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KNOWLEDGE-BASED ECONOMY, STRUCTURAL CHANGE AND PRODUCTIVITY: THE ITALIAN EVIDENCE

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Knowledge-Based Economy, Structural Change and Productivity: The Italian Evidence[1].

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ABSTRACT. In this paper we investigate if and to what extend productivity dynamics are affected by the transition towards the knowledge-based economy, understood as a process of structural change. We explicitly study the effects of the change in the employment mix of manufacturing and service sectors, and check for the hypothesis of adaptation efforts following such a mutation. The empirical test carried out on a panel data of 20 Italian regions over the period 1981-2001, provide support to the hypothesis of the emergence of the knowledge based economy as a structural change process, deeply affecting the dynamics of productivity. Moreover, innovative activity turns out to be sensibly influenced by the changes in the employment mix, with increasing relevance of service sectors in the second half of the 1990s.

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1. Knowledge Based Economy and Structural Change

The diffusion and the implementation of the new system of information and communication technologies (ICTs) is likely to foster the diffusion of knowledge intensive business services, and the growth of the knowledge intensive business service industry. Such technologies actually change the conditions of access, retrieval, processing and communication of all types of information, and influence the actual generation and organization of knowledge in that they affect its tradability and commercial potential. In this new situation knowledge intensive business services play the crucial role of providers of “quasi-generic” knowledge and interface between internal and external knowledge. By increasing connectivity and receptivity, they are at the basis of the creation of the so called knowledge based economy (Antonelli, 1998).

Moreover, the penetration of information and communication technologies (ICTs), at the basis of the emergent digital economy, requires the realization of two important complementary conditions. Firstly, ICTs are technologies with a strong bias in favour of skilled labour and specific fixed capital. Secondly, and most importantly, the full deployment of their potentials as general purpose technologies calls for the emergence of an array of related services (Lipsey et al., 2003; Antonelli, 2003a).

In view of this, the emergence of the knowledge based economy and the diffusion of ICTs may well be regarded as two related aspects of a broader process of structural change in which the crucial mutation consists in the change of the employment mix in favour of the service sectors to detriment of the manufacturing ones (Antonelli, 1998). Such a process is in turn likely to have important effects on growth and productivity dynamics, as already showed at European level (Fagerberg and Verspagen, 2002).

The fact that a change in the economic structure gives impulse to economic growth is actually quite an old statement in economic theory. As an example, Fabricant (1940) clearly argues that disparities in growth rates across sectors are affected by changes in the economic structure. Maddison (1987) puts structural change within the supplementary factors accounting for cross-country differences in productivity growth. In general, in the growth-accounting approach the change in the employment mix, i.e. the shift from low-productivity to high productivity activities is regarded as particularly relevant. It represents indeed one of the elements able to provide further explanations to output growth (Fagerberg, 1994). A similar treatment is also provided by Pasinetti (1993), who shows how the differences in income distribution across sectors affect output growth.

Fagerberg (2000) provides a large review of the literature dealing with structural change and economic growth, and stresses that not so many empirical analyses have been carried out within this field of enquiry. While the traditional works within the growth accounting approach mainly focused on the impact of the shift from agriculture to manufacturing, he chooses to strictly focus on the analysis of the dynamics *within* the manufacturing sector. He found that *on average* structural change is not conducive to productivity growth, with the exception of those areas specialized in technologically progressive industries, i.e. those affected by the electronics revolution.

Such analyses share a basic limitation, in that they are mostly based on proportional dynamics, i.e. as if the relative proportions of different activities were frozen at the initial time. An interesting alternative may consist of thinking about productivity growth rates as emergent properties of economic systems. In this direction two distinct and, to our opinion, yet complementary approaches deserve to be mentioned here.

One the one hand Metcalfe et al. (2006) stress the inherent restless character of capitalism, which evolves through the sequence of self-propelling feedbacks between innovation and economic growth. Structural change is linked to the growth of knowledge because transformation and adaptation are the way the system reacts to emergent novelty. The changes in economic structure in turn continually redefine the aggregate relations between productivity, employment and output growth.

Diffusion of technologies is strictly related to industrial growth, and in particular the delays in the adoption of new technologies within a specific sector may be the cause and the effect of the differential profitability of new industries, according the stage of their life-cycle they are operating. According to Kuznets[2], "an industry does not continue its vigorous growth indefinitely, but slackens its pace after a time, and is overtaken by industries whose period of rapid development comes later". Those industries in the early stages of their activity experience higher growth rates, and a likely acceleration in the diffusion rate (Nelson, 1968; Metcalfe, 1981).

[2] Kuznets (1930) pages 4-5, quoted in Metcalfe (1981), pag. 351.

On a complementary ground, Antonelli (2003b) proposes to look at the process of structural change through the change in relative prices of production factors. In this framework inputs' prices are signalling devices, in that they provide information about the relative factors endowment of a region. The absolute cost level of one factor doesn't really matter. It is its relation to other factors' costs to be the main critical element. In a context characterized by high supply of labour and low supply of capital, the ratio between wages and rents will be lower than in a context characterized by the reverse situation. The same applies if one thinks about the relative endowment of skilled and unskilled workers. The ability to introduce contingent technological change, so as to fit the specific conditions of the context of introduction, give raise to the possibility of productivity growth.

Moreover the introduction of a biased technology is likely to foster structural change through the increase of the derived demand for a production factor to detriment of some other one. The interaction between the demand and the supply of the (new) most productive factor shapes the dynamics of relative prices, and the profitability from the actual adoption of the new technology. Hence the emergence of new technologies and the emergence of a new economic structure are strictly related, and their relation is at the basis of the emergence of productivity growth.

In this paper we look at the actual change in the employment shares of five different sectors, and their productivity. Such macro-sectors allow us to directly compare the dynamics occurring within the manufacturing aggregate and those related to two broad service sectors. If structure is changing, the first step to undertake is hence to investigate how the patterns of the employment and output shares change over time (Metcalfe et al., 2006). We also investigate the related adaptation dynamics, i.e. innovation as proxied by patent applications. Changes in the structure are actually likely to be engender agents' creative reactions, which eventually generate innovations (Antonelli, 2003).

