"S. Cognetti de Martiis"

Via Po, 53 – 10124 Torino (Italy)
Tel. (+39) 011 6704917 - Fax (+39) 011 6703895
URL: http//www.de.unito.it

WORKING PAPER SERIES

KNOWLEDGE, INNOVATION AND LOCALISED TECHNOLOGICAL CHANGE IN ITALY, 1950-1990

Cristiano Antonelli e Federico Barbiellini Amidei

Dipartimento di Economia "S. Cognetti de Martiis"

LEI & BRICK - Laboratorio di economia dell'innovazione "Franco Momigliano"
Bureau of Research in Innovation, Complexity and Knowledge, Collegio Carlo Alberto

Working paper No. 13/2009

Università di Torino

Knowledge, innovation and localised technological change in Italy, 1950-1990[1]

Cristiano Antonelli* & Federico Barbiellini Amidei**

Abstract: *The paper is an attempt to provide an interpretation of the Italian puzzle in the post-WWII era consisting of very low levels of expenditure in R&D and yet high TFP growth. The research aims to supply the basic tools and the framework for a better understanding of the Italian industry innovation system and of its contribution to the country's long term growth performance. The study applies the localized technological change approach to implement the notion of knowledge interactions so as to appreciate: a) the role of external factors in the generation and exploitation of technological knowledge; b) the role of creative adoption in TFP dynamics. The analysis is based on a new dataset containing sectoral and regional series of TFP, capital intensity, wages per labour unit, R&D expenditures, patents granted in the USA, Technological Balance of Payments receipts and expenses, etc. for Italy over the 1950-1990 period. Using a SURE model framework, the impact of user-producer interactions on the dynamic efficiency of the Italian industrial sector is investigated across industries and regions. The significant and distinctive features of Italian innovation dynamics in the post WWII era that result are: i) the emerging and functioning of an innovation system based upon both horizontal dynamics of technological cooperation within industrial districts and vertical dynamic interdependence within industrial filieres; ii) a relevant, albeit incomplete, diffusion/catching up process in Italian regions.*

JEL Classification: N60, O31, O33
Key words: TFP, Innovation system, industrial filieres, localized technological change.

* Università di Torino and BRICK-Carlo Alberto
** Banca d'Italia, Structural Studies Department, Economic and Financial History Unit, and BRICK- Carlo Alberto

1. INTRODUCTION

[1] A preliminary version of this paper has been presented at the Session "Innovation systems and economic performance: Past leaders, catch-up countries and new late comers (20th-21st centuries)" of the XVth World Economic History Congress, Utrecht, 5 August 2009. The authors thank Alberto Baffigi, Claire Giordano and Francesco Quatraro for reading earlier drafts. The views expressed in this article are those of the authors and do not necessarily reflect those of the Institutions of affiliation. Corresponding author: federico.barbielliniamidei@bancaditalia.it.

The economic growth of the Italian economy in the second part of the XX century provides large and systematic evidence concerning fast rates of growth of output and especially of total factor productivity and yet low levels of efforts in the generation of technological knowledge, as measured by traditional indicators such as expenses in R&D activities or patents. A mainly quantitative approach, which includes some interpretive tools explicitly based on economics of innovation, is here adopted. The analysis concentrates on industry, because of its particular relevance assumed during the examined historical period, because of the contribution made to overall growth and productivity growth, and because of the innovation processes developed and the role played in national and international technology transfers.

The role of innovation is crucial when interpreting the Italian economic growth experience in the four decades after WWII. Total factor productivity increased significantly for Italian industry in comparative terms. The Italian industry's capacity to increase efficiency persisted for almost two decades notwithstanding the general severe productivity slow down prevailing in early 1970s. The empirical analysis shows how total factor productivity experienced a fast increase, not only in modern industries, but also in the traditional sectors. The rejuvenation of the traditional industries clustered within industrial districts appears to be one of the key characteristics of the process. In this context, the emergence of key sectors specializing in the supply of specialized capital and intermediary goods, was at the same time, an input and an output of the process leading to the creation of industrial and technological filieres where systematic user-producer interactions implemented internal learning processes.

Faced with such a situation, few historical studies give much importance to technological innovation as a crucial variable when interpreting the economic growth in Italy during the second half of the 20th century. Moreover, the conclusions are, on the whole, pessimistic. Other studies acknowledge the overall importance of technological change in understanding the dynamics of growth, but they suggest that Italian capitalism did not contribute autonomously and creatively to the innovation process which characterized the second half of the last century. Instead during the 1980s and 1990s, a wealth of mainly empirical research was built up, regarding sectors, firms and regions which records the relevance and complexity of the innovative processes which were developed during the 50 post-war years, highlighting an innovative activity, which had been neglected for a long time and whose relevance had been underestimated.

Our research aims to draw attention to the relevance and uniqueness of technological change which characterized the industrial system in Italy. Therefore we identify and evaluate the significant elements of empirical evidence which show how, contrary to current opinion, the Italian economic system had a notable capability to innovate, producing relevant technological change both with regard to its rate and direction. By focusing attention together on total factor productivity, on indicators of research and development activity, patenting at home and abroad, on the purchase on international markets of not incorporated technological knowledge (TBP), and on the purchase abroad and at home of capital goods, it is possible to provide an interpretation of the Italian puzzle consisting of very low levels of statistically recorded classical innovation activity and yet high levels of total factor productivity growth. The basic argument is that the emergence and functioning of an original innovation system centred on internal learning and user-producer interactions in industrial filieres and manufacturing clusters have increased the dynamic efficiency of the low levels of R&D activities and engendered fast rates of introduction of innovations. In fact, the innovative ability of Italian firms was based more on creative adoption processes and the systematic development of localized learning than on the traditional mechanism of formal research as revealed by statistics regarding research and development and measured by indicators such as patents and bibliometric citations. From this point of view, the technological change which characterized Italian economic growth was highly original. The main conclusion is that technological change, based upon qualified vertical and horizontal interactions among firms, played a central role and it is indispensable to understand the characteristics, the rhythms and the innate fragility of Italian economic growth during the second half of the 20th century.

The remainder of the paper is organized as follows. In Section 2 we explore the evolution of Italian innovative activity, across sectors and regions, as expressed by statistics on R&D, on patents registered both in Italy and abroad, on Technological Balance of Payments. In Section 3, we perform a total factor productivity calculation for Italian industry to highlight the wide heterogeneity both in diachronic terms and synchronic terms, across sectors and regions, and to identify through a *shift-share analysis* the relevant locus of technological innovation/efficiency gains and the evolution of sectors' and regions' contribution to the overall productivity dynamic. In Section 4 we first bring into play the economics of knowledge basic framework necessary to elaborate a specific interpretive hypothesis for the apparent Italian paradox of a high TFP growth notwithstanding the modest level of the standard indicators of the intensity of innovative activity. We then trace the structuring of vertical industrial filieres and the shaping of mechanisms of interaction and accumulation technological knowledge, to finally elaborate and test the hypothesis of the emergence of an original innovation system capable to reconcile the evidence of sections 2 and 3, and to solve the apparent Italian puzzle. In Section 5 we draw our conclusions.

2. The evolution of innovative activity across industries and Italian regions

This paragraph offers a descriptive analysis of the evolution of the (visible) production of technological knowledge in Italy in the second half of the XXth century, crosschecking three kinds of indicators - the expenditure on research and development, transactions in the technological balance of payments and patents granted to Italian residents in the US by the USPTO. From an analytical point of view the decision to integrate these three indicators is quite significant, reflects the long debate regarding the limits of each single indicator, and aims at maximizing their specific strong points, overcoming their specific weaknesses.

2.1 Research and development

The statistical data on research and development expenditures cover research activity mostly carried out by big companies and public institution, and so favour formalized research activity. They confirm that in Italy both the public sector and above all the private sector invested few resources in research activities.

The data (see fig. 2.1 and 2.2) show that the overall volume of R&D expenditure increased both in absolute and relative terms, starting in 1963 from modest figure (0.6% of GNP compared to an average 1.9% for the 6 main OECD countries), but the gap to the other main industrialised countries remained considerable and the R&D/GNP ratio remained anchored at rather low levels, incompatible with Italy's economic position on the international scene (1.3% against 2.4% in 1990)[2]. In this evolution has a crucial part the relatively modest weight of R&D expenditure of Italian enterprises, compared to the other most industrialized countries (see figure 2.3).[3]

[2] Also limiting the comparison to R&D civil programmes, the ratio to GNP in 1985 was 1.1 in Italy compared to an average of 1.6 for the EU, 1.9 for the USA and 2.0 for Japan.

[3] In the 1960s, the corporate system acted as the driving force of R&D growth. The role of state enterprises was particularly interesting, in that it was a real tool of public research policy and played a central role in a failed (timid) attempt to develop a corporate centred national innovation system. In Italy, state action to support research carried out by (private) firms began only at the end of the 1960s (Law 1076 of 1968, Fondo IMI-Ricerca Applicata). See Antonelli, 1989; Giannetti and Pastorelli, 2007.

The **Regional** pattern of public and private R&D activity (see figure 2.4) shows a strong concentration (75% of national R&D in 1978-1995) in only three Regions: Piemonte (26%), Lombardia (35%) and Lazio (14%). The Northern and Central regions cover 93% of the total on average, leaving to the eight Southern Regions (with more than 35% of the Italian population) an increasing but tiny share. Over the period only the above mentioned three Regions and Liguria invested in R&D more than 1% of their regional gross product. Second tier good performer were Emilia Romagna and Friuli Venezia Giulia in the North-East, Toscana in the Centre, Abruzzo in the Mezzogiorno (see figure 2.5).

The analysis of the pattern of R&D expenditure by **economic sector** shows a strong and stable concentration. Manufacturing industry was by large the most important contributor to Italian R&D, both in absolute and value added terms. R&D expenditures in the manufacturing sector were concentrated in few branches: in early 1990s transportation accounted for almost 30% (and within that group, the aeronautical industry alone accounted for 12%), then electrical and electronic machines with more than 25%, followed by chemicals with a little less (pharmaceutical firms alone accounted for almost 15% of total expenditure).[4] The evolution of the pattern of R&D expenditure by sector reveals some interesting trends: the 1960s and 1970s were characterised by growth of R&D in the sectors at the technological frontier (in the fields of electronics, chemicals, nuclear energy); since 1980s there was a relative fall of research activity in the high-tech industries and an intensification in the intermediate technological industries (car industry, machine tools and electrical machines and appliances). In the long run the mechanical industry in particular made up ground. [5]

In short, such data certainly confirm that R&D activity was, for the whole period, a marginal and even "eccentric" phenomenon in the overall system. The extreme character of these figures, suggest that in Italy (in particular) R&D expenditures covers only a limited part of the production of technological knowledge useful for industrial innovation. Such expenditures reflects a kind of behaviour and operational criteria typical of large firms active in sectors with a strong scientific base, having laboratories with highly trained scientific staff, almost rare in Italian industrial landscape. Most of Italian industry is characterised by a completely different kind of firm, often small in traditional sectors. The

[4] See Antonelli and Barbiellini Amidei (2007).

