UNIVERSITA' LUIGI BOCCONI
DIPARTIMENTO DI ECONOMIA POLITICA

RICCARDO CAPPELLIN

PRODUCTIVITY GROWTH AND TECHNOLOGICAL CHANGE IN A REGIONAL PERSPECTIVE

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GIORNALE DEGLI ECONOMISTI E ANNALI DI ECONOMIA
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PRODUCTIVITY GROWTH AND TECHNOLOGICAL CHANGE IN A REGIONAL PERSPECTIVE*

In spite of the high degree of economic integration among the countries and regions of the European Community, regional disparities in percapita income remain significant and relatively stable. Economic analysis and regional policy have often emphasized the role of capital and labor movements in the evolution of regional disparities. In recent years, however, an increasing attention has been focused upon the «endogenous factors» of regional growth.

Therefore, it is important to analyse the factors that explain the differences in the technologies adopted and in the productivity levels of local resources in the various regions.

The objective of this paper is to show that technological change does not occur at the same time in all firms of the same sector and that its diffusion occurs at different rates according to the incentives and the obstacles which characterize each regional environment. Regional policy, therefore, should not only affect the interregional flows of production factors and the location of the various sectors, but it should also promote the competitivity of regional activities and deal with the economic, social and institutional factors which influence the productivity of local resources.

This paper will first analyse the role of regional factors in the diffusion of technological change, then it will examine the relationship between sectoral composition and aggregate productivity levels. Finally, an operational framework for the evaluation of the regional innovation potential will be proposed.

1. Regional factors in productivity growth

1.1. *The Role of Endogenous Growth and Barriers to Entry*

The regions of the European Community differ widely with respect to both levels and rates of economic growth. Traditional theories of regional disparities have emphasized the role of the interregional flow of resources, such as capital and labor and of the decision to locate or relocate made by interregional firms.

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Contrary to this theory, empirical studies reveal that varying rates of growth in employment are the result of differing birth, death and growth rates among existing firms rather than the effect of interregional firm movements.

The crucial process seems to be less the choice of the best location among the various areas by single economic activities, than the adoption of the best feasible economic activities by single areas.

In fact, regional resources are relatively spatially fixed and some basic characteristics of single regional environments such as the quality of the labor force, the level of technical and management know-how and the social and institutional structures are relatively stable. Therefore, regional growth as well as sectoral location are largely determined by the endowment and productivity of the stock of regional resources rather than by the external flow of resources [1].

Notwithstanding the original causes of the historical location of various economic activities, interregional competition determines the location of the various productions through an «implicit» rather than «explicit» process. This latter is based on the fact that the most competitive firms, which are in appropriate locations, survive and develop, while the others disappear or contract.

The growth process typical of most regions may be described as «endogenous» to a considerable extent, since it is determined by the ability of local firms to fully and efficiently employ the resources which are available locally. On the contrary, cases of truly «exogenous» growth, such as those associated with the establishment of foreign firms and the inflow of external resources, are rare. However, even in the latter case, local factors are particularly relevant since they affect the choice of a particular region with respect to other regions.

The critical factor in an «endogenous» growth process is the evolution of «barriers to entry» with respect to interregional competitions, as described by modern oligopoly theories. Thus the birth and growth of local firms, as well as the location of non-local firms, are determined by the relative position and the changes of the demand and supply schedules relative to the various productions in each area.

In particular, an increase in demand determined by an increase in consumer revenues, or a decrease in costs determined by a decrease in factor prices, may influence the feasibility of some productions. Even more salient is the role of the adoption of product and/or process innovations. In fact, product innovations, by reducing the relevance of price competition, allow an increase in product prices, while process innovations allow an increase in unit costs.

1.2. *The Role of Productivity and Innovations in Regional Growth*

The growth rate of productivity, measured as value added per employee, largely reflects the relative speed of innovation adoption in a region. In fact, process innovations increase productivity by reducing intermediate inputs and employment. On the other hand, product innovations lead to a rise in real output and/or in unit prices, thereby increasing productivity.

In considering the relationship between productivity, on one hand, and product and employment, on the other hand, a distinction must be made between short and long term effects. In the short term, during which employment adjusts slowly, changes in productivity are highly correlated with changes in output or value added. If output is fixed, however, an increase in productivity can be achieved only by reducing employment. In the long term, during which structural adjustments can be made,

[1] See R. Camagni - R. Cappellin [7, 1982].

the relevance of productivity is altered. In fact, productivity gains increase the competitiveness or the market power of firms by decreasing unit costs or by increasing unit prices, thereby leading to improvements both in output and in employment. In particular, productivity growth facilitates the reconversion process within firms as well as the birth of new firms by removing the barriers to entry into new productions. Thus it becomes possible to increase the employment of regional resources.

The vast regional disparities in productivity may be interpreted as the result of two factors:

a) the *differring composition* of the regional economies,

b) the *change in the composition* of the regional economies.

The differring composition of the regional economies with respect to sectoral structure, firm size, the organizational structure of the firms, the product mix and the processes adopted within single firms may affect both the productivity levels and productivity growth rates of the regional economies. This is especially true if the various classes, into which the regional firms may be divided, are characterized by differing productivity levels and growth rates.

Secondly, there are individual patterns and rates with which the restructuring process takes place within single regions. This may imply intersectoral shifts of resources from sectors of lower to those of higher productivity, or intrasectoral shifts, such as in the cases of the birth of firms with above-average productivity and the death of firms with below-average productivity. Intrasectoral shifts also include shifts of employment from firms of lower to those of higher productivity. Finally the restructuring process could occur within single firms, as in the case when resources are transferred from products and/or processes with lower productivity to those with higher productivity.

1.3. *The Spatial Diffusion of Innovations*

Regional disparities in productivity growth are affected by the spatial diffusion of innovations and not by the degree of the inventive activity in the various regions. In fact, inventions are relevant only if they are applied to economic processes and the process of imitation may be as relevant as the first adoption of an invention.

More specifically we may define innovation from a regional point of view as *any change in the allocation of resources which leads to an increase in regional productivity.* In this respect, it is important to consider not only the time lag before the individual innovations are adopted with respect to other regions or countries, but also the difference between the productivity levels implied by the new technology and those of the technologies previously adopted in the same region and the process of intraregional diffusion, e.g. the speed by which regional resources are transferred from old to new technologies.

In contrast to the traditional dichotomy between technology-push and demand-pull innovations, recent contributions stress the fact that the various causes and effects of an innovation are strictly interdependent and represent a continuous process. In fact, a sound coupling of technology and marketing is one of the characteristics that is most significant in distinguishing the relative successful innovators from the relatively unsuccessful ones [2].

It is clear, therefore, that the adoption of a new products or process depends upon the evolution of both demand and supply factors, since they jointly affect the

[2] See E. Mansfield [15, 1981].

«barriers to entry» in new productions. In particular, the adoption of an innovation is determined by three complementary conditions:

a) the availability of relevant information,

b) the expected value of the profits of the new technology relative to that previously in use,

c) that the profits brought about by the new technology exceed adjustment costs.