The remainder of the paper is organized as follow. In the next Section we provide a brief outline of the main traits having characterized the evolution of the post-war industrial organization in Italy. In Section 3 we describe the data we used to carry out the analysis and the research method. In Section 4 the results of the econometric estimations are provided. Finally, in Section 5 we summarize the conclusions and propose some policy implications.

2. The Empirical Context

The evolution of the Italian economy after World War II, has been represented by economic historians as one characterized by two distinct forms of capitalism, which are supposedly complementary. The expression "first capitalism" refers to a system featured by a core of large firms, both private and publicly owned, which mainly emerged in North-western Italy. These firms usually operated in highly capital-intensive sectors, like chemicals, steel and car production. Their growth was also enabled by the relying on government support, sometimes even in direct monetary terms. Some authors have argued that the Italian government in this period played the role of an entrepreneur (Amatori and Colli, 2000).

The "second capitalism" is instead the outcome of a dynamic and dispersed entrepreneurial spirit, which has venerable origins. It mainly consists of small and medium sized firms, which are settled in areas traditionally based on the work of artisans and croppers. It is the outcome of the evolution of proto-industrial systems, helped by the changes in the production technology and the conditions of the 1970s. Firms are usually linked by systemic ties, giving rise to the well known industrial districts, which are specialized in the production of consumer goods in the sectors of the so called *Made in Italy* (Antonelli and Militello, 2000).

These two capitalistic formations differ not only with respect to the organization of the production activity. They also elaborated two distinct ways of organizing the innovative activity[3]. On the one hand the large firms within the "first capitalism" are the only one able to integrate R&D activities within their boundaries (Nelson, 1959). In this respect they represent the very modern side of the national economic system, even if their efforts measured in terms of R&D expenditure and patents applications are weak in comparison to other large firms in OECD countries. This particular regional system of innovation basically corresponds to the North Western Italian regions. Firms carry out internal R&D activities aimed at introducing radical and generic technological innovations, able to engender a shift in the technological frontier.

On the other hand, the "second capitalism" which flourished in a macro-regional area roughly corresponding to the Adriatic coast, expanding from the original core in Veneto and Emilia towards Abruzzi and Puglie. One can find here a prevailing number of small firms, which are characterized

[3] This point has been elaborated more pervasively in Antonelli and Quatraro (2006).

by the mainly tacit content of technological knowledge. Learning activities are the core of knowledge accumulation, as they become a complementary factor in the innovation process. The adoption of innovations created elsewhere was followed by an intense effort aimed at adapting such technologies to the local characteristics of the economic system. Thus firms within this context carry out an innovative activity directed to the movement along the technological frontier rather than shifting it (Quatraro, 2005a).

In the late 1990s Italy started experiencing the same process of structural change which affected the United States in the 1980s and the United Kingdom in the early 1990s. The transition from the declining industrial economy towards the new digital economy in Continental Europe is slow. In many ways it follows the changes experienced by the US and UK economies, in the late 1990s. At the same time it exhibits its own path that reflects the idiosyncratic characteristics of their economic systems and their own specific momentum. The Italian case is characterized by a clear and strong divide between the path of change followed by the old industrialized regions and the late industrializing ones. While in the first firms seems exposed to raising problems, unable to cope with the decline of performances in both domestic and international markets, the second capitalism seems better able to take advantage of the new general purpose information and communication technologies by means of a process of creative adoption (Antonelli and Quatraro, 2006; Quatraro, 2006a).

3. Research Design

3.1 The Data

In this work we basically deploy two data sources. First, we use data drawn from the regional accounts provided by the National Bureau of Census (ISTAT). Unfortunately this source presents some limitations for what concerns the level of detail. Longer time series (1980 – 2001) are available at the regional level, but just for five macro-sectors. The five sectors are *agriculture and fisheries*, *manufacturing*, *constructions*, *real estate services and monetary and financial intermediation*, *trade and hotels and communication*. Further levels of detail are available at the regional level, but starting from 1995. We use both of the alternatives to investigate the impact of structural change on productivity growth. The value added, number of employees, gross fixed investments, and labour income have been used to calculate multi-factor productivity (see Appendix).

In the Tables 1 and 2 one can find the average growth rates of respectively employment and value added for the basic macro-sectors[4]. The share of employees in the service sectors evidently show up positive growth rates, in all of the Italian regions. On average the rates related to the *Real estate activities and the monetary and financial intermediation* are higher than those relative to the *trade, hotels and communication*. Moreover in both of the aggregations a clear pattern can be identified, whereby North-Eastern and Adriatic regions show up faster growth rates than North-Western regions. Indeed in Emilia-Romagna, Abruzzo, Umbria, Marche and Molise the employment in the service sectors increased more than in Piedmont, Lombardy and Liguria. In the traditional sectors, it is not a great surprise that *Agriculture and Fisheries* are characterized by negative dynamics in the whole regional sample. For what concerns the *Manufacturing* sector, growth rates are negative, with some exceptions in Southern regions and Umbria, Molise and Abruzzo. Anyway, whereas they are positive, the magnitude is on average lower than that observed in the service sectors. Finally, the rates of growth in the *Construction* sector are positive almost in every region, but even in this case they are sensibly lower than in the case of service.

[4] For the sake of homogeneity with the following analyses, we consider the period 1995 – 2001 in the description of data.

The data about value added are somehow better behaved. The growth rates in the *Manufacturing* sector are positive in almost all of the regions, with the only exception of Piedmont, Valle d'Aosta and Sardinia. The case of *Construction* and *Agriculture and Fisheries* sectors is fairly similar. In both the rates are mostly positive, with some exceptions evenly spread across the regions. As far as the service sectors are concerned, even in this case growth rates are positive everywhere, and the rates related to the *Real estate activities and the monetary and financial intermediation* are higher than those relative to the *trade, hotels and communication*.

