions show the highest specialisation in chemical products (*SPchem*= 0.98) due in particular to Brabant Wallon, Vlaams Brabant, Luxembourg (B), Cantabria, Comunidad de Madrid, Cataluńa, Sardegna and Lisboa e Vale do Tejo (even though relatively low in the group). Besides, these regions present the second highest level of specialization in agriculture, construction and energy (a particular mention to Principado de Asturias and Wales with an average *SPener* equal to 6.61 and 3.81, respectively. The diversity index in this group is 0.125.

- *Group 3*. These regions (21), belonging to Belgium, France, Germany, The Netherlands, Spain, UK except for Abruzzo (I) show an estimate for the GDP growth rate of 106% and an average initial level of income equal to 6920.6. This group is mostly specialised in manufacturing (*SPmanu*=1.03), in mineral products (mean *SPmin*=1.13), in construction (*SP constr*=1.22), in food and beverage (*SPfood*=1.45) and in energy (*SPener*=1.21). Respect to the other groups these regions are the most specialised in the energy and manufacturing branches. A slightly higher variety of productive activities is confirmed by the value of diversity index (*PD*=0.1382).

- *Group 4*. This group includes 68 regions: almost all German, French and Italian (North-Centre) and some belonging to Belgium and The Netherlands. The estimation of the GDP growth rate is the lowest among the groups and equal to 97.8% despite their highest initial GDP level (average *GDP81*=8893.9). This result, together with the evidence showed by the first group, would support the existence of a catching-up process in the period 1981-2000. This group is the most specialised in the branches of the services sector *(SPcred*=1.16; *SPtransp*=1.07) and in machinery (*SPmach*=1.01). %). The regions are less specialised in agriculture, food and beverages, textile and construction activities. This group appears to be relatively more diversified, when compared with the others (*PD*=0.1387), supporting the hypothesis that concentration of economic activities would favour local economic growth.

The main result of the whole econometric analysis is the presence of a catching-up process showed both in the cross-section model and in the CART investigation. In particular, regions belonging to the first group (Spanish, Portuguese and Greek), starting from the lowest

initial level of per capita GDP, grow faster than the others despite their highest specialization in the agriculture sector. These regions, since the beginning of the 1980s, have largely benefited by the Structural Funds that the European Commission devolved to Objectives *5a* (structural change in agriculture and fishing) and *5b* (development of rural areas with a high share of employment in agriculture). The development of these regions, therefore, may probably be explained by the implementation of advanced technology in a sector traditionally considered as a "backward" one.
Besides, productive activity of the first two groups, when compared with the last two, appear to be less diversified. This evidence may suggest that a lower variety of the economic activity would favour local growth.

6. Conclusions

The final aim of this work was to evaluate the impact of productive specialization on EU regions economic growth. The empirical analysis implemented in this work is both descriptive and econometric.

The descriptive analysis shows considerable economic growth of the geographic area as a whole and highlights two groups of regions which seem to support the catching-up hypothesis. In particular, 98% of the regions shows a considerable increase in income growth starting from 1992 coincident with a downturn in its variability, probably explained by important changes occurred in each economy. The consideration of a stable time trend for each economy could therefore generate heavy distortions in the empirical analyses of regional economic growth. As considering the evolution of regional productive specialization in the period 1981-2000, the descriptive analysis, carried out using specialisation indexes, shows that the sample as a whole is mainly specialised in agriculture sector and in non-metallic minerals and mineral products and food-beverage-tobacco branches. Except for construction, manufacturing and fuel and power branches, average values of specialisation indexes generally increase between 1981 and 1985, decrease slightly from 1985 until 1990 and finally increase up to year 2000.
Allocation of agriculture and manufacturing activities evidences a specific geographical distribution, in fact, regions of Mediterranean areas appear to be the most specialised in the primary sector while Continental regions (Northern-Italian, German and Belgian) are the most specialised in regards manufacturing branch and the less specialised in agriculture.

The innovative element of our work is the application of a new classification technique for econometric analysis, namely Classification And Regression Tree analysis. This methodology allowed us to generate 4 groups of regions which showed the minimum *intra*-group heterogeneity of per capita GDP growth rate and specific levels of initial specialization in the considered sectors and branches. Regions which show the highest growth rate (groups 1 and 2) are characterized by strong specialization in the agriculture sector and in construction and in the food and beverages compartments. Besides, productive activity of these regions appears to be less diversified, suggesting that a lower variety of the economic activity would favour local growth.

The main results of the study are, first of all, the presence of a catching up process showed both in the descriptive and econometric investigation. In particular, regions belonging to the first two groups start from the lowest initial level of per capita GDP and grow faster than the others, despite their highest specialization in the agriculture sector. Secondly, the importance for regional economic growth of productive specialization in food and beverages, chemical, credit, metal products and machinery and textile activities.