A) *Availability of relevant information*

A large number of studies have examined the role of the diffusion and availability of technological information in explaining the lag between an invention and its regional application [3].

Among the factors that influence the speed of the flow of information are: the proportion of non production workers on total employment, the type of sectoral specialization, access to transportation and communication networks, population potential, the size of urban centers and the levels of education.

A variable highly correlated to all these factors is the availability of service activities. In fact, these activities deal explicitly with the collection and elaboration of information and may be defined not only as factors in the diffusion of information but also as indicators of the level of the availability of information.

Insight into the problem of the diffusion of innovations may be gleaned from studies which deal with the problems of location of service activities. In particular, these studies stress the roles of the market potential of the various areas, of high and increasing economies of scale in the production of services, of agglomeration economies among the various service activities, both private and public, of transportation and communication networks, of the availability of qualified labor and also of the residential quality of the urban areas [4].

B) *Relative profitability of new and old technology*

Technological change is determined either by the explicit choices made by single firms regarding the adoption of technologies which allow the highest profits, or by an implicit process by which firms having adopted the most appropriate technologies are selected. In fact, these firms are capable to pay higher prices for local resources than prices paid by the less efficient firms. The resulting increase in the price of production factors determines the closure of the latter, thus leading to a general increase in regional productivity.

According to the «technology push» interpretation of the diffusion of innovation, the most modern technology is always the most efficient and, once it is known, only social or psychological factors can explain its lack of adoption. In reality, it may instead be the case that the more traditional technology is the most appropriate or profitable given the characteristics of the available regional resources. Various factors, such as the availability of skilled or unskilled labor and differences in the demand of various products among the various regions may determine differences in the prices of production factors.

The profitability of innovation also depends upon the internal characteristics

[3] See R.P. Oakey et al. [21, 1980], R. J. Buswell - E.W. Lewis [3, 1970], B.J. Berry [2, 1971], e Pedersen [22, 1970].

[4] See J.B. Goddard [14, 1975], I. Alexander [1, 1979], P.W. Daniels [10, 1970]

of the firm, such as its sector of activity, its size and the competitive structure of its markets. It should be stressed that even these elements, which are usually analysed by industrial economists in an aspatial context, are affected by regional factors.

It is certainly true that, if the various sectors are characterized by different technological trajectories and average productivity increases, the sectoral composition of a regional economy affects its productivity level and growth rate. However, a particular firm within a specific sector may use different technology, depending on the prices of the factors in the various regions. Moreover, the significance of the various sectors and of the various firms in particular regions depends on the relative availability of location factors with respect to the other regions.

The profitability of specific forms of innovations also depends upon the scale of the firms involved and the competitive structure of their markets. Small firms have special advantages in the innovation process: the decision to go ahead with new and risky projects may be easier to make, the number of people involved in the decision process is smaller, the probable personal pay-off for the innovator himself may be greater and it may be easier to ask for the advice of outside specialists. On the other hand, larger firms often have larger resources with which to carry the considerable costs of the development and marketing of new products, they may diversify the risk involved with a greater number of projects, there may be external economies between different products and important economies of scale with respect to research and development, production and marketing, and they may have easier access to financing.

The market power of a firm also affects its technological performance. In fact, firms whit monopoly power have higher profits and are more apt to command the vast financial resources required to invest in advanced technology. They may also be able to internalize most of the benefits arising from the adoption of an innovation since firms in competitive markets are less capable to defend themselves against imitators. On the other hand, competitive firms are compelled to search continously for new processes and products in order to outstrip the competition and may not exhibit the complacent behavior which often characterizes monopolistic firms.

As in the case of sectoral specialization, the size and market structure of firms varies among the different regions and is highly influenced by regional factors. In fact, the small size of firms is often the result of the limited capability of local entrepreneurs, who are not experienced enough to collect large capitals or to manage complex organizations. Where the spatial pattern is characterized by rural settlements and by many small or medium urban centers, the small size of firms facilitates the recruitment of the labor force [5].

Moreover, firms in peripheral regions are compelled to sell their products in competitive markets since they are relative late-comers to industrial production and have thus specialized in fields where the barriers to entry are lower but the number of competitors is larger. They lack the financial and human resources which would enable them to enter into more innovative productions, by requiring more sophisticated technology and the ability to operate in distant markets.

C) *Adjustment costs*

Regional disparities in productivity may be due to differences among the technologies which may be appropriate to the various regional environments. Such disparities may be due to the existence of substantial regional differences in the availability and price of specific resources, such as skilled and unskilled labor, and

[5] See G. Fuà - C. Zacchia [13, 1981].

differences in the price of products, *i.e.* goods or services protected from outside competition by transport and other barriers. The relevance of this explanation may decrease if the differences in question diminish due to progress in economic integration, advances in communications, the effects of demonstration processes on the equalization of factor prices and the increase in educational levels.

On the contrary, the costs involved in shifting local resources from old to new technology become a particular important factor in the adoption of innovations. Moreover, the criteria that the adjustment costs determined by the reallocation of resources be lower than the relative profits of the new with respect to the old technology refers to specific dynamic factors in the diffusion of innovations, while the condition that the new technology be more profitable with respect to the old technology implies a comparative static comparison of two abstract alternatives.

In order to overcome resistances which may be determined by economic, social or even psychological factors, firms must encounter specific new costs, which may be measured either in terms of new expenditures or loss of profits. The specific dynamic character of these adjustment costs is also underlined by the fact their level is positively related to:

a) the *level of the technological gap to be overcome,*

b) the *time span required for change.*

Moreover, as with the relative profits discussed above, these adjustment costs vary according to the various periods and the various regions under consideration.

R&D investments have been the adjustment costs most carefully studied. It is important to note that R&D investments vary not only over time and regions, but that their efficiency may vary according to the region under consideration. In fact, in the cases of less developed regions, investment in development research or even into patent acquisition may be more productive than investments in applied and basic research. It seems, moreover, that the productivity of the R&D expenditure is highest for small firms in terms of patent or output growth[6], R&D productivity decreased in the '70s with respect to the '60s and the '50s, thus explaining the decrease in R&D investments and the shift toward more applied research.

A second major factor explaining adjustment costs is the size and age of the capital equipment in use. In fact, frequent technological changes require frequent replacement of equipment and imply higher depreciation costs. In this respect, reconversion may be facilitated by the establishment of new firms more than by restructuring of existing firms, since new firms are not hampered by previous obsolete equipment and may have special advantages with respect to existing firms in the adoption of the latest technology.

Frequent and vast technological changes imply higher costs than do more gradual changes financed by internal resources. Therefore, another form of resistance to technological change may be represented by the size thresholds of new technology, which represent constraints on particular firms in comparison to external financial borrowing.

Another fixed factor which may give rise to resistance to technological change is the organizational ability of particular firms. Very rarely do innovations consist only in the introduction of new equipment. They often involve a reorganization of the production process and a systematic interaction among the contributions of various agents. Additional resources should therefore be devoted to the elaboration

[6] See W.S.Comanor - F.M. Scherer [9, 1969] and A.N. Link [15, 1978].

of new organizational procedures and to the training of the labor force in new areas of specialization. Other costs may arise from inefficiency due to the gradual «learning by doing» process and from possible conflict with organized labor.