INSERT TABLE 1 AND 2 ABOUT HERE

In Table 3 we investigate the dynamics of two crucial micro-sectors, i.e. the *Informatics* and the *Communication* service sectors. For what concerns employment, the first sector has very high growth rate, compared to those of the *Communication* sector. It must be noticed that no clear-cut geographical patterns can be found, in that in all Italian regions figures are within the range from +3.1% to +6.7% (with the only exception of Valle d'Aosta). The growth of employment in the service sectors related with the informatics and the communication hence appears to be a pervasive phenomenon, and especially relevant in the case of the former. For what concerns value added reveal, the difference among the two sectors a appears to be less pronounced, but even in this case growth rates are comparatively higher than those we have seen above in the macro-sectors.

INSERT TABLE 3 ABOUT HERE

The evidence of the transition from manufacturing to service sectors would appear to be clearly evident from the analysis conducted so far. Across all the Italian regions there is evidence of a shift in the employment mix, mainly towards the *Informatics* sector. In the second step of the analysis, data about the use of computers are coupled with those about TFP.

We may thus reasonably argue that the evidence of a structural change is fairly evident in the Italian case. Such a mutation takes the shape of a growing transition towards the service sectors, with particular relevance for the informatics one. The extent to which such a mutation is likely to engender an adaptation effort, sustained by innovative activity, can be investigated by looking at patent applications. To this purpose we have drawn data from the European Patent Office (EPO) relative to the number of patent applications submitted in the period 1981-2003, by region.

In table 4 we report the annual growth rates of the patents applications per unit labour. The evidence is quite striking of a quite generalized decreasing trend of growth rates in the period considered. In most (but not all) of Italian regions the growth rate tend to be stationary in the second half of 1990s, witnessing the existence of a kind of saturation process. According to the Wolff's law, one can argue that such an evidence may be ascribed to the temporary exhaustion of technological opportunities in industrial R&D, and the consequent reduction in creative potentialities.

Elsewhere (Quatraro, 2006c) we showed how patents applications per capita follow a logistic time-path, with a conspicuous cross-regional variance in the penetration rate. A parallel with optimization procedures can help understanding the situation. Actually, we can imagine an envelope of S-shaped curves[5], which refer to the inventive activity tied to a specific pattern of industrial specialization. As soon as the system starts being affected by structural change, and the traditional sectors decline, the rate of inventiveness within their provinces decrease more or less slowly. The emergence of a new sector may engender the renewal of inventive forces, and eventually a good reprise in patenting activity as long as parallel changes in demand make it profitable. Thus the saturation observed turns

[5] See Metcalfe, 1981.

out to be *local* rather than *global*, as structural change should provide new room for further inventions.

INSERT TABLE 4 ABOUT HERE

Figure 1 helps to better understand cross-regional differences in patenting activity. In particular one can observe how the growth rate trend is pretty stationary in the case of Southern regions, but the comparison of the remainder macro-areas is quite puzzling. Actually it can be noted that central regions show up a recovery process represented by the steepest trend line after 1994. In the same period also the North-Eastern regions are characterized by a positively-sloped trend, steeper than in the North-Western regions case. These latter, in particular, show a very slow reaction process.

INSERT FIGURE 1 ABOUT HERE

In light of this, from table 4 it is evident that the exhaustion of technological opportunities is mainly affecting regions like Piedmont, Liguria and to a less extent Lombardy. On the contrary, regions like Emilia Romagna, Umbria, Marche, Abruzzo and Molise seems to be in that phase of the logistic characterized by exponential growth. This can be due either to late industrialization or to a prompt movement towards the service economy. Separate evidence provide support to the second hypothesis (Quatraro, 2006b).

3.2 Method

The analysis we carried out in this paper is articulated in two stages. Firstly we test the hypothesis about the relationship between structural change and productivity growth, through the relationship between the change in the employment mix and the growth of TFP. According, among the others, to Fagerberg (2000) and Metcalfe et al. (2006), when structural change is at stake, what deserves to be investigated is the impact of a change in the employment share of each sector. As aggregation represents a non-trivial problem in such kind of analyses, in this first stage we decided to carry out two distinct, and yet complementary, tests. First of all we specify the following econometric model:

$$\mathrm{dlog}TFP_{it}/\mathrm{dt} = \alpha_i + \beta_1(INV_{it}) + \beta_2(\mathrm{dlog}AGR_{it}/\mathrm{dt}) + \quad (1)$$

$$+ \beta_3(\mathrm{dlog}MAN_{it}/\mathrm{dt}) + \beta_4(\mathrm{dlog}CON_{it}/\mathrm{dt}) +$$

$$+ \beta_5(\mathrm{dlog}TRADE_{it}/\mathrm{dt}) + \beta_6(\mathrm{dlog}FIN_{it}/\mathrm{dt}) + u_i$$

which allows us to exploit both the time (t) and space (i) dimension in the panel data of Italian regions in the period 1980 – 2001. The need for deriving the capital stock (see the Appendix) from the investments series determined the loss of two years of observations. As noted above, this analysis consider the change in the employment share in the five macro-sectors (Agriculture, Manufacturing, construction, Trade-Hotels-Restaurants, Real Estate – Financial and Monetary Intermediation). The variable INV_{it} is meant to control for the part of TFP growth due to technological change embodied in fixed capital investments.

This first estimation in some sense provide the frame within which we put the analysis carried out on more disaggregated data, but on a shorter time span. The low number of available periods actually make the estimation through panel data models unfeasible, as there are not enough degrees of freedom. For this reason we estimate the following model:

$$\mathrm{dlog}TFP_i/\mathrm{dt} = \alpha + \beta_1(INV_i) + \beta_2(\mathrm{dlog}AGR_i/\mathrm{dt}) + \quad (2)$$

$$+ \beta_3(\mathrm{dlog}MAN_i/\mathrm{dt}) + \beta_4(\mathrm{dlog}CON_i/\mathrm{dt}) +$$

$$+ \beta_5(\mathrm{dlog}INFO_t/\mathrm{dt}) + \beta_6(\mathrm{dlog}COM_i/\mathrm{dt}) + \mathrm{u}$$

Where *i* still refers to the regions. It is basically identical to the previous, except for the variables $\mathrm{dlog}MAN_i/\mathrm{dt}$, $\mathrm{dlog}INFO_t/\mathrm{dt}$ and $\mathrm{dlog}COM_i/\mathrm{dt}$, which are respectively a subset of manufacturing sector, *Informatics and R&D* services and *Logistic and Communication* services. As it can be noticed from the subscripts, we estimate in this case through an OLS regression on pooled data. The comparison with the results obtained in the previous estimation is meant to provide a robustness check.