[5] Machinery and mechanical equipment rose from 3% in 1963-1973 to 4% in 1974-1988 to 7% of R&D expenditure in 1989-1997, the R&D/VA ratio also overtook the one for manufacturing in the early 1980s.

particular dimensional structure of the Italian industrial system, is one of the main reasons of the low level of R&D activity[6].

2.2. Patenting activity

The statistics regarding patents granted by USPTO can be considered a useful measure of the flow of prevalently scientific innovation which the (few) Italian big corporation developed. The overall share of patents granted in the United States to Italian residents was rather modest. The comparisons between Italian patents and other foreign patents issued in the US show (see figures 2.6-2.9)[7]: the limited number and share of Italian patents in the initial period; the growth of the Italian share during the "economic miracle years" up to the historical maximum of 4.1% in 1963, and a (limited) catch-up with respect to the main industrialised countries, with the significant exception of Germany; the decline of Italy's patent share during the subsequent three decades. Up to early 1990s, however, the gap with respect to the other industrialised countries, excluding Japan (the big winner of this phase), narrowed. During the 1990s, instead, the dynamic of Italy's patent activity in the US diverge from the overall trend of her competitors (remarkable the South Korea's performance). Certainly Italy did not experienced, not even during its economic boom period, any "take off" in foreign patent activity similar to those of Germany and Japan (in the 1950s and the mid-1960s respectively). [8]

The **Regional** pattern of patenting activity (see table 2.1) shows a milder concentration than R&D, and behind the two North-West big players (Piemonte, 16%, and Lombardia, 39% of European Patents granted to Italians on average in the benchmark years 1980-1985-1990), other Regions show good relative performances (notably Emilia Romagna, Veneto, Lazio and Toscana; also Marche improves significantly its position). Here the technological catch-up of North-East and Centre Regions emerges more clearly; again the Mezzogiorno is far behind, with a mere 3% of Italian EU-patents in 1990.

---

[6] In fact, up to 1985 the number of firms involved in Istat's annual survey on R&D activity did not number 1000 units. R&D reached levels similar to those found in most advanced competitor countries, only in a limited number of enterprises and industrial sectors. Recent European surveys on innovation (Community Innovation Survey, CIS) show more similarity in the share of "innovative" firms recorded by size in Italy with those of the European partners. The original specialization model, biased towards traditional sectors, it is a second major cause of the low involvement of domestic firms in R&D activity.

[7] The comparison is within USPTO "foreign" patents. United States patents are excluded, in order to avoid evident effects of asymmetry in favour of domestic patenting activity for US firms. See Antonelli and Barbiellini Amidei (2007) for a description of the database on Italian patenting activity.

[8] It is interesting to note that also the data regarding patent applications submitted to the Italian Patent Office signal difficulties emerging in the late1960s. During the whole period under exam a increasing (but limited) share of Italian patents were issued by USPTO; the percentage of Italian external registrations reached significant values during the 1980s, with the creation of the European patent Office and the "European patent".

The data regarding the patents distribution by **sector** (SIC) reveal an interesting pattern: the single most important Italian contributor during the whole period 1950-2000 was machinery and mechanical equipment (30%), followed by chemical products (22%), and electric and electronic machinery (15%). Here stands out the significant absence of transportation equipment among the leading patenting sectors, in contrast to R&D expenditures.[9]

We calculated a specialisation index (index of relative technological advantage) in order to identify the relative strengths and the weaknesses of Italian technological innovative performance, obtaining some light and some dark areas (see table 2.1): [10]

- specialisation in the machinery sector progressed significantly in the long run;
- the process of technological specialisation in the chemical industry proceeded vigorously up to the mid-1960s, reaching in the end, after some troubles, appreciable levels;
- in the sphere of electric and electronic machines there was a (timid) process of relative specialisation only in the first twenty-five years, then prevailed de-specialisation, with the index well below one.

Overall during the long post WWII phase the mechanical industry faced the problem of technology and made a more than average effort to equip itself with levels of technological skills and innovative capacity apt to sustain its successful presence on national and international markets. The industrial machinery, in particular, developed a well structured technological base, establishing itself as an area of relative national technological strength. Instead Italy's patenting profile remained seriously inadequate in the fields of electronics and precision instruments. And the failed attempt of Italian firms to make their mark in advanced electronics was apparently a serious problem for the evolution of the technological strategies of Italian industry.

2.3 Acquisition of foreign non-incorporated technology

Italian payments of the Technological Balance of Payments, i.e. the purchase by Italian firms of non-incorporated technological knowledge developed abroad, are another important indicator of the amount of resources invested in the accumulation of scientific and technological knowledge directly aimed at the introduction of innovations, another crucial input of Italian innovative activity. The volume of resources invested by Italian firms

[9] The three main sectors were followed, at some distance, by precision instruments (8%) metal products (6%), transportation equipments (4.5%) and rubber and plastic products (4%); the traditional industries' share was rather low (less than 1%).

[10] The index is the ratio of the relative patents share (to other foreign patents) of the single Italian industries and the national share.

in purchasing non-incorporated technology appears to be significant, when compared to the modest sums invested in R&D.

In the 50 years after WWII Italian technological trade experienced a sustained growth (see figure 2.10).[11] Italy's effort to purchase technology abroad stands out among OECD countries up to late 1970s (see figure 2.11); also the coverage ratio (receipts over payments) improved (see figure 2.12).

At the level of **sectoral** distribution, emerge the concentration of purchases in the field of electronics (29% on average in the 1972-1988 period) and of sales in the field of mechanics (13%) and chemicals (25%); at the end of the period the traditional sectors gained ground too. These results confirm that electronics was the Achilles heel of Italian technology, while mechanical in its many forms represents its strength, and the chemical industry represented the challenge once won, but mostly renounced.[12]

The net differences in the way non-incorporated technology was purchased (patents and licences, 75% of total expenses in 1972-1988) and transferred (technical assistance and design, 48% of receipts) reflect, together with the weakness of domestic research and industry's peculiar specialisation, the original (emergent) Italian innovation system: the relevance of technical assistance and *know-how* as a form of transfers of technology signal the country's strength in intermediate technologies (especially, industrial machinery), in rejuvenated traditional technologies (made in Italy), and the importance of specific and localised learning in industrial innovation processes. [13]

The technical and geographical patterns of the TBP show Italy's characteristic position as an economy which "transforms" technology. Italy bought (codified) technology from the more industrialised countries (63% of total payments in 1972-1988) in the forms of greater relative value (patents and licences) and sold (specific and tacit) relationship-based technological knowledge (technical assistance, know-how, model and design, etc.) to less developed countries (45% of receipts).

Finally, the high values of the ratio TBP payments/R&D (more than 35% until mid-1980s), on the one hand point to a hard-won tendency to balance internal and external sources of

---

[11] See Antonelli and Barbiellini Amidei (2007) for a description of the Italian TBP database.

[12] An additional positive element for the machinery industry was the growing importance of sales of services with a high knowledge content (KIBS) to foreign firms. Such forms of technology transfers (particularly towards developing and recently industrialised countries) remain for the most part outside TBP, an exception being eventual supplies of non-connected technical assistance. The phenomenon emerged at the end of the 1970s as particularly important for Italy (in 1979 a revenue of more than 260 billion lire against an income in TBP for the branch of machinery of 24 billion lire; the figures reflect sales by engineering and consultancy firms other than manufacturing firms).

[13] However, the weakness of Italian industry in exporting codified non-incorporated knowledge is evident, and ancillary to the limited multinational growth of Italian firms. The weakness of international transfers of technology was even reflected in the relatively small amount of resources devoted by Italian firms to direct investment abroad, notwithstanding the huge internationalization effort reflected in export fluxes.

technological knowledge, on the other hand suggest that the Italian process of "technological emancipation" and the formation of solid autonomous innovative capacity was incomplete. At the same time, it suggests that technological payments should be considered an integral and crucial part of the domestic innovative effort, a complementary factor to R&D, an important input of Italian industry localised innovation processes. In the period under consideration Italian firms made in fact a considerable effort of creative adoption: acquired codified/scientific foreign technological knowledge and used it in processes of technology recombination, which allowed adaptation, adoption and valorisation of specific knowledge result of localised learning.

3. The effects of innovative activity and total factor productivity

R&D expenditure, patents and TBP, in fact, measure different levels of elaboration of resources invested into that special economic process defined as innovation, but certainly do not sufficiently cover the much wider range of innovative activities typical of Italian firms. Combining the three indicators with the analysis of the evolution of total factor productivity at a disaggregate level can help to build a wider and better-grounded interpretive framework.

International comparison of **labour productivity** levels (GNP per worker and working hours) highlights Italy's strong recovery from the end of the war up to the 1980s, both in respect to the USA and to main European partners (see table 3.1). Italian progress cannot be traced simply to an increase in capital per worker. **Total factor productivity growth** was in fact higher than the average of the main industrialised countries, and the TFP contribution to Italian GNP growth result the highest during the twenty-five post-war years (see table 3.2)[14]. TFP growth after 1973 experienced a significant slowdown in all the main OECD countries, but a milder one in Italy up to the end of the 1980s[15]. Our calculations of

[14] As showed in the international comparisons by the main experts of growth accounting (see Christensen, Cummings and Jorgenson, 1980; Dougherty, 1991; OECD, 1992; Maddison, 1995; Dougherty and Jorgenson, 1997; Barro and Sala-i-Martin, 1995).

[15] See OECD (1992), Maddison (1995). In the early 1970s a decisive decline in the rate of growth of productivity started in the USA and then spread to Europe (and Japan). There were many possible factors for such a negative trend and some have been identified as: weak investment activity; a slowdown in incorporating new technology into the stock of capital; changes in the composition of the workforce, an increase in the numbers of young people and women employed during the 1970s (even if offset in some countries, by increases in investment in education and training); a slowdown in the dynamics of investment in R&D and its productivity; fewer opportunities to catch up as the distance between the catching-up countries and the leader narrowed. Today, it might also be possible to consider the phase of technological transition between the early 1970s and the early 1990s, as a prelude to a change in technological systems, passing from mass production to new productions centred on information and communication technology, intensive in intangible capital, went to seed in the early post-war years and developed fully after (and perhaps partly because of) the great energy crisis. Italian industry had particular difficulty in taking part in this technological transformation for it had either not entered the new key advanced sectors or had left them prematurely, and was scarcely endowed with highly

total factor productivity for the main economic sectors show that Italian catch-up was based to a considerable extent to efficiency gains and strengthening of innovation dynamics in **manufacturing industry**. TFP growth was higher in manufacturing than for the whole economy and slowed down only slightly after 1973 (see table 3.3, 3.4)[16].

The TFP analysis inside the manufacturing industry returns a wide heterogeneity of TFP dynamics both in diachronic terms and synchronic terms (across sectors), and highlight significant changes in the hierarchy of the sectors as contributors to the overall productivity dynamics (see tab. 3.5).

To identify "the locus of technical progress" we performed a *shift share analysis* on aggregation of sectors: the "modern" sectors, relative to the Italian productive system of the 1950s and 1960s (chemicals, mechanics, transportation and rubber), the "traditional" sectors (food, textiles and clothing, wood and furniture), and the "intermediate"/ capital intensive sectors (ferrous and non-ferrous metals, non-metalliferous metals, paper). Here sectoral analysis helps to break down the productivity growth of manufacturing industry into its sector components, and to evaluate the contribution of different branches TFP dynamics and the composition effects which resulted from changes in industrial specialization (see table 3.6 and 3.7, fig. 3.2)[17].