The relationships between firms and the external environment may also represent obstacles to innovation. Major changes require coordination with other firms and with public administration. Efforts in this direction will depend, on the one hand, on the level of social consensus among the various economic and social forces, the organizational and political ability of public institutions and the ease of industrial relations and, on the other hand, on the relevance and pace of the planned changes.

Finally, adjustment costs as well as relative profits may vary not only in absolute terms but also in the way they are perceived by various firms. In fact, elements such as management aggressiveness, experience and attitude toward risk, as well as the firms degree of autonomy with respect to firms external to the region, may all influence resistance to technological change.

1.4. *Lags in the Adoption of Innovations*

The model of the spatial diffusion of innovations, described above, may be further elaborated through the use of a graphic representation. In fact, the necessary condition for the adoption of a new technology at a time ($t0$) is that the present value of the relative profits ($RP01$) of the new technology with respect to that previously in use be greater than, or at least equal to, the present value of the adjustment costs ($C01$)

$$RP01(T) \leq C01(T) \tag{1}$$

Clearly, both the value of the relative profit as well as that of the adjustment costs vary according to the time (T), in which the innovation is adopted. In fact, the firms may anticipate or postpone the decision to innovate in order to maximize the difference between these two values. This process may explain the time lags in the adoption of innovation among the different regions.

In particular, if a firm located in a particular area is the first potential adopter of the innovation and chooses to accelerate the time of adoption, it will be obliged to pay higher costs for R&D or other types of adjustment costs in order to overcome resistances to technological change. These higher costs could be due to a number of factors: the necessity of overlapping experiments, which usually must be done successively, the diminishing returns which results from investing larger resources in the same technological assignment, the accelerated rate of depreciation of old equipment or to increased management costs due to the resistance of organized labor. Therefore the trade-off between time and the levels of adjustment costs may be represented by the curve ($C01$) in Fig. 1.

The potential new adopter should, however, consider the benefits of proceeding more rapidly. These may be represented by the relative profit function ($RP01$), which indicates the present value of the relative profit resulting from the adoption of the new technology (1) in comparison to that resulting from the use of the old technology (0).

This function has a negative slope for two reasons: «completing the development effort earlier allows the firm to tap the market's profit potential over a longer time span, and earlier completion improves the firm's competitive position relative to rivals, with possibly lasting implications for its market share and hence its share of the market's total profit potential» [7].

[7] See F.M. Scherer ([24, 1980], p. 427).

If the firm desires to maximize the surplus of benefits ($RP01$) over costs ($C01$), it will introduce the innovation at the time ($T1$), in which the slope of the benefit function equals the slope of the time-costs trade-off function.

In the case of a late innovator located in a different region, the time-cost trade-off function ($C01^*$) will be higher, since its initial technological level is lower and its distance from the centers of inventions and the internal organizational resistance to early adoption of the innovation are greater. This curve is negatively sloped as well, since the cost and risk of adoption will be lower, the larger is the number of firms having adopted the new technology and the more standardized this latter becomes.

Similarly the benefit function ($RP01^*$) for the late adopter will be lower initially than it was for the first adopter. It may even be negative if the actual price of the product and of the inputs in the area, where the late adopter is located, make traditional technologies more convenient. With time, however, the relative profits may increase and become not only positive, but even greater than those of the first innovator.

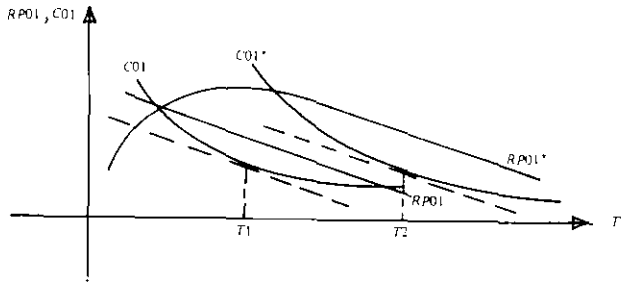

Fig. 1 - Time lags in the process of innovations diffusion.

In fact, revenues may increase according to a number of factors: improvements in communications may increase the market potential, progress may be achieved in marketing organization and the development of the area may lead to an increase in the size of the local market. The cost of production may, instead, diminish as improvements occur in the quality of the labor force, in the ability of firms to raise capitals or in the local availability of intermediate products or services, such as maintenance services which previously had to be imported. With time, however, the relative profit function will start to decrease for the same reasons as it did for the first adopter. Therefore, if this second firm also desires to maximize the surplus of benefits ($RP01^*$) with respect to costs ($C01^*$), it will introduce the innovation at a time ($T2$) later than the first adopter.

This model, moreover, may explain the factors which determine the persistance of regional disparties in productivity. Although each technology will be gradually adopted by even the most peripheral and least developed regions, the elaboration of new technology and its early adoption by the most developed regions is a continuous process. Therefore, if the flow of inventions is rapid with respect to the speed of the

diffusion of innovation, as determined by the slopes of the relative profit curve and of the adjustment costs curve of the individual regions, then the lag in the adoption of the individual innovations by each region will remain more or less constant as will the overall technological and productivity gap between the various regions.

This model may also be applied to the case of two, more complex, situations. The first is characterized by the gradual adoption of new technologies by individual firms and by the combination of various forms of old and new technology within the same firm. The second case is characterized by the existence of several firms using different technologies and by the gradual increase in the number of firms using new technology. This more general case allows this model to be applied not only to the analysis of lags in the adoption of specific innovation, but to the analysis of regional disparities in aggregate productivity as well.

In particular, it may be assumed the adoption of new technology determines an increase in productivity among the adopting firms as well as an increase in their profits. One can also assume that the level of adjustment costs is related to the speed of technological change. It is clear, then, that if the share of total employment related to the new product or process within the individual firm grows, or if the share of the firms adopting new technologies increases, aggregate productivity will also grow. Therefore, the rate of aggregate productivity growth ($RPR01$) is positively related to the present value of the long term aggregate profits (RP) of the various firms within the sector under consideration and of the various products and processes within the individual firm under consideration. The rate of aggregate productivity growth is also positively related to the present value of the aggregate adjustment costs (CA) incurred by the individual firms, as pointed out by the following two equations:

$$RP = f(RPR01, Z_1, Z_2, \ldots Z_n) \quad (2)$$

$$CA = f(RPR01, Y_1, Y_2, \ldots Y_n) \quad (3)$$

where Z_i indicate the various factors which affect the profits of the technologies to be adopted with respect to those actually in use and Y_i represent the factors which affect the adjustment costs due to the change from old to new technology.

The optimal rate of change in productivity in the various moments and the various regions may be identified by the following graph:

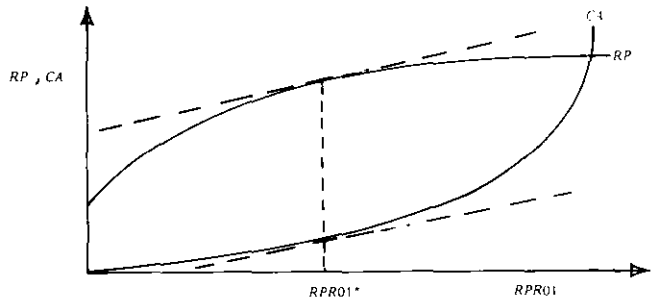

Fig. 2 - Factors of the appropriate change in productivity.