Bibliography

-Barro, R.J., 1991, "Economic growth in a cross section of countries", *Quarterly Journal of Economics*, CVI, pp. 407-443.
-Barro, R.J., Sala-i-Martin, X., (1992), "Convergence", *Journal of Political Economy*, vol. 100, no. 2, pp.223-251.
-Baumol W.J., 1986, "Productivity growth, convergence and welfare: what the long run data show", *American Economic Review*, no. 76, pp. 1072-1085.
-Bernard A.B., Durlauf S.N., 1996, "Interpreting tests of the convergence hypothesis", *Journal of Econometrics*, March, vol. 71, no.1-2, pp. 161-73.
-Braunerhjelm P., Faini R., Norman V., Ruane F., Seabright P., 2000, *Integration and the regions of Europe: how the right policies can prevent polarization*", CEPR .
-Breiman L., Friedman J.L., Olshen R.A and Stone C.J., 1984, "*Classification and Regression Trees"*, Wadsworth, Belmont, CA.
-Brülhart, M., 1998, "Economic Geography, Industrial Location and Trade: the evidence", *World Economy*, 21, pp. 775-801.
-Brülhart, M., 2000, "Evolving Geographical Specialisation of European Manufacturing Industries", *DEEP Working Papers*, March, University of Lausanne.
-Durlauf S.N., Johnson P.A., 1995, "Multiple regimes and cross-country growth behaviour", *Journal of Applied Econometrics*, vol.10, pp. 365-384.
-Emerson, M., 1991, "Aspects of the economics of EMU", *European Economic Review*, no.35.
-European Union, 2003, "Regulation (EC) No.1059/2003 of the European Parliament and of the Council on the Establishment of a Common Classification of Territorial Units for Statistics (NUTS) 26th May 2003", *Official Journal of the European Union*, 21/06/2003.
-Feldman, M.P., Audretsch, D.B., 1999, "Innovation in cities: Science-based diversity, specialization and localized competition", *European Economic Review*, 43, pp. 409-429.
-Fujita M., Krugman P., Venables A., 1999, *The Spatial Economy. Cities, Regions and International Trade*, Cambridge, Massachusetts Institute of Technology Press.
-García Solanes J., María-Dolores R., 2002, "The impact of European Structural Funds on Economic Convergence in European Countries and Regions" in *Convergence Issues in the European Union* by Meeusen W., Villaverde J., Edward Elgar, pp. 61-82.
-Glaeser, E.L., Kallal, H.D., Scheinkman, J:A:, Shleifer, A., 1992, "Growth in Cities", *Journal of Political Economy*, vol 100, 2, pp. 1126-1152.
-Grossman G.M., Helpman E., 1991, *Innovation and growth in the global economy*, MIT Press, Cambridge, MA.
-Hallet M., 2000, "Regional Specialisation and Concentration in the EU, Directorate-General for Economic and Financial Affairs*, European Commission, Economic Papers* no.141.
-Helg R., Manasse P., Monacelli T., Rovelli R., 1995, "How much (A)Symmetry in Europe? Evidence from industrial sectors", *European Economic Review*, vol.39, no.5.
-Hirschman A.O., 1958, *On the strategy of economic development*, Yale University Press, New Haven.
-Jacobs, J., 1969, *The Economy of Cities*, London: Jonathen Cape.
-Johnson P.A., Takeyama L.N., 2001, "Initial conditions and economic growth in the US states", *European Economic Review* no.45, pp. 919-927.
-Kaldor N., 1966, *Causes of the slow rate of growth in the United Kingdom*, Cambridge University Press, Cambridge.
-Kaldor N., 1968, "Productivity and growth in manufacturing industry: a reply", *Economica*, 35, pp. 385-391.
-Krugman, P., 1991, *Economic Geography and Trade*, Cambridge, MA:MIT Press.
-Lewis R.J, 2000, "An Introduction to Classification and Regression Tree (CART) Analysis", presented at the *2000 Annual Meeting of the Society for Academic Emergency Medicine* in San Francisco, California.
-Lewis W., 1954, "Economic development with unlimited supply of labour", *Manchester School,* 22, pp. 137-191.
-Lucas R.E., 1988, "On the mechanics of economic development", *Journal of Monetary Economics*, 22, pp. 3-42.
-Marshall, A., 1980, *Principles of Economics*, London, MacMillan.
-Midlefart-Knarvik K.H., Overman H.G., Redding S.J., Venables A.J., 2000, "The location of European Industry", Report prepared for the Directorate-General for Economic and Financial affairs, *European Commission, Economic Papers* no. 142.
-Ottaviano G., Puga D., 1997, "Agglomeration in the Global Economy:a Survey of 'The New Economic Geography' ", *Centro Studi sui Processi di Internazionalizzazione*, WP no. 97.