It is worth emphasizing that such a narrower focus on the second half of the 1995 is not merely due to data constraints. Actually in the second half of the 1990s the former clues of the transition process affecting Italy can be found. Such a process is characterized by the decline of manufacturing sectors and the rise of service ones, leading the system towards the so called digital economy (Antonelli and Militello, 2000; Berta, 2004). Indeed in Quatraro (2006a) that a dummy variable on the period proved to affect significantly and negatively the impact of a change in relative prices on productivity, witnessing a general difficulty in adapting to the changing environment. To be sure, in Table 5 we report the means and the variances for the variables relevant to our purposes, split in two subsets, i.e. post and after 1995. We have also carried out the comparison test for both the descriptive statistics.

INSERT TABLE 5 ABOUT HERE

It can be noted that in the case of TFP growth rates, the difference between the two groups is not significant as far as variance is concerned, while the mean in the second period is significantly lower than that relative to the first one. The variables related to the sectors' employment share show statistically significant differences both in the variance and in the mean. In the case of manufacturing the mean turned out to increase, while in the case of service of service sectors there is evidence of a decrease. This of course support the splitting of the sample, and provide an early clue of the shape the structural change process has been taking in Italy.

The second stage of the analysis is meant to check the hypothesis according to which mutation in economic environment is likely to engender a creative reaction ending up in the introduction of innovations. For what concerns this work is concerned, we are interested to investigate the relationship occurring between the dynamics of labour shares for each sector and patenting activity. It is quite straightforward that this kind of analysis should be bounded to consider just manufacturing and service sectors, since the probability of generating a patent within the agriculture and construction sectors is very low. Moreover, it must be considered that the process of switching from agriculture to manufacturing is long completed in Italy, while it is direct comparison of manufacturing and services to be of interest now. In view of this, we estimate the following regressions:

$$Y_{it} = \beta' X_{it} + \delta year + \alpha_{it} + \nu_{it} \qquad (3)$$

Where Y_{it} is the measure of innovative activity, X_{it} is the vector of variables related to the share of each sector, in particular *manufacturing, trade, accommodation and communication* and *real estate, financial and informatics sectors*, α_{it} is the fixed effect and ν_{it} the error term. We also control for the time trend by including the variable *year*.

The equation (3) is subsequently estimated on pooled data, after having split the sample in two periods, i.e. distinguishing between data before and after 1995, in the same vein as above. In the last row of Table 5 we compare the mean and the variance of the number of patent applications in the two periods. It is straightforward that the variance decreases while the mean considerably increases. Hence the evidence about patent applications is consistent with that related TFP and employment shares, in that all of them show significant differences in the two periods we decided to keep separated.

4. The Econometric Results

4.1 Structural Change and Economic Growth

In Table 6 we report the results of the econometric estimation concerning the first step of analysis (Equation (1)). In the first two columns one can found the estimation results using respectively fixed and random effects panel data models. It can be noted that the coefficients for fixed capital investments, and the agriculture and construction sectors are fairly similar, while in the other regressors they are sensibly different. Both regressions behave well, but the statistic of the Hausman test allows us to choose the fixed effect estimation. This means that controlling for regional idiosyncrasies, the effect of investments is negative and statistically significant. This proves that the embodiment hypothesis doesn't work very well in the Italian case. Evidently it represents a defence strategy with a very low creative content, and as such scarcely contributing to productivity growth.

INSERT TABLE 6 ABOUT HERE

As far as the effect of the change in the employment mix is concerned, the logarithmic specification of Equation (1) makes it possible to read the outcome of the econometric test directly in terms of elasticity. Focusing on traditional sectors, as expected the coefficients are negative. In particular the manufacturing sector has a higher value (in absolute terms) than the agriculture. This might well be due to the fact that the exodus from agriculture jobs had been completed since a long time in the last decades of the 20th century. Thus in that period it is the movement from manufacturing to services the crucial event. This could be the reason why the coefficient on the manufacturing sector is twice that on agriculture.

It is interesting at this point to look at the service sectors. In this case the evidence is somewhat puzzling. Actually on the one hand the coefficient on the real estate, financial and monetary services is positive and statistically significant, even if comparatively small. On the other hand the trade, hotel and communication services show up a negative coefficient, even higher than that of the manufacturing one. It would hence seem that the process of structural change entirely lean on one side. To gain a better comprehension of the phenomenon we turn now to consider the results of the pooled regression on more disaggregated data.

In the third column of Table 6 the pooled model is reported[6]. The fixed capital still shows up a negative and significant coefficient. Differently from the previous, the change in the manufacturing and in the agriculture sectors wouldn't seem to have a significant impact on productivity, while that in the construction sector is positive and statistically significant. The more interesting result concerns the service sectors. Both regressors

[6] We want to stress that we carried out a further estimation (omitted here) by adding to the Equation (1) a dummy variable for the period 1995-2001. The variable, as expected, proved to be negative and statistically significant.

actually have positive and statistically significant coefficients. Their magnitude is also pretty relevant. It is worth recalling that this second analysis has been carried out on a narrower time span.

Thus from these results we can reasonably argue that in the last part of the 1990s the shift towards the service sectors grows important. In particular the employment growth within the *Informatics* and the *Communication* sectors can be understood as an effect (and a cause) of the progressive diffusion of information and communication technologies within industrial sectors. Actually, service sectors are characterized by higher rates of utilization of ICTs, as an effect of the skill bias effect engendered by the introduction of a such a kind of technological change (Bresnahan et al., 2002; Antonelli 2003b; Kaiser, 2001). It remains to be investigated now if and to what extent such a mutation in the economic structure has stimulated an adaptive reaction within the system.