In fact, $RPR01^*$ corresponds to the value which allows the maximization of the difference between relative profits and adjustment costs and which may be defined as the «appropriate speed» of technological change in the region under consideration. Therefore, from the dynamic equilibrium condition

$$\frac{d\,(RP)}{d\,(RPR01)} = \frac{d\,(CA)}{d\,(RPR01)} \tag{4}$$

an equation may be derived which can be used in the econometric estimation of the factors which affect the productivity changes in the various regions

$$RPR01 = f(Z_1, Z_2, \ldots Z_n, Y_1, Y_2, \ldots Y_n) \tag{5}$$

The model described by equation (4) and Fig. 2 may also be applied to a third, more general, case which corresponds to Nelson and Winter's «evolutionary model» [8] of technological change. This model is based upon the hypothesis that the turnover in firms and their different rates of expansion are the causes of aggregate changes in productivity.

In particular, as in the case of the models of oligopolistic competition, the birth and growth of individual firms is determined by their ability to overcome specific barriers. The model described above may be useful both in order to verify the relevance of the various factors which encourage or hinder the birth and growth of more productive firms, and to examine the adoption of innovation within individual firms. In fact, productivity growth may be determined by an «implicit» process since the number of firms having adopted the innovation under consideration will increase if their relative profits exceed their adjustment costs. This proces will continue until the last firm finds that relative profits exactly equal adjustment costs. Thus condition (4) will hold for the entire sector. On the other hand, less productive firms will be forced to close down, due to the competition of more productive firms in the markets either of factors of production or of the products.

In the case of the European regions the empirical test of this model faces the traditional constraint imposed by the scarcity of comparable data on the various structural factors which characterize both the single firm and their respective regional environments. Therefore, the explanatory variables which can be considered are «proxies» of the original variables. These empirical tests may, however, be useful in pointing out some basic relationships affecting regional productivity growth.

2. Sectoral Versus Regional Factors in Productivity Growth

Regional disparities in the growth rate of productivity may be decomposed into the three following effects, which are due to:

1) different sectoral composition of the regional economies, if the various sectors are characterized by different productivity performance (MIX effect),
2) different productivity performances of the same sectors among the various regions (DIF effect),
3) differences in the process of employment reallocation toward sectors characterized by higher productivity levels and/or growth rates at the regional level (REALLR effect) and at the national level (REALLN effect).

[8] See R.R. Nelson [19, 1981].

An analysis of regional disparities in productivity based on this approach may be performed through an analytical expression which is similar to the shift-share analysis which is described in Appendix 3. An empirical application of this expression has been performed in the case of the Italian and French regions, but it is impossible to do so for the other European regions due to the lack of comparable data on sectorally disaggregated employment.

The results for the 1970-1978 period [9] show that in many «follower» and fast growing regions the reallocation effect is quite strong and often more relevant than the MIX and the DIF effects. This is particularly true for the Molise, Abruzzi, Marche and Umbria regions in Italy and for the Haute Normandie, Picardie, Bretagne and Limousin regions in France. The reallocation of resources from sectors such as agriculture and retail trade towards industrial sectors proves to be a strategic element in the pursuit of higher levels of economic efficiency in lagging regions.

The same reallocation effect also proves to be a very important effect in other, more advanced, regions, where it may play a significant role in the presence of a slowdown in the possibilities for innovation within the individual sectors. In these cases, the reallocation process takes place in favour of advanced industrial and tertiary sectors, as in Île de France, particularly in the subperiod 1974-1978, and some «central» Italian regions such as Piemonte, Liguria and Lazio. In the case of the Italian regions, however, this process was too weak to overcome the slow process of restructuring the single sectors, as indicated by the negative values of the differential effect. It is important to stress the fact that the MIX effect appears to be of secondary importance in almost all cases, since it reaches a relevant (negative) level only in the cases of Val d'Aosta and Lorraine.

The shift-share analysis provides a useful framework for the investigation of regional disparities in productivity. In particular, it is important to verify both the relative importance of the first effect (MIX) with respect to the two other effects (DIF, REALLR and REALLN), and the empirical relevance of the hypothesis, according to which regional disparities in productivity levels and growth rates would be due to the different sectoral compositions of the regional economies. In fact, this hypothesis would clearly deny the relevance of the influence of regional factors on productivity performance as well as the need for new regional policy measures aimed at promoting productivity and innovation, in contrast to traditional incentives for the location of high productivity sectors.

2.1. *The Role of Sectoral Composition*

The role of regional factors in the explanation of disparities in productivity is highlighted when compared to the opposite hypothesis, i.e. that disparities in productivity are principally determined by differences in the sectoral composition of regional economies. According to this hypothesis, productivity should be equal for the same sector in all regions. A regional approach, on the contrary, would point out that productivity levels are relatively homogenous within the individual regions.

The sectoral approach's relevancy to the explanation of regional disparities in productivity can be tested by decomposing the Theil index of disparities in productivity *among the various sectors and among the various regions* (F) according to the two different methods, which are described in Appendix 2. These methods are based upon the disaggregation of total disparities into disparities *among* classes and

[9] See R. Camagni - R. Cappellin [8, 1983].

disparities *within* classes. In fact, if we consider the various sectors as classes, it is possible to distinguish between:

a) disparities *among the various sectors at the Community level* (*F*2),

b) disparities *in each sector among the various regions* (*F*4).

Therefore, if the sectoral approach were valid, the effect (*F*4) would be particularly low, while the contrary would take place if the regional and intersectoral approach were to hold. In fact, according to the latter, the productivity of all sectors of the same region would be relatively homogenous.

According to the second method, the regions would become the classes and it would be possibile to distinguish between:

a) disparities *among the various regions* in aggregate productivity (*F*5) and

b) disparities *among the various sectors within each region* (*F*7).

If the regional approach were valid, the effect (*F*7) would be particularly low. Use of the sectoral approach would, on the contrary, result in a high value for this effect, which would be similar to the effects (*F*2). Moreover, according to the regional approach, the effects (*F*4) and (*F*5) would be similar.

TAB. 1 -*Sectoral Composition of Disparities in Productivity.*
(Theil indices, Appendix II)

Effects	1970	1974	1978
*F*1	371	361	383
*F*2	207	165	147
*F*4	163	197	236
*F*5	132	159	190
*F*7	239	203	193
*F*3 agriculture	593	635	714
*F*3 industry	158	214	178
*F*3 services	78	111	210
Agriculture: share	10.07	8.50	7.67
Industry: share	41.34	39.84	37.47
Services: share	48.58	51.66	54.86

The results indicated in Tab. 1 reveal that neither of the two extreme hypotheses holds true. However, the relevance of the regional intersectoral hypothesis appears to increase with time. In fact, if the first method ($F1 = F2 + F3$) were adopted, the regional hypothesis would have explained 44% of total disparities in 1970, while it explained 61% in 1978. Moreover, if the second method were adopted ($F1 = F5 + F7$), these percentages would have increased from 36% to 49%. The increase in disparities in the period 1970-78 can only be explained by the increased relevance of the interregional effects (*F*4 and/or *F*5, since the intersectoral effects (*F*2 and/or *F*7) would have led to a decrease in total disparities in productivity. Therefore, it may be concluded that disparities in productivity are greater among different regions for the same sector than among the various sectors within the same region.