The calculations reveal that the **modern sectors** had, during the whole period 1955-1988, above average rates of TFP growth, and made the highest contribution to manufacturing TFP, bigger than their Value Added share (47% against 42%). Moreover, in 1974-1988, when manufacturing TFP growth was slowing down, the contribution of the modern sectors increased significantly, proportionately more than their growing share of VA, so much so as to explain more than half of total TFP growth (57% against 47% of the share of VA). Considering the results of the single branches, stands out the mechanical industry which becomes in 1974-1988 the most important single contributor to manufacturing TFP growth; while the significant chemical industry's TFP contribution was eased out by the early (mid-1960s) interruption of the sector expansion.

The **traditional sectors** in 1955-1973 turned out being capable to increase efficiency significantly and resulted key contributors to manufacturing TFP growth (more than their

---

skilled human capital. See Wolff (1996); Gordon (2000); Jorgenson, Stiroh (2000); Oliner, Sichel (2000); Bassanini, Scarpetta, Visco (2000); Rossi (2003); Blanchard (2004).

[16] Our calculations of standard TFP-Solow residual are based on a dataset built with data collected from various sources, notably Golinelli (1998) for VA and labour units, and Annunziato, Manfroni and Rosa (1992) for capital, but also Rossi, Sorgato and Toniolo (1993), Lupi and Mantegazza (1994), and Istat (1951-98); see Antonelli and Barbiellini Amidei (2007) for a description.

[17] In our calculations we used weights based on VA valued both at constant and current prices. Generally different weights do not modify the overall picture of the results. In the tables presented here the reference is to a share of VA at constant 1990 prices.

VA share, 41.5% against 37.8%). In the subsequent phase, notwithstanding a drastic retrenching of their VA share, they still contribute for almost 30% of TFP growth (but less than their VA share).

Throughout the 1955-1988 period, instead, the **intermediate/capital intensive sectors** contributed to the manufacturing TFP growth proportionally less than their share of VA (16% against 22%). Here was particularly hurting the ferrous metals industry's performance.

The productivity slowdown was widespread, hitting almost all the industrial branches, nevertheless, a significant compensating *effect* came from the *shift* of VA towards higher TFP growth/level modern sectors. At the same time, the areas where productive and innovative "opportunities" were not fully achieved were mainly in the modern sectors, which were much less developed in Italy's productive system than in her main foreign competitors. The chemicals sector stands out as it had been unable to complete its expansion, but also the transportation industry was an underperformer (being essentially represented by the branches of automotive and motorcycle industry). The new high-tech industries (IT, aerospace, fine chemical and pharmaceutics), after the progress made during the first fifteen years, remained in an embryonic state and were wiped off, or were confined in productive niche. It is therefore necessary to emphasise not only the positive effects of structural/sectoral change achieved during the period under examination, and the success of the modernisation of traditional sectors, but also the heavy opportunity costs involved, due to the insufficient (in respect to main industrialised competitors) structural evolution of the Italian industrial system towards new science based sectors, technologically more dynamic[18].

The **Italian Regions'** industrial TFP performance results quite heterogenous trough time and territorial areas (see tab. 3.8, 3.9). It need to be mentioned: the Centre (Marche in particular) and the NorthEast (Veneto in particular) industry's strong efficiency gains of the 1960s (after a decade of significant internal catch-up against the NW industrial triangle), and the lead of NorthEastern regions in 1970s (Emilia Romagna in particular), which bring the new industrialised regions close to the TFP levels of the NW first movers (Piemonte

[18] Considering labour productivity levels in international comparisons, up to the early 1980s the biggest progresses were concentrated in the traditional industries (largely in the area of made in Italy, the branches of textiles and clothing, leather and footwear, wood products and furniture as well as ceramics), whose competitive advantages were the most difficult to defend against the new industrialising countries (see Dollar and Wolff, 1988; Broadberry, 1993). On the other hand, the hypothesis that since the 1960s "the relatively new sectors in terms of rate of technological innovation were also the most dynamic in terms of rate of growth of world exports" was not confirmed for years to come (Onida, 1978). For all the 1970s and beyond, higher rates of growth were registered in those sectors which were not the most technologically advanced, such as metal products, some basic branches of chemicals, plastic materials, rubber and capital goods, those "specialised suppliers" sectors where Italy's exports gained ground.

and Lombardia); the recovery of the NorthWestern regions in the 1980s which re-establish a (challenged) hierarchy, remaining the industry "triangle" by far the main contributor to the national TFP levels, well above its VA share (see tab. 3.10); the ephemeral industrial Mezzogiorno's catch-up, which fades away after the good 1960s performance, leaving the South industry contribution to national TFP levels well below its VA share.

4. The formation and decline of a national system of innovation: the Italian case after WWII.

The dynamics of sectoral relationships has been a crucial factor in the process of technological and structural change which characterised the growth of the Italian economy after WWII. In fact, it seems reasonable to argue that the Italian industry developed a special innovation system, thanks to which **creative adoption** by firms in the durable and non-durable consumer goods industries facilitated the growth of strong sectors specialised in the manufacture of capital and intermediary goods[19]. This, in turn, led to the introduction of further technological innovation which was mostly incorporated in machinery and intermediary inputs, and gave life to a system of virtuous interaction between process innovations introduced by user firms and product innovations introduced by upstream producers. These virtuous interactive processes were possible because of the strong qualified relations between user and producer industries. These relations were built up in the Italian economy during the period 1950-1990, they were encouraged and strengthened by the typical spatial productive structure, characterised by numerous industrial districts and by various key manufacturing local labour systems[20] centred around some regionally rooted medium-to big-sized industrial firms. [21] In this way, a two-fold process of structural change and of localised technological change developed: the structuring of vertical and diagonal industrial filieres (value added chains), together with the shaping of mechanisms of interaction, accumulation, transmission, exploitation of mostly tacit technological knowledge.

The economics of knowledge provides a consistent body of research that enables to acknowledge the variety of inputs in the generation of new technological knowledge. The latter can be generated only if four main activities and distinct sources are mobilized (Table 1 summarizes the main points).

[19] Creative adoption is the systematic process of reshaping technologies so as to increase their fit to user's factor and technological endowment, while localization is a way to adapt products/technologies for non-native environments.
[20] See ISTAT (2005) for a definition.
[21] See Brusco (1982), Fuà (1983), Becattini (1989).

TABLE 4.1: GENERATION OF TECHNOLOGICAL KNOWLEDGE	TACIT KNOWLEDGE	CODIFIED KNOWLEDGE
INTERNAL KNOWLEDGE	LEARNING ITALIAN MODEL	R&D CORPORATE MODEL
EXTERNAL KNOWLEDGE	KNOWLEDGE INTERACTIONS	KNOWLEDGE TRANSACTIONS

These activities can be classified according to two dimensions. The rows identify the two extremes of **internal/external knowledge**. No firm can command the overall knowledge available at each point in time: hence external knowledge is an essential input that complements the internal generation. The columns define the two extremes of **tacit and codified knowledge**. All codified knowledge requires an essential component of tacit knowledge in order to be used and integrated.

Neither of the four extremes are supplementary and all are essential complements. The generation of new technological knowledge consists in the active integration and recombination of the four distinct and yet strictly complementary sources of knowledge. The mix of components however can vary. According to the different weights of each component, alternative models can be identified.

The Italian case can be considered a model of an open innovation system alternative to the corporate model. In the corporate model the generation of technological knowledge is mainly based on large firms that have identified a specific function, research and development activities, to generate codified knowledge. In the corporate model learning activities play a lesser role. External knowledge is important but it is mainly acquired by means of specific knowledge transactions formalized as long-term contracts with universities and other public and private research centres. Transactions enable the acquisition of codified knowledge embedded in patents and blueprints. In the Italian model, learning activities are the primary source of technological knowledge. The generation of technological knowledge relies on a variety of learning processes such as learning-by-doing, learning-by-using and learning-by-interacting. Learning processes enable the accumulation of competence based primarily on tacit knowledge. Seniority and long-term relations between skilled workers and managers within family-owned firms, qualify industrial relations and provide the context for the valorisation and appreciation of the tacit knowledge accumulated by means of learning processes. External tacit knowledge is a key source of technological knowledge: it is incorporated mainly by means of qualified interactions, rather than formal transactions. Knowledge interactions take place with both customers, competitors and vendors of capital and intermediary inputs. Proximity within industrial districts and clusters favours knowledge interactions also because of intense inter-firm mobility of skilled personnel. Vertical mobility among firms that co-operate within the same filiere plays a key role as it provides the context into which user-producer interactions take place, and enables the generation of tacit knowledge.

The Italian model of open innovation is consistent with the **national innovation system** (NIS) approach that has been developed in a long process of theoretical elaboration in the area of economics of innovation[22]. The analysis of the emergence of the Italian innovation system also enables to appreciate the limitations of the standard NIS approach. In the latter, in fact, very little attention is paid to analyzing the process that leads to the creation of a virtuous system of interdependent feedbacks and interactions that are at the core of the systemic approach. From this viewpoint the Italian evidence suggests to pay attention to the system dynamics approach elaborated in the new context of the economics of complexity[23]. The emergence of the Italian Innovation System can be viewed as the result of the regional spreading of intensive user-producer interactions that has been taking place since the early 1950s originating from the industrialized core regions of the Northwest. In that part of the country, the sectors of mechanical engineering industry became

[22] See Nelson (1993). Fagerberg (1987), Freeman (1997) and Antonelli (1999, 2008). This approach highlights the systemic character of innovative processes, the importance of interdependence among the actors, the importance of the structural context in terms of geography, institutions and sectors. The large amount of empirical research carried out in this area has made it possible to confirm the relevance of the theoretical model, not only through the identification of various operational levels, so as to distinguish between national, regional and local systems, but also to highlight a variety of innovative systems which have proved to be successful (see Edquist, 1997; OECD, 1997a, 1997b, 1999a, 2002; Cantwell and Iammarino, 2003; Malerba, 2004). Two fundamental points are confirmed. First, a domestic innovation system is the result of a set of regional, industrial and institutional subsystems. Secondly, various domestic innovation systems can give different innovative results because of the specific conformation of the various subsystems as well as of their relationship structure. In the approach of national innovation systems, the structural architecture of the system, in terms of the topology of the network of connections and channels of knowledge externalities, plays a central role in interpreting the innovative capacity of single actors.