4.2 Mutation and Adaptation

The analysis conducted so far has provided clear-cut evidence of a transition occurring in the Italian industry, characterized by the rise of service sectors to detriment of the manufacturing ones. The growth rates of productivity have proved to be positively related to the growth rates of employment shares in service sectors. In this Section we wonder whether productivity growth may be considered as emergent properties in a system characterized by adaptation efforts. Such adaptive reactions are represented here by creative efforts directed to the introduction of innovation.

Hence we may turn now to estimate the Equation (3). Patents applications are non-negative integers, and the distribution of applications is highly skewed, with significant overdispersion and a large number of zeros. Therefore Equation (3) is estimated using a Negative Binomial model (Hausman et. al., 1984). Even in this case, we firstly compare fixed and random effects estimations on the whole sample. In table 7 we report the results of the analysis.

INSERT TABLE 7 ABOUT HERE

It can be noted that the Hausman test is supportive of the fixed effect model. It is worth emphasizing that the coefficient on *manufacturing* employment share is lower than that on *real estate, financial and informatics sectors*. This clearly means that the latter has a higher impact on the propensity to patent. As far as the pooled estimations are concerned, the columns 4 and 5 of Table 7 provide a direct comparison of the two subsets described in Section 3. We may note that the shift from the early period to the late one is characterized by the decrease in the coefficient of the *manufacturing* sector and a parallel increase in the coefficients of both of the service sectors. In the *real estate, financial and informatics sectors* show up a coefficient twice that of *manufacturing*.

These result may well be interpreted as clue of a reaction engendered by the mutation in the economic structure. The comparison of the two periods actually suggests that in the late 1990s service sectors gained relevance in fostering the innovative activity, as proxied by patent applications, while manufacturing sectors partly lost their weight. The increase of the employment share in service sectors showed in Section 3 is hence closely related to an increase in their weight in innovation dynamics. The rise of service sectors may be hence viewed as stimulating the creative efforts leading to the adaptation of the system, and eventually to productivity growth.

5. Conclusions

Structural change and productivity growth has been long regarded in literature as closely intertwined. Much of the empirical evidence on this subject is focused on the investigation of the dynamics within manufacturing sectors, by using a proportional dynamics approach. Looking at productivity growth rates as emergent properties of the system leads to an approach in which employment shares for each sector change over time, and eventually assess the impact of such a change on productivity growth. Moreover, the emergence of growth rates is strictly related to the extent to which the economic system is able to trigger creative efforts aimed at adapting to the new situation. This perspective is complementary to the localized approach, in which the mismatch between relative prices and the features of technology are likely to create situations in which adoption choices need to be delayed, with subsequent impact on profitability and competitiveness.

In this paper we have carried out an analysis of the effects of the transition towards the knowledge-based economy, understood as a process of structural change, focusing on the Italian case in the period 1981-2001.. The diffusion of ICTs is actually likely to foster the growth of knowledge-based business sectors as a result of a two way dynamics. On the one hand interface services become the core of a system characterized by increased knowledge tradability, and hence the creation of markets for knowledge. On the other hand an array of informatics related services are necessary complement to fully deploy the potentials of ICTs as general purpose technologies.

As it emerged from Sections 2 and 3, such a transition is affecting also the Italian economy, with sensible differences across regions. While at the aggregate level it seems that the growth in the employment shares of service sectors is not fostering positive dynamics of TFP, at the regional level the situation is slightly more puzzling. Such a variance may well be ascribed to the peculiar process of evolution which characterized the Italian industry after the World War II. The increasing divide between the two forms of capitalism are at the basis of the differences in the ability to engage in a process of creative reaction, where north-western regions are facing more difficulties than the north-eastern ones.

Controlling for regional fixed effects, the growth of employment shares of service sectors proved to be positively related to TFP growth. A more detailed analysis, focused on the second half of the 1990s, reveals that the impact of *informatics* and *communication* sectors is really remarkable. On a parallel ground, the propensity to submit patent applications is affected by the share in *real estate, financial and informatics sectors* more than *manufacturing* sectors, while the *trade, hotel and communication* sector has no significant influence, when controlling for regional fixed effects. Splitting the dataset in two sub-periods allow us to appreciate the changes in the impact of service and manufacturing sectors. The former indeed has higher coefficients when one focuses on the second half of the 1990s, providing a clue of the relationship between the adaptation effort and the change in the economic structure.

Even if in this paper we reached a good level of disaggregation, in that we were able to deploy both the time and the space dimensions, it is still necessary to couple the analysis with an investigation of the dynamics occurring at the firm level. Nonetheless the results provided here has confirmed the existence of a set of relationships between mutation, adaptation and productivity growth, as far as the Italian case is concerned, emphasizing that the creative efforts are still far to be fully effective for the growth of productivity.

6. Appendix

In the construction of multi-factor productivity we followed Solow (1957). We derived a Hicks-neutral measure of technological change, by accounting for the shifts in the production function. Differently from that framework, we didn't apply the Divisia-Tornquist methodology. We obtained the output elasticity of labour starting from the production function:

$$Y = AK^{1-\alpha}L^{\alpha} \qquad \text{(A1)}$$

Which implies a constant-returns-to-scale framework. Under the assumption of perfect competition, production factors are paid their marginal productivity, and hence one can write down the following relationship:

$$P'_L = w$$

Which can be written as follows:

$$\alpha \frac{Y}{L} = w \quad \rightarrow \quad \alpha_{it} = \frac{w_t L_{it}}{Y_{it}} \qquad \text{(A2)}$$

This expression allows us to calculate the output elasticity of labour, assuming a Cobb-Douglas production function. The multifactor productivity is then obtained through the following relation:

$$A_{it} = \frac{Y_{it}}{K_{it}^{1-\alpha} L_{it}^{\alpha}} \qquad \text{(A3)}$$

Where the stock of fixed capital is obtained by applying a lag operator to gross fixed investments (*GFI*) as follows:

$$K_t = GFI_t + 0.8GFI_{t-1} + 0.4GFI_{t-2} \qquad \text{(A3a)}$$

The index we obtained in such a way is a measure of multifactor productivity which is consistent with the Solowian TFP, although we allow output elasticities to vary over time. Some basic questions of course remain as to what interpretations to give to differences in levels and rates of change of TFP. While Solow (1957) associated TFP growth with technological advances, Abramovitz (1956) defined the residual as some sort of measure of ignorance. Nonetheless it remains a useful signalling device, in that it provides useful hints on where the attention of the analysts should focus (Maddison, 1987).