This test of the relevance of the sectoral interpretation of disparities in productivity is limited by the fact there are comparable data of regional employment in the

Community for only three sectors: agriculture, industry and services. However, the sectoral breakdown may be greater in the case of regional value added since data are available for 17 sectors.

TAB. 2 -*Sectoral Composition and Productivity Levels and Changes.*
(equation n. 1 and 2, period 1970-78)

Coefficient (*a*) and Student's *t* (*t*)	year	a_0	$t\,(a_0)$	a_1	$t\,(a_1)$	R^2
Equation 1	1970-1978	2.41	39.90	−5.19	−2.77	.09
Equation 2	1970 1978	−.16 −.07	−2.91 −2.91	1.92 2.14	6.54 5.91	.40 .35

Therefore, a simple test of the relevance of sectoral composition in the explanation of regional disparities in productivity may consist of estimating the correlation between the actual productivity levels and growth rates of the various regions and the productivity levels and growth rates which would have occurred if productivity levels and growth rates in each sector of the various regions had been equal to the corresponding Community averages, as illustrated in the following equations

$$\frac{{}_tN_r}{{}_tX_r} = a_0 + a_1 \left(\sum_i \frac{{}_tX_{ir}}{{}_tX_r} \frac{{}_tN_{ic}}{{}_tX_{ic}} \right) \tag{1}$$

$$\frac{{}_1N_r/{}_1X_r}{{}_0N_r/{}_0X_r} = a_0 + a_1 \left(\sum_i \frac{{}_0X_{ir}}{{}_0X_r} \frac{{}_1N_{ic}}{{}_0X_{ic}} \Big/ \sum_i \frac{{}_0X_{ir}}{{}_0X_r} \frac{{}_0N_{ic}}{{}_0X_{ic}} \right) \tag{2}$$

where X indicates the product, N the employment, i the sector, r the region, c the Community, t the time period and 0 and 1 the initial and final year. The results show that sectoral composition is a relevant variable in the level and change of regional productivity, but that its explanatory power, as pointed out the ($R2$) test, is clearly rather low, thus indicating that also other variables should be considered.

2.2. *Patterns of Sectoral Specialization*

The interregional concentration of the various sectors or the sectoral specialization of the various regions are neither constant nor easily predictable. In fact, according to the growth stage theory, the agricultural share of total product and employment should decrease with the growth of per-capita product, while the share of industry and services should increase. The assumptions underlying this theory could be verified through the econometric estimation of the following equations

$$ln \frac{X_{ir}/X_r}{X_{ic}/X_c} = a_0 + a_1 \, ln \frac{X_r/PO_r}{X_c/PO_c} \tag{3}$$

where PO indicates the population and the parameter a_1 indicates the elasticity of the sectoral location quotient with respect to the index of per-capita product.

The analysis of this equation for the 17 SEC-REG sectors and the years 1970 and 1978 are presented in Tab. 3. They indicate that the elasticity between product shares

TAB. 3 -*Relationships Between Sectoral Shares and Per-Capita Product.* (equation n. 3)

Coefficient (a) and Student's t (t)	year	a_0	t (a_0)	a_1	t (a_1)	R^2
Agriculture	1970	—.18	—1.69	—2.69	—6.97	.43
	1978	—.12	—1.05	—2.35	—5.78	.34
Energy products	1970	—.16	—1.88	.20	.70	.00
	1978	—.21	—2.52	.18	.63	.00
Ferrous metals	1970	—.47	—1.87	1.39	1.57	.02
	1978	—.41	—2.19	.39	.58	.00
Non metallic minerals	1970	—.16	—2.56	—.56	—2.63	.08
	1978	—.18	—2.46	—1.03	—4.04	.19
Chemical products	1970	—.25	—2.78	1.20	3.78	.17
	1978	—.28	—3.18	.75	2.37	.07
Metal products	1970	—.32	—3.16	2.14	6.10	.36
	1978	—.28	—3.23	1.65	5.34	.30
Transport equipment	1970	—.45	—2.94	1.65	3.10	.12
	1978	—.54	—2.54	.51	.67	.00
Food	1970	—.06	—1.12	—.04	—.20	.00
	1978	—.00	.13	—.10	—.60	.00
Textile products	1970	—.26	—2.88	—.57	—1.83	.00
	1978	—.22	—2.38	—.97	—2.91	.10
Paper	1970	—.30	—3.56	1.31	4.41	.22
	1978	—.26	—3.02	1.08	3.51	.15
Various industries	1970	—.15	—2.28	.23	1.01	.00
	1978	—.14	—1.89	—.25	—.94	.00
Construction	1970	—.00	—.17	—.53	—6.19	.37
	1978	.02	.97	—.60	—5.88	.35
Trade	1970	—.04	—1.05	.27	2.03	.04
	1978	—.11	—2.30	.13	.76	.00
Transport and communications	1970	—.04	—1.05	.27	2.03	.04
	1978	—.11	—2.30	.13	.76	.00
Credit and Insurance	1970	—.06	—1.55	.71	4.58	.24
	1978	—.13	—2.14	.34	1.54	.02
Other market services	1970	—.10	—3.42	.11	1.04	.00
	1978	—.05	—1.71	.43	4.27	.21
Non market services	1970	—.00	—.09	—.46	—4.92	.27
	1978	—.04	—1.44	—.43	—4.04	.19

and per-capita product is *positive* for the following sectors, listed according to decreasing elasticity value, with the symbol (*) pointing out low significant values:

— Metal products, paper, chemicals (*), transport equipment (*), credit and insurance.

On the contrary, elasticity is negative and decreasing for the following sectors:

— Construction, non market services, minerals and non metallic mineral products (*), textiles (*), agriculture.

The relationship reveals almost null ($R2$) values for the other sectors:

— Energy, minerals and ferrous metals, food, various industries, trade, transport and communication and other services.

It is worthwhile to state that the absolute values of these elasticities decrease across all sectors in the period 1970-1978, indicating that the regional pattern of sectoral specialization is becoming more independent of the respective level of economic development.