[23] See Anderson, Arrow, and Pines (1988).

progressively the main manufacturing activity, while the new industries specializing in light consumption goods such as textile and clothing, furniture and leather products, spread progressively in the NE, Centre and SE of the country. The fast growth of the latter industries provided an increasing derived demand for capital goods and advanced intermediary inputs manufactured mainly (initially) in the northwestern industrialized triangle. The interactions produced mutual benefits with positive effects in terms of the growth of a dedicated competence in providing the final goods industries with up dated and innovative capital and intermediary inputs that sustained the rapid penetration of Italian exports in the international markets. The analysis of the historic process highlights the endogenous character of the emergence of the national innovation system. The key element here, in fact, is dynamic coordination between two distinct processes: the specialization of the old industrialized regions in the provision of capital and intermediary goods and the specialization of the new industrializing periphery in consumption goods. This dynamic coordination should be regarded as the fragile product of a system of interactions that gained strength and structure. From this viewpoint it was much more the result of a path-dependent process exposed to localized positive feedbacks rather than a past-dependent process (where the hysteretic elements were set from the onset). As a matter of fact the Italian Innovation System seems to be the result of a growing complementarity between the core of large companies, dating back from the early XIX century and regionally concentrated in the northwestern part of the country, and new industrializing regions that found in the specialization in light consumption industries the opportunity for growth, with the opening of international and European markets. The ability of the northern industries to identify an emerging captive market in the derived demand of the new emerging industries in the new industrializing periphery and to become the dedicated supplier of capital and intermediary goods, is the result of a historic process. User-producer interactions provided large benefits to both parties: the industrializing periphery discovered the advantages, in terms of fast TFP growth, of the supply of process innovations embodied in the dedicated capital goods provided by the advanced northern industries. The mechanical engineering industries of the north could benefit from the interactions with the product innovations introduced by the firms based in the new industrial districts and clusters.

The main hypothesis is that innovation, that is to say, the capacity to innovate and to promptly adopt innovations, and therefore increase the overall efficiency of the economic system and, consequently, TFP, depends not only on the innovative efforts of the single agents, but also, and perhaps above all, on the interdependence between the various innovative processes, ultimately on the architecture of the system in which the agents operate. Therefore, the outcome of the special combination of elements which make up the system depends on the typology of the dynamic relations which tie the actors together and on the capacity of the system to evolve in such a way as to develop the most functional architecture for its growth.

On the basis of a detailed analysis carried out on the Italian case (Antonelli and Barbiellini Amidei, 2007), starting from a NIS interpretation, it is possible to elaborate a **specific interpretive hypothesis for the apparent Italian paradox** of a high TFP growth notwithstanding the modest level of the standard indicators of the intensity of innovative activity (R&D, patents): the Italian innovation system after WWII was crucially empowered by bidirectional processes of stimulus and feeding of the innovative activity developed through strong vertical relations between manufacturing sectors.

The functioning of the Italian innovative system is based on the combination of two specific and strictly interdependent processes:

i) the pressure of the demand for innovative capital equipment and intermediary inputs exerted by traditional and durable consumer good manufacturing industries on the upstream industries. The "made in Italy" and some other key national industries (textiles, clothing & leather, furniture, building materials and ceramics industry, food industry, etc.; white goods, automotive industry, etc.) pulled their suppliers' growth and innovative capacity both through the typical Smith-Young-Kaldor dynamics (where an increase in the size of the market is at the origin of an increase in division of labour, specialization, learning, investment and development of new technologies), and through collective and shared learning-by-doing and –using, made possible by strong virtuous localised relationships between users and producers of capital goods and key intermediary inputs;

ii) upstream sectors' total factor productivity, which trickled down on user industries, also thanks to their direct involvement (creative adoption) in the development of incremental innovations, crucially based on external, shared knowledge.

4.1 The building of the interdependence: induction, innovation and structural change

The Italian economy's long catching-up process after the second world war was based on the development of a new form of capitalism, characterised by an original and effective innovation mechanism. It is a model which is very different, in particular in its technological innovation black box, from both the Anglo-American "big corporation" model, and the typical financial ties Rheinish model. In fact, Italian firms increased total factor productivity not as much through the systematic exploitation of research and development activity, as through an articulated system of industrial vertical link-ups. A crucial piece in this "Italian puzzle", it was the development of a domestic machinery industry.

The process of **structural change**[24] which accompanies technological change, had a crucial influence on Italian economic and innovative performance in the post WWII era.

The abundance of under-used labour in agriculture and the opportunities of employing it in more productive growing and emerging manufacturing industries made an important specific contribution to TFP growth (more and for longer than in the rest of Europe)[25].

Considering the higher TFP levels and the reduced impact of the *productivity slowdown* after 1973, the manufacturing sector's expansion (particularly in the first twenty-five post-war years and until 1980s) was a major factor behind productive and innovative dynamics for the whole economy. [26] At the beginning of the 1950s, Italy stood out because of the high percentage of workers employed in agriculture[27]. Furthermore, Italy had an elastic supply of labour and the relations prevailing in the labour market favoured the establishment of a long virtuous phase (destined to have a traumatic end in 1970s), in which wages grew more slowly than labour productivity, facilitating high profits which encouraged investment (see fig. 4.1, 4.2, 4.3).

In the 1950s, Italy had the opportunity to "exploit" the technological gap accumulated during the long Fascist dictatorship by taking part in Europe's unequalled process of catching up on the USA.[28] The process was to a great extent linked to the ability to adopt mass

---

[24] Structural change is traditionally defined by long run changes in the relative share of the main economic sectors (see Lewis, 1955; Kaldor, 1966). The necessary conditions for the effects of structural change (changes in the sector composition of VA) to work, are the existence of differences in sector productivity levels and the net movement of resources from sectors with relatively low productivity to sectors with relatively high levels of productivity.

[25] As shown by shift-share analysis of sectoral changes and their consequences on labour productivity and TFP dynamics (see Antonelli, Barbiellini Amidei, 2007). When the main industrial economies are compared, the structural effects were in Italy relatively more important and significant until the end of 1970s (van Ark, 1996).

[26] Considering the VA share at constant prices, the manufacturing sector nearly doubled from about 12% in 1951 to nearly 23% in 1980, fluctuating just below this figure until the second half of 1990s. Considering the VA share at current prices, the manufacturing sector reached almost one third of the total in the mid-1970s, and then in the 1980s it began to fall gradually reaching about 21% in the 1990s. Considering employment, the manufacturing industry's share passed from 23% at the beginning of the 1950s to a maximum of 27.5% in the early 1970s, then it gradually fell to 22% at the end of the 1980s.

[27] See O'Brien and Prados De La Escosura (1992). All countries experienced a strong decline in agriculture employment share, particularly in the first twenty years after WWII. However, Italy (together with Spain) started with a much higher share (45% of the total in 1951 compared to about 25% in the main continental European countries).

[28] The Marshall Plan in fact provided supplies of American machinery and loans at reduced rates for the purchase of new equipments, while financing a wide range of initiatives to favour productivity. During the 1950s many of the most important industrial plants were built up or modernised with American machinery.

production methods[29]. On the basis of this opportunity, the growth of internal demand (higher per capita income, spreading of modern consumption patterns) was an important factor leading to intense technological diffusion in manufacturing, especially with investments increasing production capacity[30]. **Demand induction** resulted, in the 1950s and 1960s, in a significant lowering of the average age and a technological modernisation of capital[31]. Italian post-war *golden age* was a phase of strong investment. Through this renewal of capital and the technology incorporated in it, industry in fact benefited from the spread of technical knowledge from more advanced countries and used the opportunity and stimulus to innovate production processes and products, adopting and increasingly adapting imported technologies.

In the subsequent phase, since 1970s, if the average age of the stock of industrial capital in machinery and equipment rose, the process of *capital deepening* continued on intensely (see fig. 4.4). [32] In this phase (labour) **cost induction** and a different innovation process prevailed. [33]

If investment in new machinery has generally represented in the XXth century one of the main channels for the introduction of new technologies for the most part of the industrialized countries, this was especially true in the Italian case[34]. Adopting new investment goods turned out to be the main source of innovation for firms of all kinds, size, and sectors up to 1990s[35]. In the 1970s/80s, investment goods as a source of innovation

[29] See Maddison (1996), Rossi and Toniolo (1996). In the 1950s even in Europe the automation of mass production machines became a central line of development for machine tools technology.

[30] See Sylos Labini (1972).

[31] Considering only the mechanical sector, the share of plant not more than 5-years-old in Italy passed from 24% in 1958, to 33% in 1961, and to about 41% in 1964. When machine tools are considered , at the end of the 1960s about 54% of the stock of equipment was less than 10-years-old (see *Produzioni e Mercati. Le machine utensili*, in "Bancaria" 1971), while in the early 1970s, this share had risen to 59% and almost 20% of the stock of machine tools was less than 5 years old (see Antonelli and Garofalo 1978). The average age of plant in the manufacturing industry was, in estimates at the time, less than in many others industrialised countries (see Cacace and Gardin 1968). See also Wolff (1991).

[32] With a different pattern: from a strong synergic growth of capital and labour, manufacturing passed since 1970s to capital growing at lower rate and labour units employed less and less until a net decrease in the 1980s. Large firms, in particular, reacted with a combined strategy of increasing capital intensity, investing in automation and decentralising production. In some industries (particularly heavy industries) there was significant investment aimed at enlarging productive capacity with State help. See Nardozzi (1974); Barca, Magnani (1989).

[33] See Antonelli, Barbiellini Amidei (2007).

[34] Classical economics from the time of Smith and Marx has centred the analysis of economic growth on the theme of the production of machinery because of its role in the processes of accumulation and innovation. In the last few decades especially through the historical research on the technological evolution of industry, the understanding of the role of capital goods in the growth of the economy and in the innovative processes has improved (see Rosenberg, 1963, 1982; Rosenberg and Mowery, 1998). The machine tool industry, in particular, has been seen in these analyses as a crucial mechanism in the spread of technological innovation in US industry: in the nineteenth century for the expansion of productive technology based on interchangeable components; at the beginning of the twentieth century for the advent of methods of mass production.

[35] Certainly with different weights depending on the sector in which the firm belonged, on the different degrees of involvement in formal and informal R&D activities, patents, trade in non-incorporated technology. In the mid-1960s, 60% of the manufacturing firms which declared having innovated, reported "investment in new machines and/or new

appear to have been of the highest importance for the “traditional” consumer goods industries (made in Italy) and their intermediate inputs producers (textiles, etc.).

Structural change in Italy was accompanied on a much lesser scale by increased investment in **human capital** (classified according to the level of education) with respect to physical capital. In the 1950s, Italy had a relatively low educational levels of the workforce (not only with respect to the US, but also to many European countries and Japan). [36] Italy had a good supply (well qualified) of engineers and a skilled workforce. [37] The average level of education rose significantly during the 50 years after WWII, but the most significant progress, especially in terms of university education, took place from the late 1960s. [38] Important for the development of the national absorbtive capacity, i.e. the capability to adapt the technologies being adopted (often from abroad), was the increased investment in the technical secondary education and in particular in the technicians educated and trained in the “Istituti Tecnici Industriali” (technical-industrial high schools) (see fig. 4.5 and 4.6).[39]

4.1.1. The development of a domestic machinery sector and innovation dynamics in Italian industry

Structural change also expressed the fulfilled opportunity to develop a domestic machinery industry, crucial in the emerging Italian innovation system.

The ability to adopt external foreign knowledge depended initially on **imports of foreign machinery**: the data collected show that until mid-1960s, a significant part of investment passed through the purchase of capital goods produced abroad (see fig. 4.7, 4.8)[40].

---

processes” as their way of innovating (see Cacace, 1970). In 1980s and 1990s, the purchase of innovative investment goods continued being the main channel of innovation in Italy (see Istat 1987, 1989, 1995). It is interesting to note the relative greater weight given in the early 1990s to R&D for the machinery and mechanical equipment industries.

[36] See Maddison (1995).