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Figure 1 – Dynamics of the Growth Rates of Patent Applications per Unit Worker

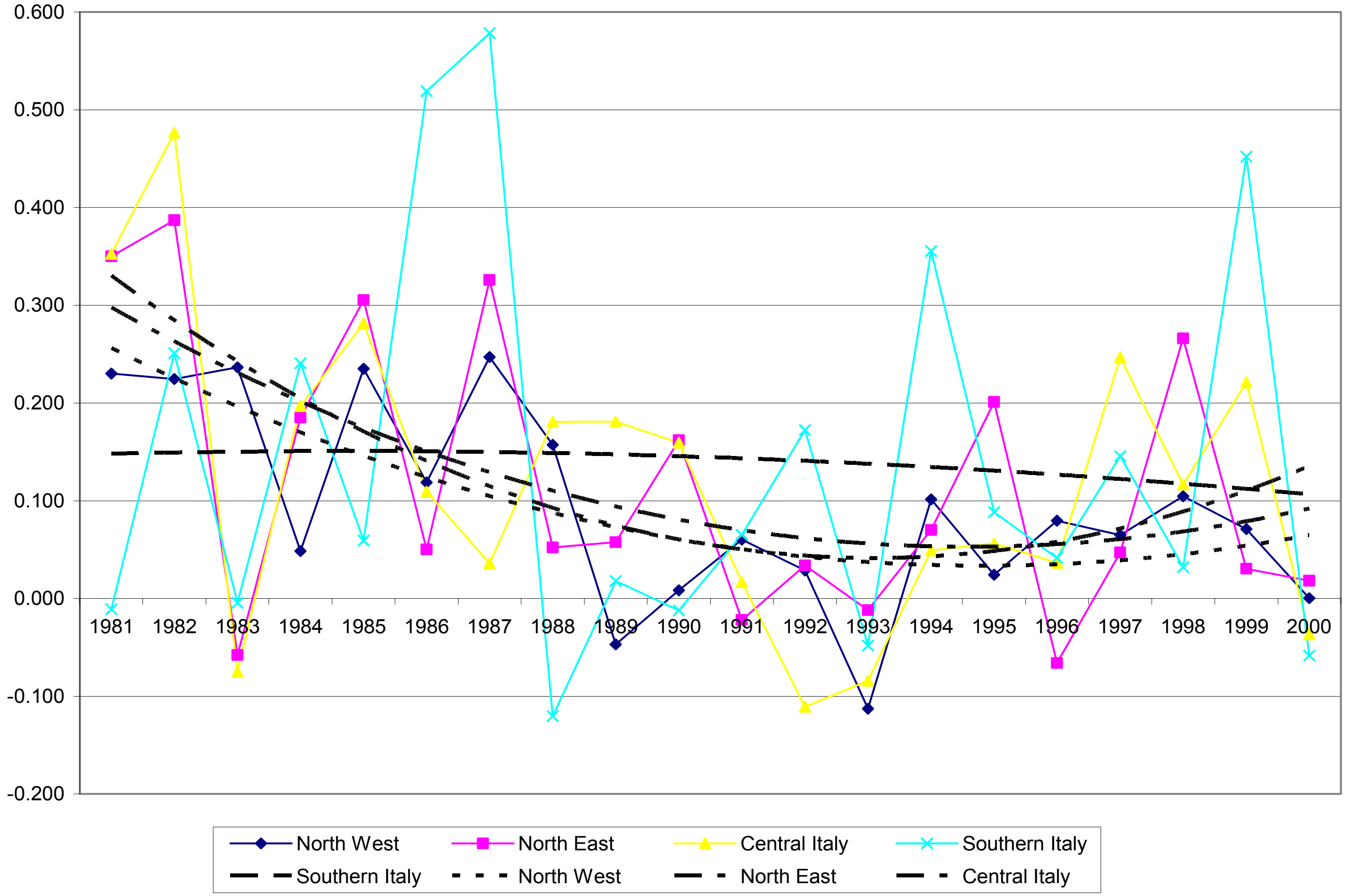

Table 1 – Employment growth rate in the four sectors, by Region (1995-2001)

Region	Agricolture and Fisheries	Manufacturing	Construction	Trade, Hotels Communication	Real Estate, Fin&Mon Int.
Piemonte	-0.034	-0.013	0.002	0.010	0.033
Valle d'Aosta	-0.039	0.010	0.023	0.001	0.008
Lombardia	-0.022	-0.014	0.001	0.012	0.037
Trentino-Alto Adige	-0.016	-0.002	0.019	0.012	0.039
Veneto	-0.026	-0.011	0.013	0.014	0.041
Friuli-Venezia Giulia	-0.024	-0.009	0.003	0.010	0.032
Liguria	-0.017	-0.010	0.011	0.006	0.023
Emilia-Romagna	-0.029	-0.004	-0.002	0.009	0.037
Toscana	-0.009	-0.016	0.012	0.011	0.039
Umbria	-0.033	0.001	-0.008	0.019	0.045
Marche	-0.049	-0.004	0.010	0.013	0.037
Lazio	-0.012	-0.014	0.009	0.008	0.034
Abruzzo	-0.030	0.004	-0.009	0.012	0.036
Molise	-0.058	0.004	0.005	0.017	0.057
Campania	-0.037	-0.008	0.012	0.015	0.033
Puglia	-0.020	-0.003	0.017	0.012	0.029
Basilicata	-0.039	0.021	0.006	0.015	0.040
Calabria	-0.026	0.001	0.004	0.010	0.036
Sicilia	-0.023	0.002	-0.002	0.014	0.040
Sardegna	-0.023	0.002	0.000	0.021	0.050

Source: Elaborations on ISTAT data.