The low stability of the parameters of these equations suggests the application of a similar methodology to the study of the changes, rather than levels, of the sectoral shares of value added. In fact, this analysis may clarify the patterns of the diversification processes which characterize the development of the European regions. Therefore the following equation has been estimated for changes in the product shares of the three major sectors

$$\frac{{}_1X_{ir}/{}_1X_r}{{}_1X_{ic}/{}_1X_c} - \frac{{}_0X_{ir}/{}_0X_r}{{}_0X_{ic}/{}_0X_c} = a_0 + a_1 \ln \frac{{}_0N_{ar}/{}_0N_r}{{}_0N_{ac}/{}_0N_c} \qquad (4)$$

The results, presented in tab. 4, are less satisfactory than those of eq. (2), as the values of the statistical tests are rather low. However, the agricultural share of employment is a significant explanatory variable, that reveals a strong tendency of the industrial and service sector to diffuse into rural regions. The opposite tendency is demonstrated by the agricultural and non market service sector's change in product shares. The industrial sectors most oriented toward the rural regions appear to be the following:

— Metal products, transport equipment, textiles, food, various industries, paper.

TAB. 4 -*Changes in Sectoral Specialization.* (equation n. 4, period 1970-78)

Coefficient (a and Student's t (t)	a_0	t (a_0)	a_1	t (a_1)	R^2
Agriculture	—.0200	—7.70	—.0080	—4.60	.22
Ferrous metals	—.0005	—1.30	.0005	1.28	.02
Chemical products	—.0016	—2.21	—.0056	—1.62	.02
Metal products	.0020	1.45	.0043	3.48	.13
Transport equipment	.0036	3.39	.0028	3.08	.10
Food	—.0035	—1.73	.0024	1.37	.01
Textile products	—.0026	—2.35	.0024	2.48	.06
Paper	—.0003	—.47	.0013	3.10	.10
Other industries	.0017	2.65	.0015	2.67	.07
Trade	—.0027	—1.33	.0057	3.16	.11
Non market service	.0145	6.24	—.0043	—2.15	.05

The findings demostrate that conclusions based upon the growth stage theory, as well as those derived from the simple classification of the various sectors into «traditional» and «advanced» sectors according to their elasticity to per-capita product, should be considered with great caution. In fact empirical tests demonstrate that actual regional specialization and performance may often contradict these conclusions and may be determined to a larger extent by different factors. Thus there is considerable scope for greater sectoral diversification of the various regional economies, as well as for the choice, within each sector, of those production phases which are most appropriate to the various regional environments.

2.3. *The Role of Horizontal Factors*

Since the regional trends in productivity cannot be fully explained in terms of sectoral composition and since the latter has become more homogenous, it may be

deduced that the factors determining regional trends in productivity have chiefly horizontal effect and are homogenous for all sectors.

The relationship among the productivity levels of the various sectors in the same regional economy may be examined by estimating the following equation

$$\frac{X_{ir}/N_{ir}}{X_{ic}/N_{ic}} = a_0 + a_1 \frac{X_r - X_{ir}}{N_r - N_{ir}} / \frac{X_c - X_{ic}}{N_c - N_{ic}} \qquad (5)$$

where the explanatory variable indicates the average productivity level of all sectors different from that under consideration. If the productivity level of each sector were equal in all regions to the respective Community average, then the parameter (a_0) in the above equation would be 1, while the parameter (a_1) would be 0. If, instead, the productivity level of each sector were equal to the productivity of the other sectors in the same regional economy, then the parameter (a_0) in the equation would be 0 and the parameter (a_1) would be 1.

Tab. 5 shows that the reality of the three macrosectors lies midway between these two extreme hypotheses. Both intraregional homogeneity, i.e. among all sectors of the same region, and interregional homogenity, i.e. for the same sector among alla regions, are shown to be important. In particular the parameter (a_1) differs from 0 in the case of industrial and service sectors, demonstrating that there are factors which affect the productivity of these sectors and which are common to other sectors in the same regional economy. The low values of the ($R2$) test point out that the factors influencing sectoral productivity in particular regions are complex, and that the regional productivity growth of the individual sectors is often quite different from that of the corresponding Community average.

TAB. 5 -*Horizontal Factors of Productivity.*
(equation n. 5 and 6)

Coefficient (a) and Student's (t)	year	a_0	$t\ (a_0)$	a_1	$t\ (a_1)$	R^2
Equation n. 5						
Agriculture	1970	—.13	—.41	1.32	3.99	.17
	1978	.17	.67	1.00	3.90	.17
Industry	1970	.08	.97	.93	10.84	.61
	1978	.25	2.45	.77	7.31	.42
Services	1970	.73	16.71	.25	5.70	.30
	1978	.57	9.54	.41	7.05	.40
Equation n. 6						
Agriculture	1970-1978	2.66	5.09	.04	.22	.00
Industry	1970-1978	1.00	2.14	.66	3.59	.14
Services	1970-1978	1.91	8.81	.17	2.27	.05

The relationship between the productivity growth rate of each sector and those of all the other sectors of the same region may be estimated by the following equation

$$\frac{{}_1X_{ir}/{}_1N_{ir}}{{}_0X_{ir}/{}_0N_{ir}} = a_0 + a_1 \frac{({}_1X_r - {}_1X_{ir}) / ({}_1N_r - {}_1N_{ir})}{({}_0X_r - {}_0X_{ir}) / {}_0N_r - {}_0N_{ir})} \qquad (6)$$

The fact that the coefficient a_1 is significant and positive for the industrial and service sectors shows that productivity changes in the various sectors within the individual regions are positively related.

Therefore, the empirical evidence does not indicate the prevalence or success of an unbalanced growth pattern based on a deep sectoral dualism within each regional economy. On the contrary, the sectoral productivity levels and growth rates seem to be homogenous for each region. This fact stems from the deep interdependence among the sectors of the same region, in the form of intersectoral factor mobility, which is based on the complementarity of human and environmental resources as well as dependence on local income and demand.

The role of horizontal or intersectoral factors in the growth of sectoral productivity in the various is clearly delineated by the econometric equations presented in table 6. The dependent variable is the rate of change of productivity and the explanatory variables (Z_i) have a clear intersectoral character and are related to factors often discussed by various studies on the diffusion of innovations.

TAB. 6 -*Regional Factors in Changes in Productivity.*
(period 1970-78) (equation n. 7)

Sectors	C	RXN	REST	SEI	SEA	RPN	R^2
Total	.13	.76	1.32		.94		.24
—	(.20)	(2.80)	(2.24)		(2.01)		
Agriculture	—.76	.95	1.41	1.67		1.71	.04
—	(—.46)	(1.70)	(1.31)	(1.59)		(2.15)	
Industry	.24	.69	1.86		1.59		.18
—	(.26)	(1.79)	(2.23)		(2.39)		
Services	.46	.81	1.54	—1.10	—.80		.29
—	(.65)	(3.32)	(2.91)	(—1.43)	(—1.45)		

Variables:

C = constant; RXN = $\frac{{}_1X_n}{{}_0X_n}$; REST = $\sum_i \left| \frac{{}_1X_{ir}}{{}_1X_r} - \frac{{}_0X_{ir}}{{}_0X_r} \right|$; RPN = $\frac{{}_1T_n}{{}_0T_n} - \frac{{}_1PP_n}{{}_0PP_n}$

The specification of this equation is the following:

$$\frac{{}_1X_{ir}/{}_1N_{ir}}{{}_0X_{ir}/{}_0N_{ir}} = a_0 + a_1 Z_1 + a_2 Z_2 + \ldots\ldots + a_n Z_n \qquad (7)$$

Given the paucity of comparable data at the EEC level on the structural characteristics of firms and regional environments, the explanatory variables under consideration are quite simple. In particular, the variable REST may be considered to be an indicator of the mobility of regional resources. The variable SEA, which measures the share of agriculture, is an indicator of congestion costs and of space availability. The variable RXN, which represents the growth rate of the national product of the respective country, is an indicator of the demand management policies pursed in the various countries. Finally, the variabe RPN, which is the difference between the growth rate of the exchange rate and that of the purchasing power parities index, may be interpreted as a factor promoting exports and production.