[37] Italy had a significant spread of entrepreneurial “spirits” but a limited supply of managerial resources.

[38] See Istat (1950-72, 1973-98). Moreover, up to the end of the second half of the 1960s, scientific studies and engineering at university were in decline both for enrolled and graduates. Despite improvements, large gaps remained in the area of formal education. Even as late as 1977 little more than 40% of those employed had finished Junior school and the percentage of graduates in the working population remained comparatively low (see Vasta, 1999).

[39] The “Istituto tecnico industriale” was developed in the post WWII educational system as a 5 years secondary school teaching technical-scientific subjects relevant for industrial technology development (mechanical engineering, electrical engineering, measures, fluid dynamic, automation, material technology, etc.). After graduating, school leavers could qualify as “periti industriali” after a national exam. The number of “Istituti tecnici industriali” increased from 89 (21 in Lombardia, 9 in Veneto, 8 in Piemonte, 7 in Emilia Romagna) in 1949, to 434 in 1969 (69 in Lombardia, 50 in Piemonte, 41 in Veneto, 32 in Emilia Romagna), and to 636 in 1979 (115 in Lombardia, 71 in Piemonte, 54 in Veneto, 39 in Emilia Romagna). In the course of 1950s among Italian firms the tendency to use educated technicians to cover the chief technician (capo tecnico) functions in the production lines emerged, in addition to skillful heads of units who came from rows of the workers. Data sourced from Istat (1950-72, 1973-1998) and Crenos Databases Regio-IT 1951-93, Regio-IT 1960-96 (see Paci and Saba, 1997).

[40] The figures for capital goods imports refer to an aggregate flow of foreign trade relative to capital goods produced in various branches of mechanics (class 7 in the SITC classification) and in the branch producing tools and precision

In the two decades after WWII, however, a process of quantitative and qualitative growth of the rising **Italian machinery industry** was set in motion. Imported machinery provided an important impulse and were an important input in the process of imitation, adoption and technological innovation for investing Italian industries as well as for domestic producers of capital goods. Increasingly, investing industrial firms targeted domestically produced machinery. It was with the economic *boom* of early 1960s that internal demand for capital goods exerted decisive pressure on domestic industry: the strong and prolonged growth of investment, while initially finding the domestic productive structure unprepared and inadequate, set off significant up-grading, innovation and growth of the sector. As can be seen from the data, domestic production of capital goods exceeded internal absorption from the mid-1960s[41]. Within domestic production of capital goods, machine tools were already on a good track, textile machinery and wood and furniture machinery grew since 1950s, since 1960s gained weight also the domestic production of machinery for the leather industry, of machinery for the paper, printing, packaging and packing industries, of machinery for the ceramics industry and for plastic materials.

Since 1965, the balance of specific commercial trade in capital goods was positive (a similar profile emerges, on a bigger scale, for machine tools). Exports grew strongly in the long run and Italy gained in this sector a new significant and long lasting competitive advantage. [42]

Structural change and industrialisation, as processes of increasing division of labour and specialisation, led to the progressive development of upstream sectors and to the formation of articulated national manufacturing filieres.

Crucial was the emergence of a domestic machinery industry competitive in developing specialized machinery, tailored on the needs of the users. Through creative adoption,

---

instruments (861 SITC; elaboration on data sourced from Istat). Also data from ISCO (1977), regarding trade in final and non-final investment goods, confirm the evolution of external trade in these classes of investment goods showed in the graphs. For machine tools we elaborated data from Ucimu-Istat.

[41] There was a similar evolution in the relationship between domestic investment and the internal production of machine tools. Investment in machine tools accounts for a significant share (between 5% and 10%) of total industrial investment over the whole period 1950-1980. See "Commission of enquiry and study into the machinery industry, *La produzione delle macchine utensil*i, December 1950" in ASBI, Fondo 11, Serie 1.

[42] During the 1960s Italy's exports gained ground in the "specialised suppliers" sectors, just where firms producing capital goods were important. This progress reached since 1970s and 1980s a quite relevant quantitative and qualitative level, despite being concentrated in sector niches (see Gomellini and Pianta, 2007; developments until mid 2000 confirme this trend, see Bugamelli, 2005). The Italian share of world exports of machine tools doubled, passing from 2.5% in 1955 to 5.4% in 1965. During the period 1955-1965 the growth of Japanese exports (from 0.5% to 2.5%) was remarkable, German exports stabilized (from 24.5% to 27%), while sales abroad of US and British machinery fell (from 23% to 16% and from 10.5% to 7%, respectively; see Mazzoleni, 1999). Italian exports of machine tools, despite some dips, continued to increase their share of the international market between the 1970s and the 1990s, passing from 7.4% in 1975 to 9.1% in 1990 (ahead US); Japanese exports managed to gain a quarter of the world market, as more or less the German ones.

increasingly reshaping new (foreign) technologies so as to increase their technological congruence with respect to the needs and characteristics of the industrial domestic users, the development of the Italian capital goods industry resulted in fact a decisive boost to the diffusion of technological innovation and to productivity growth in important domestic manufacturing sectors. The growing supply resulted in a reduction in the price of capital goods (while the cost of labour was increasing and its ready availability decreasing), feeding capital deepening.

Starting since 1960s, domestic demand for investment goods increasingly concerned more specialized and technologically sophisticated machinery, stimulating and feeding innovation by the national suppliers, resulting through interaction with the industrial users.

Important was the impulse of the demand of the growing Italian consumer durables industries (white goods, cars, motorcycles, typewriters, etc.), which stimulated more formalized innovative activity, through the purchase of licences abroad and the formation of joint research centres[43]. In this period Italian industry, and the mechanical sector in particular, benefited from the development of the technical secondary education in the "Istituti Tecnici Industriali". This educated human capital (endowed with good structured technical skills with some epistemic base) fruitfully matched the industry's internal development of skilled labour, and was pivotal to develop and successfully exploit technological innovations along vertical manufacturing filieres .

In the 1970s, the Italian machine tool industry entered a new and important phase of growth, with the development of the production of numerically controlled machines (automated machinery based on numerical information)[44]. In a few years, as a result of the access to new technology and of incremental localised innovations, the spectrum of

[43] Notably, the experimental centre UCIMU (Unione Costruttori Italiani Macchine Utensili) and the joint research institute (Istituto per le ricerche di tecnologia meccanica e per l'automazione, RTM) of Fiat, Finmeccanica and Olivetti. In the mid-1960s, the ratio of R&D on total sales in the Italian mechanical industry was modest, instead, the flow of *know-how* from abroad was considerable. In the 1970s and 1980s decreased reliance on foreign licences and increased sales of know-how and technical assistance. At the end of the period analysed, the machinery sector accounted for a significant share of Italian industry's R&D (as seen in 2.1), of sales of non-incorporated technology abroad (as seen in 2.3) and of Italy's international patenting (as seen in 2.2).

[44] After the second world war, the US machine tool industry (technological and commercial leader from the middle of the nineteenth century, replacing British industry) opened a new path of technological innovation: the development of automated systems to control the movement of machine tools with high levels of precision (as a result of research carried out in the early 1950s at the Servomechanism Laboratory of MIT, with financing from the US Defence Department). Numerically controlled machinery was produced and used in the USA essentially from the early-1960s and reached quickly an appreciable diffusion even among Italian firms. In the 1960s some Italian firms (notably Olivetti and San Giorgio) who were active in the electronics field developed control systems for domestic machine tool producers (see "Relazione sull'esercizio chiuso al 31 dicembre 1965, Olivetti", p. 26 e 27, in ASBI, Banca d'Italia, Raccolte diverse - Relazioni e Bilanci, cart. 1326). Wider diffusion of numerically controlled machine tools was reached in the mid-1970s worldwide (see Antonelli and Garofalo, 1978). It is estimated that in 1978 numerically controlled machinery accounted for 10% of total Italian production compared to a little higher share for Germany and double that percentage for the USA and Japan (see Mazzoleni 1999).

manufacturing processes over which was efficient the use of numerically controlled machine tools was increased. In particular numerical control machines became attractive also for small and differentiated production batches, helping the search for productive flexibility[45]. These technological and productive developments of the machine tool sector favoured the spread of decentralisation and articulation of productive processes in Italian regions manufacturing industry.

During the 1980s Italian producers were able to adapt and apply the new technologies to their typically specialised and customized machinery competitively, thanks to the relationships linking producers, users and suppliers of components.[46] In so doing the domestic machinery industry made a decisive contribution to the competitive strategy of Italian final goods producers. The innovations incorporated in machinery contributed significantly to increase productivity and to improve quality and widen variety of products in the downstream manufacturing sectors. In particular, the innovative capacity of Italian machinery industry made a significant contribution to the competitiveness of the country's traditional manufacturing sectors[47]. As a result, the machinery sector played a central role in Italian industry TFP dynamics, as a growing advanced branch of Italy's productive system, as a supplier of goods vector of technological change and as a lever for technological and organisational innovation in users industries.

In fact, the emergence of a competitive machinery industry can be considered the most effective, tangible and long-lasting single result of a bottom-up process of development that led to the accumulation of a widespread, collective and localised heritage of original technological knowledge, based on processes of learning by doing, learning by using and learning by interacting. The emerging Italian system of innovation found in the machinery industry its original keystone.

---

[45] Thanks to improvements in performance and the lower costs made possible by the introduction of control systems based on the new technology of the microprocessor and by specific localised innovations. In the subsequent years, the growing application of the innovations in microelectronics and information technology made available machinery characterised by more and more flexible automation (typically, flexible automotive systems and CAD-CAM systems). See Carlsson and Jacobsson (1991).

[46] It is estimated that numerically controlled machines accounted for 38% of all Italian machine tools production in 1988, compared to a similar share for the USA, a 50% share for Germany and a share of almost 60% for Japan (see Mazzoleni 1999).

[47] The data confirm the empirical evidence which has emerged from numerous sector studies, according to which the production of investment goods in Italy reached levels of technological excellence at an international level, above all, in the upstream sectors of traditional products in Italian industry. Textile machinery which is upstream to the textile and clothing industries, packaging machinery which is upstream to the food industry, specific machinery for the ceramics and wood industries, but also special machinery and robots which are upstream to the transport equipment, white goods and fine mechanics industries, offer unequivocal empirical evidence of the technological capability of the Italian capital goods industry and of the crucial role it played in the competitive growth of various Italian manufacturing industries. Consider, for example, the analysis of the role of textile machinery in the growth of the textile industry by Antonelli, Petit and Tahar (1992); Carlesi, Lanzara and Sbrana (1983) for furniture and paper industry; Bursi (1984) for ceramic industry.

4.1.2 Chronology of the emergence of an innovation system

We now have the building blocks to draw briefly the evolutionary process which led to the emergence of an original innovation system.