Table 2 – Value Added growth rate in the four sectors, by Region (1995-2001)

Region	Agricolture and Fisheries	Manufacturing	Construction	Trade, Hotels Communication	Real Estate, Fin&Mon Int.
Piemonte	0.001	-0.001	0.011	0.017	0.018
Valle d'Aosta	0.029	-0.006	-0.085	0.018	0.009
Lombardia	0.024	0.005	0.013	0.016	0.029
Trentino-Alto Adige	0.030	0.010	0.040	0.016	0.027
Veneto	0.022	0.007	0.007	0.021	0.029
Friuli-Venezia Giulia	0.020	0.002	-0.004	0.021	0.024
Liguria	-0.010	0.020	0.052	0.019	0.018
Emilia-Romagna	0.024	0.010	0.039	0.014	0.025
Toscana	-0.017	0.011	0.037	0.019	0.030
Umbria	0.012	0.010	0.019	0.022	0.033
Marche	-0.009	0.015	0.010	0.024	0.031
Lazio	-0.003	0.015	-0.004	0.022	0.013
Abruzzo	0.005	0.017	0.018	0.017	0.024
Molise	0.019	0.021	0.001	0.032	0.032
Campania	0.011	0.010	0.012	0.028	0.028
Puglia	-0.010	0.007	0.023	0.027	0.026
Basilicata	0.010	0.032	-0.022	0.035	0.025
Calabria	0.015	0.030	0.004	0.033	0.024
Sicilia	-0.006	0.003	0.000	0.031	0.025
Sardegna	0.023	-0.001	-0.016	0.028	0.031

Source: Elaborations on ISTAT data.

Table 3 – Average growth rates for the Informatics and Communication Service Sectors

Region	Value Added		Employment	
	Informatic Services	Communication Services	Informatic Services	Communication Services
Piemonte	0.021	0.031	0.046	0.004
Valle d'Aosta	0.009	0.054	0.010	0.006
Lombardia	0.022	0.033	0.046	0.005
Trentino-Alto Adige	0.026	0.039	0.048	-0.005
Veneto	0.030	0.027	0.049	-0.002
Friuli-Venezia Giulia	0.027	0.036	0.036	0.001
Liguria	0.022	0.019	0.038	0.000
Emilia-Romagna	0.027	0.024	0.046	0.001
Toscana	0.029	0.018	0.047	-0.002
Umbria	0.033	0.021	0.043	-0.007
Marche	0.029	0.040	0.044	-0.005
Lazio	0.019	0.031	0.042	-0.014
Abruzzo	0.022	0.033	0.038	0.012
Molise	0.036	0.026	0.067	0.003
Campania	0.031	0.037	0.049	0.001
Puglia	0.030	0.027	0.048	-0.009
Basilicata	0.026	0.014	0.050	-0.020
Calabria	0.021	0.042	0.031	0.001
Sicilia	0.030	0.046	0.053	-0.001
Sardegna	0.036	0.023	0.049	-0.013

Source: Elaborations on ISTAT data.

Table 4 – Growth Rates of Patent Applications per Labour, by region

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Piemonte	2.314	0.063	0.542	0.219	-0.072	0.242	0.175	0.071	0.122	-0.002	0.107	0.000	0.015	-0.131	0.060	0.080	0.128	-0.049	0.127	0.121	-0.108
Valle d'Aosta	0.000	4.000	-0.013	-1.000	4.000	2.821	-1.000	4.000	2.030	0.292	-0.005	0.500	-0.829	1.058	-1.000	4.000	0.317	-0.749	0.004	0.929	0.970
Lombardia	1.132	0.331	0.071	0.265	0.103	0.215	0.126	0.318	0.178	-0.071	-0.019	0.066	0.020	-0.127	0.127	-0.019	0.087	0.120	0.096	0.062	0.027
Liguria	1.707	-0.096	0.589	0.199	0.254	0.325	-0.191	0.432	-0.004	0.011	-0.219	0.484	0.341	0.105	0.040	0.211	-0.170	0.036	0.104	-0.047	0.215
North West	1.451	0.230	0.224	0.237	0.048	0.235	0.119	0.247	0.157	-0.047	0.008	0.060	0.029	-0.113	0.101	0.024	0.079	0.065	0.104	0.071	0.000
Trentino-Alto Adige	0.694	0.148	0.354	0.353	-0.399	-0.012	0.426	0.439	-0.064	0.575	0.077	-0.420	0.340	0.524	-0.094	0.343	-0.135	0.002	0.151	-0.196	0.548
Veneto	1.773	0.032	0.668	0.046	0.267	0.383	0.077	0.209	-0.093	0.339	-0.005	-0.026	-0.008	0.039	0.055	0.207	-0.100	0.064	0.375	-0.019	-0.009
Friuli-Venezia Giulia	0.064	1.243	0.001	0.156	0.378	-0.143	0.033	0.584	0.237	-0.110	0.050	0.084	-0.089	-0.096	0.197	0.025	0.086	-0.096	0.042	0.099	-0.012
Emilia-Romagna	1.030	0.365	0.407	-0.220	0.124	0.499	0.013	0.350	0.117	-0.098	0.382	-0.011	0.089	-0.061	0.062	0.237	-0.071	0.080	0.252	0.073	0.012
North East	0.954	0.350	0.387	-0.058	0.185	0.305	0.050	0.326	0.052	0.058	0.162	-0.022	0.034	-0.012	0.070	0.201	-0.066	0.047	0.266	0.030	0.018
Toscana	1.239	0.893	-0.027	0.278	0.237	0.229	0.201	-0.057	0.092	0.370	0.043	0.047	0.029	-0.225	-0.004	0.216	-0.273	0.437	0.033	0.253	-0.067
Umbria	1.775	-0.647	2.428	-0.276	0.314	0.059	-0.219	0.803	-0.040	-0.269	0.859	-0.465	0.448	-0.589	1.797	-0.137	-0.056	0.472	0.294	0.189	-0.015
Marche	3.924	0.625	1.258	-0.111	0.057	-0.416	1.278	0.431	0.241	0.050	0.006	0.150	-0.301	0.423	0.068	-0.260	0.398	0.142	0.117	0.192	0.240
Lazio	0.601	0.260	0.882	-0.275	0.236	0.540	-0.050	-0.039	0.236	0.122	0.330	-0.010	-0.214	0.021	0.031	-0.083	0.122	0.134	0.132	0.149	-0.033
Abruzzo	4.000	0.467	-0.345	0.518	-0.173	0.374	0.277	0.098	0.493	0.499	-0.344	0.426	-0.162	-0.179	-0.149	1.718	0.649	0.242	0.184	0.431	-0.197
Molise	4.000	0.045	-1.000	4.000	-1.000	0.000	4.000	-0.501	2.131	-0.673	0.025	0.963	-0.477	2.057	-1.000	4.000	0.975	-0.001	0.516	-0.514	-0.342
Central Italy	1.218	0.353	0.477	-0.075	0.197	0.282	0.109	0.036	0.181	0.181	0.159	0.017	-0.111	-0.084	0.049	0.056	0.036	0.247	0.117	0.221	-0.037
Campania	3.047	0.220	-0.108	-0.111	0.240	0.127	0.392	0.407	0.229	-0.092	-0.211	0.485	0.443	-0.132	0.206	-0.220	0.338	0.048	0.185	0.292	-0.136
Puglia	0.562	0.318	0.454	0.498	-0.229	-0.435	2.796	0.194	-0.177	0.322	-0.510	0.472	0.193	-0.035	0.145	0.117	-0.040	0.668	-0.104	0.282	0.401
Basilicata	0.000	0.000	4.000	-0.520	0.038	0.050	-1.000	4.000	-0.493	-0.334	-1.000	4.000	-1.000	4.000	0.518	-0.001	0.990	1.952	-0.072	-0.201	-0.061
Calabria	-0.530	1.010	-0.506	0.022	1.833	0.003	2.037	-0.220	-0.579	0.040	-0.014	0.664	0.202	-0.140	-0.602	-0.484	8.959	-0.400	0.690	0.278	-0.401
Sicilia	4.000	-0.172	0.582	-0.261	0.494	0.663	-0.403	2.165	-0.104	-0.016	0.530	-0.297	-0.040	0.234	0.721	0.269	-0.219	-0.150	0.000	0.971	-0.090
Sardegna	4.000	-0.752	0.954	0.478	0.724	-0.426	1.561	-0.009	-0.266	-0.011	0.460	-0.210	0.364	-0.665	1.052	0.655	-0.211	0.602	-0.229	0.794	-0.304
Southern Italy	2.704	-0.011	0.251	-0.004	0.241	0.059	0.519	0.579	-0.120	0.018	-0.012	0.065	0.172	-0.048	0.355	0.088	0.041	0.146	0.032	0.452	-0.059
Italy	1.310	0.258	0.296	0.095	0.105	0.260	0.113	0.253	0.122	0.012	0.069	0.026	0.013	-0.076	0.100	0.086	0.025	0.086	0.150	0.098	-0.006