Therefore productivity growth has been higher in the regions where the changes in the sectoral structure has been most important. In fact resources mobility is an important factor in productivity growth, as this latter requires the shift of resources from less productive to more productive uses. This reallocation of resources may take place within the various firms and *within* the various sectors as well as *among* the various sectors. It is therefore important to influence the *factors which inhibit or encourage the reconversion of resources to more productive uses in the individual regions.*

3. Demand and Supply of Innovation Factors

An analysis of regional accounts may indicate significant relationships among aggregate data, but it does not reveal the effects of the structural characteristics of firms and of their particular regional environments upon the diffusion of innovations. In order to reach a better understanding of the various regional patterns of produtivity growth, it may be useful to turn to an analysis of regional case studies. Information regarding individual cases can be gathered through discussions with experts and the study of various statistical sources available only for individual regions. Clearly, such an analysis does not permit general conclusions to be drawn, as would statistical tests of specific theoretical hypotheses. However, these case studies can be useful in comparing the evolution of productivity among the different regions as well as contribute to the evaluation of their relative «innovation potential».

To begin with, it may be assumed that the speed of the innovation adoption process in a particular region depends on the positive matching between the *supply of innovation factors* by the various regional environments and the *demand for innovation factors* by the regional firms.

The process of innovation adoption consists of various phases, in each of which positive and negative factors may affect the decision of firms to innovate (A. Piatier, 1981). Therefore, the demand for innovation factors is determined by the requirements expressed by the following production *phases*: 1) basic research, 2) applied research, 3) development research, 4) patents and technological information, 5) marketing information, 6) finance, 7) skilled labor, 8) unskilled labor, 9) equipment, 10) management and organization, 11) prototype development, 12) production, 13) distribution, 14) local markets, 15) public demand, 16) sales within the Eec, 17) sales to other industrialized countries, 18) sales to Third World countries.

On the other hand, the supply of innovation factors depends upon the characteristics of both regional firms and local environments. According to the theoretical model described in Chap. 2, it is possibile to classify the *factors* affecting the decision to innovate into those which influence: A) the diffusion of technological and marketing informations, B) the revenues to be gained from the new product or process to be adopted, C) the costs to be paid when adopting a given technology, and D) the adjustment costs due to the reallocation of resources from old to new technologies. A list of these innovation factors is presented in Tab. 7.

The importance of the phases of the process of innovation adoption by various firms may be related to the identification of phases which represent «weak» or «strong» points with respect to the growth of the firms in a framework of international competition. The regional supply of innovation factors may be classified by comparing a specific region's endowment either to the national average or to that of a specific region accepted as a standard.

In particular, the significance of each phase undergone by the firms in the region

Tab. 7 -*Regional Relevance of Innovation Factors.*
(index A_i)

	SIC.	E.A.	WALL.	N.W.	TOSC.	R.A.
A. *Information Factors*						
1. Technological information	−62	31	23	−3	45	27
2. Marketing information	−53	9	−21	25	17	5
B. *Demand Factors*						
1. Local markets	−21	6	−21	19	35	3
2. Transport accessibility	−45	21	−12	5	17	42
3. Communication accessibility	−36	61	−12	−3	21	60
4. Oligopolistic markets	−47	20	7	3	17	−39
5. Competitive markets	9	−3	−23	−9	−23	17
6. Marketing know-how	−52	32	−44	−38	16	−48
C. *Supply Factors*						
1. Unskilled labor	6	−3	0	−3	−4	14
2. Skilled labor	−42	−24	−12	22	26	26
3. Technicians	−27	9	3	36	20	62
4. Risk capital	−24	3	−58	−7	19	11
5. Credit-private	−18	12	−35	3	−6	3
6. Credit-public	0	0	−3	−9	−28	16
7. Land	−25	8	−3	−6	6	16
8. Natural environment	−27	35	−27	−31	−12	30
9. Urban environment	−45	31	−27	−27	11	19
10. Urban consumer service	−64	54	−48	−3	−15	26
11. Sectoral diversification	−81	−30	−74	0	−9	57
12. Urban producer service	−27	12	−47	35	−47	49
D. *Cost Adjustment Factors*						
1. Basic research	−23	0	−3	−7	−6	5
2. Applied research	−26	21	−18	24	−16	9
3. Development research	−48	6	6	3	−12	−3
4. Small firms	−4	22	−16	0	6	−16
5. Large firms	−50	−32	16	24	−40	16
6. Local firms	−30	−16	−18	18	10	−14
7. Non local firms	12	44	28	−6	−42	12
8. New firms	0	28	−24	−28	16	−20
9. Old firms	−42	−26	14	26	−36	4
10. Management aggressiveness	−66	6	−48	−9	22	−48
11. Management experience	−48	9	6	26	−32	14
12. Labor force education	−53	45	−3	0	−9	−9
13. X-efficiency	21	56	6	10	40	27
14. Labor force mobility	−12	0	−6	3	−3	24
15. Professional education	−15	15	3	3	−17	45
16. Management schools	−22	30	−6	18	−36	14
17. Industrial relations	12	12	−10	−6	8	9
18. Social consensus	−9	6	−29	0	21	5
19. Local institutions efficiency	−25	6	−17	6	11	−9
20. National institutions efficiency	−43	−23	−25	−25	−33	0

under consideration may be indicated with a score, varying from 1 (weak points) to 5 (strong points). Weak points indicate high demand for innovation factors relevant to the particular production phase under consideration. Similarly, a score may be attributed to the supply of innovation factors, varying from 1 (scarcity) to 5 (abun-

dance) according to their relative availability in a particular region with respect to the area chosen as a standard.

Clearly, not all the innovation factors are relevant to a specific phase of production. Therefore, a matrix (K) may be defined, the elements k_{ij} of which have a value (1) or (0) depending upon whether the combination between the innovation factor (i) and the production phase (j) seems relevant or not, as may be demonstrated by various studies on the diffusion of innovations.

The relevance of a particular factor to the process of innovation adoption depends not only upon its absolute availability in a particular region, but also upon the number of phases in which it may be required and upon the strength of the demand by these production phases. Therefore, an index A_i of the relative significance of the various factors to specific regions may be obtained by multiplying the scores of the regional supply by the scores of the phases which demand that factor, according to the following expression

$$A_i = \sum_j k_{ij} [a_i b_j - 9] \tag{8}$$

where k_{ij} is an element of the matrix K, a_i the score of the regional availability of the innovation factor (i), b_j the score of the production phase (j) and the value (9) is determined according to the hypothesis that average score both for the demand and the supply of an innovation factor is equal to (3).