During the 1950s-1960s phase:

- the expansion of the manufacturing base was greatly fuelled by a ready supply of labour at a low unit cost;
- the factor endowment was characterized by a relative abundance of semi-skilled workers, with low levels of education but with high levels of professional skills based on learning processes in quasi-craft production;
- the technological knowledge available to firms was essentially limited to labour intensive productive processes; in the whole prevailed a labour-intensive technological innovation;
- the Italian industry timely and profitably adopted new technology incorporated into capital goods and diffused it rapidly through high levels of investment;
- initially prevailed the import of innovative capital goods (foreign incorporated technology); gradually emerges and develops the crucial domestic machinery industry (locally incorporated technology);
- product innovation prevailed, based on the imitation and adaptation of foreign technology, also through the acquisition on international markets of non-incorporated innovative technology, in the form of patents and licences.
- The industrial base widened mainly thanks to the creation of new firms in the traditional sectors, spreading, from the North-West triangle, in the North-Eastern and Central regions. Also new durable goods industries enriched the national industrial base.
- The organization of the production of knowledge in Italy took place along two lines. On the one hand, the group of large firms that had emerged at the beginning of the century, many under the control of the State, adopted a modified version of the 'American' model, traditionally based upon the pivotal role of the large corporation. The latter was here articulated around the key role of direct public subsidies to State owned (SOEs) and "influential" private firms investing preferably in Southern Italy (instead of direct public subsidies to firms investing in research and development activities, associated with a strong public demand for goods and services incorporating high levels of knowledge-intensive products and the complementary role of the academic system supported by public funding). Italian corporations in this period were more and more active in funding the generation of new knowledge and played an important role in the performance of research

and development activities. Alonside the imitation and adaptation of the ‘American’ model, however, a second process took place: one where small firms played an important role, as they relied on the accumulation and valorisation of tacit knowledge based both on internal learning and the collective creation and usage of external pools of knowledge.

In the 1970s-1980s phase:

- the ready supply of labour progressively dried up to such an extent that there were growing tensions in the labour market;
- at a macroeconomic level, the strong growth of unit wages and increased competitive pressure (in both the domestic and international markets) induced technological innovation and pushed for the introduction of new labour-saving technologies to reduce costs and increase efficiency;
- capital deepening progressed largely and pervasively;
- “modern” sectors gained weight in the manufacturing industry (which was gaining ground in the national economy);
- an important part of the development of the mechanical and the chemical industry was the result of a process of “ascent of the filieres”, of building vertically integrated manufacturing chains. The strong derived demand of downstream sectors, mainly from traditional consumer goods industries (but also from producers of “new” durable goods), pulled and stimulated innovation by upstream suppliers of capital and intermediate goods. The growth of innovative capacity in upstream sectors was also the result of intense processes of qualified and close interaction between users and suppliers of capital and intermediate goods[48]. The suppliers’ increased innovative capacity, in turn, favoured the downstream industries, both offering them customized capital and intermediate goods which incorporated significant technological innovation, and spilling down pecuniary knowledge externalities[49]. In the whole industrial system (upstream and downstream) a crucial role was played by learning processes strongly localised, both in spatial terms and in technical terms [50].
- In this way a virtuous system was set off in which product innovation in upstream industries stimulated, and was fed, by process innovation of downstream industries. The Italian industry, while experiencing a down-scaling of its growth path with the failures in the

[48] See for example Patrucco (2003, 2005).

[49] When and where pecuniary knowledge externalities matter, the total cost of external knowledge, including purchasing and governance costs (articulated in transaction, networking and absorption costs), is lower than its marginal productivity for perspective users. In these conditions firms have an incentive to rely less on internal learning and more on external local knowledge pools (Antonelli and Barbiellini Amidei, forthcoming).

[50] See De Bresson and Xiaoping (1996); OECD (1999b); Cingano and Schivardi (2003).

capital intensive sectors and in high tech industries, appears able to create and exploit new technological opportunities based on a close vertical interdependence between adopting traditional sectors and modern innovating sectors: an authentic endogenous technological knowledge generating mechanism was actually activated.

- The North-Eastern and Central regions industrial development continues and consolidates, together with North-West prevalence, while South-West industrial catch-up dries-up .

This process of virtuous and cumulative interaction was one of the most positive elements of the Italian growth model after WWII. With the slowdown of the innovative dynamism of the big corporations and the crisis of the SOEs, the SME-centred part of the Italian industry was able to implement an original model for the organization of the generation, dissemination and usage of technological knowledge. When the industrial sector had accumulated a sufficient degree of technological skills and had significantly articulated and structured the vertical linkages across its sectors, an original innovation system emerged capable to develop and capitalize on its specific idiosyncratic characteristics. The growth of total factor productivity in downstream sectors appears to be the direct consequence of the growth of total productivity in upstream sectors, which, in turn, was pulled by demand in downstream sectors and by knowledge externalities derived from the interaction with and within downstream industries. A systematic action of creative adoption was developed in the industrial system. It was based on *re-engineering* foreign technology, and was increasingly characterised by a strong domestic, idiosyncratic and localised component, which developed local skills and drew inspiration from virtuous processes of interaction between users and producers. It also exploited the development of *on-the-job* learning processes, especially in directing technological change in favour of the creative use of the locally abundant resources: semi-skilled labour in the first phase; specialized and dedicated (adapted to their specific needs) capital and intermediate goods, in the second phase.
Such technological options seem to lose part of their dynamic capacity from the 1990s.

4.2 Total factor productivity growth and dynamic interdependence within industrial filieres: The econometric evidence across sectors

We now want to test the hypothesis that the Italian case was, for some decades after WWII, an example of a virtuous innovative system, developing and emphasizing the interdependence between innovative processes across manufacturing industries.

The relevance of dynamics of sectoral relationships is a remarkable feature of Italian technological and structural change after WWII.

The hypothesis of the emergence of an original Italian innovation system can also reconcile the evidence of paragraph 2 and 3, and try to solve the apparent Italian paradox of a industrial system characterized by strong TFP growth (= good productivity and innovative results) and modest magnitude of the standard classic indicators of technological innovative activity intensity. This innovation system also had a peculiar spatial configuration (we will return to this in the next paragraph).

The interpretive model put forward can be object of some empirical investigation which makes it possible to draw attention to the plurality of the innovative mechanisms operating in the Italian industrial system and the variety of relationships which link them.

Looking across industrial sectors, the following hypotheses can be formulated:

a) in the whole industry, TFP developed as the result of the introduction of technological (process and product) innovations induced by growth in wages (substitution pressure) and in aggregate demand;

b) innovative activity and growth in the upstream sectors were stimulated by the combination of expansion of the derived demand for capital goods and intermediary inputs in the downstream (mostly) traditional sectors (Smith-Young-Kaldor demand pull innovation processes) and of the setting in motion of a process of localized technological change (learning by doing and by using, user-producer interactions);

c) at the same time, in the downstream, traditional and some durable goods sectors, the growth of TFP can also be "explained" by TFP growth in the upstream sectors, due to classic spillover, trickle-down processes (technological externalities, knowledge as quasi-private good) and to pecuniary externalities.

On this basis, an econometric model is drawn up in which the dependent variable is the growth of total factor productivity ($\Delta \ln TFP$) of the various upstream producer and downstream users sectors. The industries of transport equipment, food, textiles and clothing, timber and furniture, paper, rubber, non metalliferous minerals, non-ferrous and ferrous minerals, make up the downstream sectors (D). The "key" upstream sectors (U) are identified as the chemical and mechanical industries ($D \cup U = I$, where I is the overall set of manufacturing industries).

The following system of equations hence holds $\forall i \in I$:

$$(1)\Delta \ln TFP_{it} = \alpha + \beta_1 \Delta \ln(Kmach/L)_{it} + \beta_2 \Delta \ln(W/L)_{it} + \beta_3 \ln(W/L)_{it} + a\left[\beta_4 \sum_{d\in D, d\neq i} \Delta \ln(VA)_{dt}\right] + (1-a)\left[\beta_5 \sum_{u\in U, u\neq i} \Delta \ln TFP_{ut}\right] + \varepsilon_{it},$$

where a =1 if i $\in$ U, a = 0 if i $\in$ D; i $\in$ I.

To simplify, the general equation can be rewritten as a system of two blocks of equations, with a distinct specifications for the downstream sectors (a=1) on the one hand, and for upstream sectors (a=0) on the other:

$$(1a)\Delta \ln TFP_{ut} = \alpha + \beta_1 \Delta \ln(Kmach/L)_{ut} + \beta_2 \Delta \ln(W/L)_{ut} + \beta_3 \ln(W/L)_{ut} + \beta_4 \sum_{d\in D, d\neq i} \Delta \ln(VA_{dt}) + \varepsilon_{ut},$$

for each u $\in$ U;

$$(1b)\Delta \ln TFP_{dt} = \alpha + \beta_1 \Delta \ln(Kmach/L)_{dt} + \beta_2 \Delta \ln(W/L)_{dt} + \beta_3 \ln(W/L)_{dt} + \beta_5 \sum_{u\in U, u\neq i} \Delta \ln TFP_{ut} + \varepsilon_{dt},$$

for each d $\in$D.

In both equations, the explicative variables are:

a) the rate of growth of capital (machinery) intensity, Δln(Kmach/L), so as to capture the effect of new embodied technologies;

b) the rate of growth of wages per labour unit, Δln(W/L), so as to measure the classic induction of the labour costs dynamics;

c) the level of wages per labour unit in the sector (W/L) so as to measure the effects of the relative levels of technical skills (quality of labour).

The equation which explains TFP growth in the **upstream key sectors** also includes as an explicative variable:

d_1) the growth in downstream sectors measured by the rate of change of added value, Δln(VAd), in order to measure the inter-sector effect of demand pressure exerted by downstream firms for the introduction of innovations by firms in upstream industries.

On the other hand, in the **downstream sectors'** equation we also have:

d_2) the growth of total factor productivity in key upstream sectors, Δln(TFPu), in order to capture technological *spillovers*, as well as pecuniary externalities effects.

Where α, $\beta 1$, $\beta 2$, $\beta 3$, $\beta 4$ and $\beta 5$ are the coefficients to be estimated and ε is the random error term.

The econometric model specified in this way makes it possible to carry out an analysis of the relevance of the virtuous interrelations between the dynamics of growth and innovation which characterised the functioning of the Italian system of innovation for a significant period after WWII[51].

Considering the aims of the analysis, as well as the structure of the data (characterised by a time range wider than the cross-sectional range), we adopted a SURE (*Seemingly Unrelated Regression Equations*) model. In fact, the latter model allows: i) to appreciate the behavioural differences of single sectors, in that it does not impose constraints of equality on the coefficients across sectors; ii) to test the relevance of innovation linkages between sectors and groups of sectors, in that it allows for the presence of not null contemporaneous covariance between the shocks hitting the different sectors. [52]

The estimation, carried out for 10 manufacturing sectors, covers a period of more than three decades (1955-1988)[53].

Many specifications of the model were considered.[54] The model has been estimated by using FGLS (*Feasible Generalized Least Squares*). [55] Table 4.2 shows the results of the best specification.[56] All the determinants listed above are included. The results of the regressions confirm the validity of the innovative model hypothesis, and reveal important differences across industries and in particular between the two groups of upstream and downstream industries.

The variable ΔlnTFPu, proxy of the innovative contribution of technological *spillover*s and pecuniary externalities from upstream sectors to downstream sectors, was almost always positive and significant. It is worthwhile to mention the positive contribution made by the innovative dynamics of mechanical industry to firms in the transport equipment sector, and also the positive contribution made by the innovative dynamics of both chemicals and mechanical industries to the textiles and clothing industry.