-Ottaviano, I., Puga, D., 1998, "Agglomeration in the Global Economy: a Survey of the "New Economic Geography", *World Economy*, 21, 707-731.
-Paci R., Pigliaru F., 1997, "European regional growth: do sectors matter?", *WP No.3/97, CRENoS*, Università di Cagliari.
-Paci, R., Usai, S., 2000, "The Role of Specialisation and Diversity Externalities in the Agglomeration of Innovative Activities", *Rivista Italiana degli Economisti,* August, v. 5, iss. 2, pp. 237-68.
-Padoan, P.C., Parascandolo, P. Tozzi, M., 2000, "La Nuova Geografia Economica delle regioni europee", in *Decentramento amministrativo e integrazione europea*, 10° rapporto CER-IRS sull'industria e la politica industriale italiana, Il Mulino, Bologna.
-Porter, M.E., 1990, *The Competitive Advantage of Nations*, New York: Free Press.
-Pricewaterhouse Coopers *European Economic Outlook*, 1999, September.
-Quah D.T., 1993, "Empirical Cross-Section Dynamics in Economic Growth", *European Economic Review* no. 37. pp. 426-34.
-Romer, P.M., 1986, "Increasing returns and long run growth", *Journal of Political Economy*, 94, pp. 1002-1037.
-Solow, R.M., 1956, "A Contribution to the Theory of Economic Growth", *Quarterly Journal of Economics*, no.70, February pp. 65-94.
-Yao, S. (1997), "Decomposition of Gini Coefficients by Income Factors: A New Approach and Application", *Applied Economic Letters*, no.4, pp. 27-31.

Appendix I

Groups of regions

1 Castilla-la Mancha (ES), Extremadura (ES), Andalucia (ES), Ceuta y Melilla (ES), Canarias (ES), Thessalia (GR), Kriti (GR), Norte (PT), Centro (PT), Alentejo (PT), Algarve (PT).

2 Vlaams Brabant (B), Brabant Wallon (B), Luxembourg (B), Lüneburg (D), Galicia (ES), Principado de Asturias (ES), Cantabria (ES); Aragón (ES), Comunidad de Madrid (ES), Castilla y León (ES), Cataluńa (ES), Comunidad Valenciana (ES), Murcia (ES), Molise (I), Campania (I), Puglia (I), Basilicata (I), Calabria (I), Sicilia (I), Sardegna (I), Lisboa e Vale do Tejo (PT), Wales (UK), Northern Ireland (UK).

3 Limburg (B), Hainaut (B) Namur (B), Niederbayern (D), Oberpfalz (D), Trier (D), Comunidad Foral de Navarra (ES), La Rioja (ES), Baleares (ES), Limousin (FR), Languedoc-Roussillon (FR), Abruzzo (I), Friesland (NL), Noord-Brabant (NL), Limburg (NL), Yorkshire and The Humber (UK), East Midlands (UK), West Midlands (UK), East Anglia (UK), South West (UK), Scotland (UK).

4 Région Bruxelles-capitale/Brussels hoofdstad gewest (B), Antwerpen (B), Oost-Vlaanderen (B), West-Vlaanderen (B), Ličge (B), Stuttgart (D), Karlsruhe (D), Freiburg (D), Tübingen (D), Oberbayern (D), Mittelfranken (D), Unterfranken (D), Schwaben (D), Bremen (D), Hamburg (D), Darmstadt (D), Gießen (D), Kassel (D), Braunschweig (D), Hannover (D), Weser-Ems (D), Düsseldorf (D), Köln (D), Münster (D), Detmold (D), Arnsberg (D), Koblenz (D), Rheinhessen-Pfalz (D), Saarland (D), Schleswig-Holstein (D), Pais Vasco (ES), Île de France (FR), Champagne-Ardenne (FR), Picardie (FR), Haute-Normandie (FR), Centre (FR), Basse-Normandie (FR), Bourgogne (FR), Nord-Pas-de-Calais (FR), Lorraine (FR), Alsace (FR), Franche-Comté (FR), Pays de la Loire (FR), Bretagne (FR), Poitou-Charentes (FR), Aquitaine (FR), Midi-Pyrénées (FR), Rhône-Alpes (FR), Auvergne (FR), Provence-Alpes-Côte d'Azur (FR), Corse (FR), Piemonte (I), Valle d'Aosta (I), Liguria (I),Lombardia (I), Trentino-Alto Adige (I),Veneto (I), Friuli-Venezia Giulia (I), Emilia-Romagna (I), Toscana (I), Umbria (I), Marche (I),Lazio (I), Drenthe (NL), Utrecht (NL), Noord-Holland (NL), Zuid-Holland (NL), Zeeland (NL).