This methodology allows either a comparison among different regions of a specific innovation factor's contribution to technological change, or the identification of the innovation factor which is the most scarce in a particular region. The advantage of this methodology rests upon the fact that it takes into account not only the absolute availability of each factor in the various regions but its demand as well. This latter is determined by the actual or planned characteristics of the production structure of the region under consideration.

In particular, regions which desire to specialize in «early» phases of the «product cycle» may consider phase (1), development research, to be crucial and thus classify it as a «weak point». Regions which desire to specialize in «mature» phases of the product cycle, on the other hand, may consider phase (12), production, to be crucial. In this case, the relevance of the particular innovation factors, as measured by the Index A_i, may be different, even if the two regions have the same absolute availability of innovation factors a_i. In fact, the relative scarcity of unskilled labor, for example, may represent a severe bottleneck for the regions specializing in mature phases of the product cycle, while it may have a minor effect on the innovation potential of the regions specializing in early phases of the product cycle. The same holds true for the comparison between two different innovation factors which may have the same availabilty score a_i but which may be required in different measure from the regional firms, thus having a different relevance as measured by the A_i Index.

Therefore, an «innovation oriented regional policy» does not consist of the same set of measures for each of the various regions. On the contrary, this policy should operate upon the different factors which represent the most severe obstacles to innovation adoption in specific regions, given the matching between the supply of these innovation factors and their actual, or prospective, demand.

This methodology has been applied to six regions of the EEC, which are characterized by very different per-capita product levels and sectoral specializations: Sicilia (SIC.), Toscana (TOSC.), East Anglia (E.A.), North West (N.W.), Wallonie (WALL.) and Rhone Alpes (R.A.). In particular, the survey analysed small and medium size

firms in the mechanical sector of these regions. Table 1 presents the A_i index for the various innovation factors.

The regional availability a_i of each factor has ben evaluated with respect to the respective national average, since the EEC average is a raher abstract standard of measurement. Thus the indices are not strictly comparable at the international level. However, some differences are clear and seem to correspond to the characteristics of the various regions.

In particular, it is clear that Sicilia, being less developed than Toscana, which is an intermediate region characterized by a rapid industrialization process, has a scarcity of local firms, urban consumer services and management aggressiveness. In the comparison between an old, industrialized and reconversion region such as North West and an intermediate, still industrializing region such as East Anglia, the former is characterized by greater enviromental problems and the lack of risk capital, while the latter is burdened by a vast number of non-local firms. Finally, problems with social consensus and the availability of skilled labour are crucial in the case of another old industrialized and reconversion region such as Wallonie, especially with respect to a developed, diversified region such as Rhone Alpes, where the need for research activities is more important.

Therefore, by analysing the demand and supply of innovation factors using the methodology described above, it may be possibile to systematize a large set of quantitative and qualitative information and identify the areas of intervention which may be crucial to a particular region, given their relevance in the various phases of the innovation process.

4. Conclusions

The different productivity growth rates in the various regions depend, on one hand, on the different sectoral composition of the regional economies and, on the other hand, on the rate with which resources are reallocated from less to more productive uses within single firms, among different firms in the same sector and among various sectors. Regional factors play a crucial role in this process of reallocation of regional resources.

In particular, regional factors affect the adoption of innovation as they affect the diffusion of relevant information, the relative profitability of new technologies and adjustment costs in moving from the old technologies. On the basis of these complementary conditions, it is possibile to construct a model which explains disparities in productivity growth and which may be tested by using sectoral data on the EEC regions. This model may also be applied to the comparative analysis of the innovation potential of various regions by using more detailed, although semiquantitative, information.

An econometric analysis demonstrates that the initial sectoral composition of a regional economy explains very little about its productivity performance. Horizontal or intersectoral factors, such as differing capabilities to change and the mobility of resources within and among the various sectors, are more important.

The elaboration of regional case studies indicates that a regional innovation policy should not consist of the use of the same set of instruments in each region, but should be designed according to the various regions' demand and supply of innovation factors. The need to develop appropriate strategies in order to enhance regional innova-

tion potential favous the need for a greater regional decentralization of industrial policy.

Milano, Università Commerciale «Luigi Bocconi» RICCARDO CAPPELLIN

APPENDIX 1

Productivity Shift-Share Analysis

$$\text{DPT} = \frac{{}_1P_r}{{}_0P_r} - \frac{{}_1P_n}{{}_0P_n}$$

$$\text{DPT} = \text{MIX} + \text{DIF} + \text{REALLR} - \text{REALLN}$$

$$\text{MIX} = \sum_i \left(\frac{{}_1P_{in}}{{}_0P_{in}} - \frac{{}_1P_n}{{}_0P_n}\right)\left(\frac{{}_0X_{ir}}{{}_0X_r} - \frac{{}_0X_{in}}{{}_0X_n}\right)$$

$$\text{DIF} = \sum_i \left(\frac{{}_1P_{ir}}{{}_0P_{ir}} - \frac{{}_1P_{in}}{{}_0P_{in}}\right)\frac{{}_0X_{ir}}{{}_0X_r}$$

$$\text{REALLR} = \sum_i \left(\frac{{}_1N_{ir}}{{}_1N_r} - \frac{{}_0N_{ir}}{{}_0N_r}\right)\frac{{}_1P_{ir}}{{}_0P_{ir}}\frac{{}_0P_{ir}}{{}_0P_r}$$

$$\text{REALLN} = \sum_i \left(\frac{{}_1N_{in}}{{}_1N_n} - \frac{{}_0N_{in}}{{}_0N_n}\right)\frac{{}_1P_{in}}{{}_0P_{in}}\frac{{}_0P_{in}}{{}_0PX_n}$$

NOTE:

$P = X/N$ = productivity
X = value added
N = employment
i = sector i
r = region r
n = country
0 = initial year
1 = final year

APPENDIX 2

The Sectoral Breakdown of Disparities in Productivity.

$$F1 = \sum_i \sum_r \frac{N_{ir}}{N_{ic}} ln \frac{N_{ir}/N_c}{X_{ir}/X_c}$$

$$F1 = F2 + F4$$

$$F1 = F5 + F7$$

$$F5 = F4 + (F2 - F7)$$

$$F2 = \sum_i \frac{N_{ic}}{N_c} ln \frac{N_{ic}/N_c}{X_{ic}/X_c}$$

$$F4 = \sum_i \frac{N_{ic}}{N_c} F3_i$$

$$F3_i = \sum_r \frac{N_{ir}}{N_{ic}} ln \frac{N_{ir}/N_{ic}}{X_{ir}/X_{ic}}$$

$$F5 = \sum_r \frac{N_r}{N_c} ln \frac{N_r/N_c}{X_r/X_c}$$

$$F7 = \sum_r \frac{N_r}{N_c} F6_r$$

$$F6_r = \sum_i \frac{N_{ir}}{N_r} ln \frac{N_{ir}/N_r}{X_{ir}/X_r}$$

NOTE:

i = sector i
r = region r
c = Community
N = employment
X = value added in current prices in purchasing power parities

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