Also, key upstream sectors appear to have benefited from the pull of the more important users sectors (ΔlnVAd): mechanical benefits from productive dynamics of the transport equipment and textiles industries, chemicals from transport equipment's production.

---

[51] Our next step will be to work on an enriched formulation of the equation model, which includes the variables expressing the input and output of innovative activity (R&D, patents, TBP).

[52] See Zellner (1962); Greene (1997).

[53] The variables used were built on the basis of data (at constant prices) described in Antonelli, Barbiellini Amidei (2007).

[54] We inserted variables which express in different ways the determinants mentioned above. For example, in the case of W/L, we also used as an alternative the wage per worker in each sector as a percentage of the average manufacturing wage per worker, (W/L)i / (Wmanuf/Lmanuf). Similar results were obtained.

[55] FGLS gives consistent estimates, as OLS equation by equation, but also more efficient, since equation are related and explanatory variables may differ in some respect in the different equations.

[56] The regressions in general explain between one fifth and one half of the total variance. Alternative versions of the model in which some lagged variables had been inserted did not reveal any significant differences with regard to the crucial relationships, and the overall pattern of the results is substantially confirmed.

Concerning the effect of embodied technology, the intensity of machinery per unit of labour, ∆ln(Kmach/L), has a positive and significant effect on two important modern sectors' TFP dynamics (chemicals and transport equipment industry); in two cases (food and wood) this variable is negative and significant.

The growth of the wage per labour unit, ∆ln(W/L), has a positive and significant effect on transport equipment and food industries' TFP, which may be interpreted as a positive substitution effect induced by increasing labour costs.

The level of wage per labour unit (W/L) show a positive and significant coefficient only in the key upstream sectors, chemicals and mechanical, which can be an indication of the contribution of skills and quality of labour to TFP dynamics in these sectors. Instead, in two downstream sectors (transport equipment and textiles) the significant and negative coefficients may signal a progressive drying up of technological opportunities along the preferred innovation paths. [57]

Econometric calculations on slightly different temporal windows, with respect to the one here under study (1955-1988), reveal that the workings of the intertwined system of *feedback* reached full maturity between the 1960s and 1970s. The evolution of the system's architecture during this period was fully functional to its growth and enabled the relationship between the processes of learning-*by-doing* in the upstream sectors and the processes of learning-*by-using* in downstream sectors to be fruitfully interdependent. It is worth noting that the "innovative" linkages of the chemical sector with the other sectors became progressively weaker; later, this resulted in a dampening of the system, signalling an evolution of the innovation system's architecture towards a "poorer" (less dynamic) configuration.

4.3 Total factor productivity growth, localised technological change and the endowment of technical skills: The econometric evidence across regions

In the process of building a comprehensive and integrated database of regional and industrial branches time series for the relevant variables, we also performed some econometric exercises on the regions' industrial sector productive and innovative structure. We adapted the model used in the previous paragraph, to control across Italian regions, and added a variable to capture the effect of the changing availability at the regional level of technical skills, potentially useful in the industry process of re-engineering, provided by

[57] With the risk of firms no longer able to withstand international competition as their absolute and relative efficiency gradually fall in a higher labour cost environment. These dynamics are confirmed at a regional level in Quatraro (2006).

the educational system of the “Istituti Tecnici Industriali”, particularly useful in dynamic interactions across sectors.

Looking across Italian regions’ industrial sectors, an hypothesis can be formulated that:

a) on the whole, industry TFP developed in regions as the result of the introduction of technological innovations induced by growth in wages (substitution pressure) and in aggregate demand (Italian Gdp);

b) the TFP dynamics of domestic mechanical industry may have benefited regional industries’ performance, due to positive technological and pecuniary externalities (spillovers) within and across regions on different industrial sectors;

c) the availability of industrial technical skills at the regional level, may have empowered industry productive and innovative processes, allowing creative adoption of new technologies incorporated in capital goods and intermediary inputs, technological communication within and across industrial branches (along industrial filieres), sustaining processes of localized technological change.

Again we used a SURE model to estimate the following equation, for the twenty Italian regions (J), over the period 1961-1994: [58]

$$(2)\Delta \ln TFPInd_{jt} = \alpha + \beta_1 \Delta \ln(K/L)Ind_{jt} + \beta_2 \Delta \ln(W/L)Ind_{jt} + \beta_3 \ln(THK/L)Ind_{jt} + \beta_4 \Delta \ln(GdpIta_t) + \\ + \beta_5 \Delta \ln TFPItaMech_t + \varepsilon_{jt}$$

for each $j \in J$.

Table 4.3 shows the results of the best specification. The ratio of students enrolled in “Istituti tecnici industriali” (with a four years lag) on unit of labor in industry (THKjt/Ljt) shows a positive and significant coefficient in some important Northern and Center Italy regions (notably Lombardia, Emilia Romagna, Toscana and Marche): it may be interpreted as an indication of the contribution of skills and quality of labour to TFP dynamics in these regions, through their role in processes of creative adoption and re-engineering, user-producer innovative interactions. These regions are densely populated by industrial districts and characterized by the presence of localised manufacturing clusters centred on leading firms (Lombardia and Emilia Romagna). Instead, in Southern regions this variable is generally not significant. [59]

---

[58] The model has been estimated by using FGLS (Feasible Generalized Least Squares). A regional database was built on data sourced from Antonelli and Barbiellini Amidei (2007), Crenos Databases Regio-IT 1951-93, Regio-IT 1960-96, Regio(cap)-IT 1970-94 (see Paci and Saba, 1997; Paci and Pusceddu, 2000), Svimez (1996), Prometeia (2003), Istat (1950-72, 1973-1998).

[59] This, perhaps, was also because of a technical human capital drain result of intense internal and foreign migration of young educated technicians, more than a shortage in the regional supply of educated technician the shortage. We are gathering data on regional migrations to gauge this effect.

The variable Δln(TFPItaMech) proxy of the innovative contribution of technological *spillover*s and pecuniary externalities from domestic mechanical industry is positive and significant in the most part of main Northwest and Northeast regions (notably Piemonte, Veneto, Emilia Romagna) and in the Central Adriatic Marche. On the contrary, again in Southern regions this variable is generally not significant.

The growth of the wage per labour unit, Δln(W/L), has generally a positive and significant effect on regions' industrial TFP, which may be interpreted as a positive substitution effect induced by increasing labour costs.

In the same way Italian Gdp growth, Δln(GdpIta), as a proxy of demand dynamics facing regional industries, also of course an expression of supra-regional (productivity) business cycle, has generally a positive and significant effect on industry TFP in the Northern and Central regions, less in more "isolated" autarchic Southern regions, which may be interpreted as a positive demand induced effect.

Concerning the effect of embodied technology, the intensity of total capital per unit of labour Δln(K/L) has sometimes significant, mostly positive effect on regional TFP dynamics throughout the country. [60]

The empirical exercises show that the innovative process in the whole industrial system was stimulated by a diffuse factor cost induction process, both across sectors and regions (the growth of unit wages forced firms to innovate in order to offset growing costs of inputs per unit of output) and by a (more selective) process of incorporating new generations of technology, through high investment in capital equipment and increasing capital intensity of the production processes.

Further, a novel national industrial system of innovation was active, based on processes of localised technological change, both in technical and regional space, in which the users-producers relationships played a central role. Here the development of the technical skill endowment of the industrial labour force, also through the investment in secondary industrial technical education, played a significant role where (essentially in main Northern and Centre Italian regions) it was employed in technological learning and communication processes. The demand pressures from the downstream sectors, combined with a system of inter-firm and inter-sector relationships, made it possible for firms in the upstream sectors to capitalise on tacit knowledge developed in the downstream sectors, combining it with internal learning processes. The strong economic incentives to match the specific demand of user sectors, fuelled product innovation by suppliers and process innovation by

[60] We do not have yet, unfortunately, long capital equipment time series for regional industries.

users. This helps to explain the significant industrial TFP dynamics for a long phase of the second half of the XXth century in Italy.

6.3 Conclusions and Implications

The emergence (during the golden age era) and the full functioning (until early 1990s) of a distinctive innovation system based upon both horizontal dynamics of technological cooperation within local manufacturing systems (in particular industrial districts) and vertical dynamic interdependence within industrial filieres was both a cause and an effect of the remarkable Italy's catching up process in the period: it was one of the decisive determinants of Italy's innovation capacity, while one of the more fertile effects of the intense process of structural transformation.

The evidence about the emergence of an original innovative system helps to solve the apparent Italian paradox of an economy characterized by a strong TFP growth and by the modest magnitude of the standard indicators of technological innovative activity intensity. This original innovation system also helps to explain three significant aspects of the Italian case: a) the strong successful resilience of productive specialization in the traditional sectors; b) the growth and consolidation of a relevant competitive international presence in related capital goods sectors; c) the successful strong territorial productive concentration (districts) characterized by high levels of productive and innovative complementarity and interdependence.

The successful model seems to have an epilogue. The virtuous innovation system which drove the Italian industry for a long time seems to have been progressively slowed down by at least three factors: i) the direction of technological change, based on digital technology, favors the intensive use of labour with high levels of human capital, while the supply of educated human capital in Italy is rather limited and this slowed down the process of creative adoption; ii) domestic and international demand for Italian consumer goods slowed down and was made more uncertain by new producer countries entering international markets; consequently investment in fixed capital fell and the strength of derived demand for capital goods incorporating localized technological innovations fell with it; the virtuous mechanism of innovative user-producer flows was slowed down; iii) the ability of Italian producers of capital and qualified intermediary goods to enter international markets risks not being sufficient to offset the fall in domestic demand, so as to become an autonomous driving force; at the same time the small size of these firms, on the one hand, means it is difficult to recreate at an international level, those mechanisms of virtuous interaction between users and producers; on the other hand, the small size of these firms makes it difficult for them to undertake more formal research. All these factors as well as the peculiar structure of productive specialization slowed down the process of extending the productive network towards knowledge based service sectors in Italy.

References

Abramovitz, M.(1956), *Resources and Output Trends in the United States since 1870*, in «The American Economic Review», 46, 1.

Abramovitz, M. (1986), *Catching Up, Forging Ahead, and Falling Behind*, in «The Journal of Economic History», 46, 2.

Abramovitz, M. (1993), *The Search for the Sources of Growth: Area of Ignorance, Old and New*, in «The Journal of Economic History», 53, 2.

Abramovitz, M. (1994), *The Origins of the Postwar Catch-Up and Convergence Boom*, in J. Fagerberg, B. Verspagen, N. von Tunzelmann (eds.), *The Dynamics of Technology, Trade and Growth*, Elgar, Aldershot.

Acemoglu, D. (1998), *Why Do New Technologies Complement Skills? Directed Technical Change and Inequality*, in «The Quarterly Journal of Economics», 113, 4.

Amatori, F. (1999), *La grande impresa*, in F. Amatori, D. Bigazzi, R. Giannetti, L. Segreto (eds.),*Storia d'Italia. Annali*, vol. XV, *L'industria*, Einaudi, Torino.

Anderson, P.W., Arrow, K.J. and Pines, D. (eds.) (1988), *The economy as an evolving complex system*, Addison-Wesley, Redwood City, CA.

Annunziato, P., Manfroni, P., Rosa, G. (1992), *La stima del capitale per settore e area geografica e alcuni indici di produttività*, Confindustria, Roma.