Source: elaborations on ISTAT and EPO data

Table 5 – Mean and Variance Comparison Test

	Mean		**Variance**	
	Before 1995 (1)	After 1995 (2)	Before 1995 (3)	After 1995 (4)
dLog*TFP*/dt	.0044	-.0172***	.0338	.0347
dLog*MAN*/dt	-.0128	-0.0006***	.0423	.0299***
dLog*TRADE*/dt	.0051	.0011**	.0299	.0138***
dLog*FIN*/dt	.0473	.0329***	.0547	.0262***
PAT	91.092	166.421**	167.73	265.791***
N	260	140	260	140

Key: *p<0.1 ; **p<0.05; ***p<0.001

Table 6 – Results of the econometric estimations of equations (1) and (2)

Dependent variable = dlog*TFP*/d*t*			
	Fixed Effect (1)	Random Effect (2)	Pooled OLS (3)
Const	-.0003	-.0005	-.002
	(-1.14)	(-0.19)	(-0.31)
INV_{it}	-.423***	-.425***	-.556***
	(-12.94)	(-13.26)	(-8.55)
dlog*AGR*/d*t*	-.075**	-.072**	.068
	(-1.99)	(-1.97)	(1.29)
dlog*CON*/d*t*	.023	.028	.390***
	(0.83)	(1.01)	(5.75)
dlog*MAN*/d*t*	-.139***	-.079*	.095
	(-2.71)	(-1.69)	(0.97)
dlog*TRADE*/d*t*	-.210***	-.151**	
	(-2.76)	(-2.07)	
dlog*FIN*/d*t*	.063*	.077**	
	(1.79)	(2.26)	
dlog*INFO*/d*t*			.210***
			(2.63)
dlog*COM*/d*t*			.363***
			(3.71)
R-Square	0.35	0.34	0.52
F-test / Wald stat	31.24	186.83	22.11
Hausman test	11.2		
p-value	0.08		
N	380	380	120

Notes: t of Student and z statistics between parentheses
Key: *p<0.1 ; **p<0.05; ***p<0.001

Table 7 – Results of the Negative Binomial Estimations of Equation (3)

Dependent variable = Patent Counts

	Fixed Effect (1)	Random Effect (2)	Pooled (t<1995) (3)	Pooled (t≥1995) (4)
Const	-53.209**	-47.676***	122.493***	116.670***
	(16.272)	(15.977)	(32.939)	(1.64)
log*MAN*	1.325***	1.443***	2.681***	2.544***
	(.200)	(.129)	(.110)	(.152)
log*TRADE*	-.398	-.344	1.397**	2.557***
	(.437)	(.424)	(.445)	(0.691)
log*FIN*	1.707***	1.803***	4.162***	4.747***
	(.238)	(.234)	(.037)	(.389)
Year	.031***	.029***	-.051**	-.047
	(.008)	(.008)	(.016)	(.035)
R-Square			0.17	0.12
Wald stat	1366.91	1403.77		
Hausman test	44.39			
p-value	0.001			
N	400	400	260	140

Notes: Standard errors between parentheses
Key: *p<0.1 ; **p<0.05; ***p<0.001