Antonelli, C. (1989), *Il finanziamento pubblico alle attività di ricerca delle imprese. Un tentativo di valutazione*, in C. Antonelli, L. Pennacchi (eds.), *Politiche dell'innovazione e sfida europea*, Franco Angeli, Milano.

Antonelli, C. (1995), *The Economics of Localized Technological Change and Industrial Dynamics*, Kluwer, Dordrecht.

Antonelli, C. (1999), *The Microdynamics of Technological Change*, Routledge, London.

Antonelli, C. (2001), *L'innovazione tecnologica nella grande impresa*, in V. Castronovo (ed.), *Storia dell'economia mondiale*, vol. V, *La modernizzazione e i problemi del sottosviluppo. Dal secondo dopoguerra agli anni Ottanta*, Laterza, Roma-Bari.

Antonelli, C. (2003), *The Economics of Innovation, New Technologies and Structural Change*, Routledge, London.

Antonelli, C. (2006), *Localized Technological Change*, in H. Hanusch, A. Pyka (eds.), *Elgar Companion to Neo-Schumpeterian Economics*, Elgar, Cheltenham (GB)-Northampton (Mass.).

Antonelli, C. (2007), *The Path Dependent Complexity of Localized Technological Change: Ingredients, Processes and Governance*, Routledge, London.

Antonelli, C. (2008), *Localized Technological Change. Towards the Economis of Complexity*, Routledge, London.

Antonelli, C., Barbiellini Amidei, F. (2007), *Innovazione tecnologica e mutamento strutturale nell'industria italiana nel secondo dopoguerra*, in Antonelli, C. et al..

Antonelli, C., Barbiellini Amidei, F., *Knowledge, Innovation and Regional Economic Growth: Localized Technological Change in Italy, 1950-1990*, Elgar, Cheltenham (GB)-Northampton (Mass.), *forthcoming*.

Antonelli, C., Garofalo, G. (1978), *La competitività italiana nel settore delle macchine utensili per la lavorazione dei metalli*, in P. Alessandrini (ed.), *Specializzazione e competitività internazionale dell'Italia*, il Mulino, Bologna.

Antonelli, C., Petit, P., Tahar, G. (1992) *The Economics of Industrial Modernization*, Academic Press, London.

Antonelli, C. et al. (2007), *Innovazione Tecnologica e Sviluppo Industriale nel Secondo Dopoguerra*, Collana Storica della Banca d'Italia, Laterza, Roma.

Ark, B. van, Crafts, N.F.R. (eds) (1996), *Quantitative Aspects of Post-War European Economic Growth*, Cambridge University Press, Cambridge.

Ark, B. van (1996), *Sectoral Growth Accounting and Structural Change in Post-War Europe*, in Ark, Crafts (eds.).

Barbiellini Amidei, F., Impenna, C. (1999), *Il mercato azionario e il finanziamento delle imprese negli anni Cinquanta*, in F. Cotula (ed.), *Stabilità e sviluppo negli anni Cinquanta. Politica bancaria e struttura del sistema finanziario*, «Collana storica della Banca d'Italia. Contributi», vol. VII.3, Laterza, Roma-Bari.

Barca, F. (ed) (1997), *Storia del capitalismo italiano dal dopoguerra a oggi*, Donzelli, Roma.

Barca, F., Magnani, M. (1989), *L'industria fra capitale e lavoro*, il Mulino, Bologna.

Barro, R.J., Sala-i-Martin, X. (1995), *Economic Growth*, McGraw-Hill, New York.

Bassanini, A., Scarpetta, S., Visco, I. (2000), *Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries*, «Economic Department Working Papers», 259, OECD, Paris.

Becattini G. (1989), *Modelli Locali di Sviluppo*, Il Mulino, Bologna.

Blanchard, O. (2004), *The Economic Future of Europe*, in «The Journal of Economic Perspectives», 18, 4.

Brandolini, A., Cipollone, P. (2001), *Multifactor Productivity and Labour Quality in Italy, 1981-2000*, «Temi di discussione del Servizio Studi», 422, Banca d'Italia, Rome.

Broadberry, S.N. (1993), *Manufacturing and the Convergence Hypothesis: What the Long-Run Data Show*, in «The Journal of Economic History», 53, 4.

Broadberry, S.N. (1996), *Convergence: What the Historical Record Shows*, in Ark, Crafts (eds.).

Brusco S. (1982), *The Emilian model: productive decentralization and social integration*, Cambridge Journal of Economics 6, 167–184.

Bursi, T. (1984), *Il settore meccano-ceramico nel comprensorio della ceramica. Struttura e processi di crescita*, Franco Angeli, Milano.

Bugamelli, M. (2001), *Il modello di specializzazione internazionale dell'area dell'euro e dei principali paesi europei. Omogeneità e convergenza*, «Temi di discussione del Servizio Studi», 402, Banca d'Italia, Roma.

Cacace, N. (1970), *Innovazione dei prodotti nell'industria italiana*, Franco Angeli, Milano.

Cantwell, J. (2002), *The US Patent Database, 1950-1995*, CD-ROM.

Cantwell, J., Iammarino, S. (2003), *Multinational Corporations and European Regional Systems of Innovation*, Routledge, London, 2003.

Carlesi, A., Lanzara, R., Sbrana, R. (1983), *L'apertura dell'industria ai mercati internazionali. Tendenze e problemi nei settori del mobile, della carta e delle macchine per il legno*, Franco Angeli, Milano.

Carlsson, B., Jacobsson, S. (1991), *What Makes the Automation Industry Strategic?*, in «Economics of Innovation and New Technology», 1, 4.

Christensen, L.R., Cummings, D., Jorgenson, D.W. (1980), *Economic Growth, 1947-1973: An International Comparison*, in J.W. Kendrick, B.N. Vaccara (eds.), *New Developments in Productivity Measurement and Analysis*, «NBER Conference Report», University of Chicago Press, Chicago.

Cingano, F., Schivardi, F. (2003), *Identifying the Sources of Local Productivity Growth*, «Temi di discussione del Servizio Studi», 474, Banca d'Italia, Rome.

Ciocca, P., Toniolo, G. (eds) (1999), *Storia economica d'Italia*, vol. I, *Interpretazioni*; vol. II, *Annali*, Laterza, Roma-Bari.

Crafts, N.F.R., Toniolo, G. (eds) (1996), *Economic Growth in Europe since 1945*, Cambridge University Press, Cambridge.

De Bresson, C., Xiaoping, H. (1999), *The Localization of Clusters of Innovative Activity in Italy, France and China*, in OECD (1999a).

Denison, E.F. (1967), *Why Growth Rates Differ*, Brookings Institution, Washington.

Domar, E. (1961), *On the Measurement of Technological Change*, in «The Economic Journal», 71, 284.

Dougherty, C. (1991), *A Comparison of Productivity and Economic Growth in the G7 Countries*, Doctoral Thesis, Harvard University.

Dougherty, C., Jorgenson, D.W.(1997), *There Is No Silver Bullet: Investment and Growth in the G7*, in «National Institute Economic Review», 162.

Dollar, D., Wolff, E.N. (1988), *Convergence of Industry Labor Productivity among Advanced Economies, 1963-1982*, in «The Review of Economics and Statistics», 70, 4.

Edquist, C. (ed.) (1997), *Systems of Innovation: Technologies, Institutions, and Organizations*, Pinter, London.

Fagerberg, J. (1987), *A Technology Gap Approach to why Growth Rates Differ*, in «Research Policy», 16, 2-4.

Fagerberg, J. (1994) *Technology and International Differences in Growth Rates*, in «Journal of Economic Literature», 32, 3.

Freeman, C. (1997), *The National System of Innovation in Historical Perspective*, in D. Archibugi, J. Michie (eds), *Technology Globalization and Economic Performance*, Cambridge University Press, Cambridge.

Fuà G. (1983), *Industrializzazione nel Nord Est e nel Centro*, in Fuà G. and Zacchia C. (eds), *Industrializzazione senza fratture*, Il Mulino, Bologna.

Giannetti, R., Pastorelli, S. (2007), *Il sistema nazionale di innovazione negli anni Cinquanta e Sessanta*, in Antonelli, C. et al.

Golinelli, R. (1998), *La ricostruzione dei dati di contabilità nazionale. Metodi e confronti*, mimeo, Università di Bologna.

Gomellini, M., Pianta, M. (2007), *Commercio con l'estero e tecnologia in Italia negli anni Cinquanta e Sessanta*, in Antonelli, C. et al..

Gordon, R.J., (2000), *Does the «New Economy» Measure Up to the Great Inventions of the Past?*, in «The Journal of Economic Perspectives», 14, 4.

Greene, W.H. (1997), *Econometric Analysis*, Prentice Hall, Upper Saddle River (N.J.).

ISCO (1977), *Analisi dell'interscambio commerciale con l'estero. 1952-1976*, ISCO, Roma.

ISTAT (1950-72) *Annuario statistico dell'istruzione italiana*, Istituto poligrafico dello Stato, Roma.

ISTAT (1950-87), *Statistica annuale del commercio con l'estero*, ISTAT, Roma.

ISTAT (1951-98), *Annuario statistico italiano*, ISTAT, Roma.

ISTAT (1973-98) *Annuario statistico dell'istruzione*, ISTAT, Roma.

ISTAT (1978-85), *Indagine statistica sulla ricerca scientifica*, in «Bollettino mensile di statistica. Supplemento».

ISTAT (1985), *Indagine statistica sulla ricerca scientifica*, in «Bollettino mensile di statistica. Supplemento».

ISTAT (1986), *Sommario di statistiche storiche 1926-1985*, ISTAT, Roma.

ISTAT (1987), *Indagine sulla diffusione della innovazione tecnologica nell'industria manifatturiera italiana*, «Collana 'Informazione», ISTAT, Roma.

ISTAT (1989), *Indagine statistica sull'innovazione tecnologica nell'industria italiana*, «Collana d'Informazione», ISTAT, Roma.

ISTAT (1989-95), *Indagine statistica sulla ricerca scientifica*, «Collana d'Informazione», ISTAT, Roma.

ISTAT (1995), *Indagine sull'innovazione tecnologica. Anni 1990-92*, ISTAT, Roma.

ISTAT (1998); *Statistiche sulla ricerca scientifica e l'innovazione tecnologica*, «Informazioni», ISTAT, Roma.

ISTAT (2001), *Statistiche sulla ricerca scientifica. Consuntivo 1997, previsioni 1998-1999*, «Informazioni», Roma.

ISTAT (2005), *I Distretti Industriali, 8° Censimento generale dell'industria e dei servizi 2001*, ISTAT, Roma.

Jorgenson, D.W., Stiroh, K.J. (2000), *Raising the Speed Limit: U.S. Economic Growth in the Information Age*, in «Brookings Papers on Economic Activity», 1.

Kaldor, N. (1966), *Causes of the Slow Rate of Economic Growth of the United Kingdom*, Cambridge University Press, Cambridge.

Lewis, A.W. (1955), *The Theory of Economic Growth*, Irwin, Homewood (Ill.).

Lupi, C., Mantegazza, S. (1994), *Ricostruzione delle serie degli investimenti per branca utilizzatrice, per branca proprietaria e calcolo dello stock di capitale*, «Quaderni di Ricerca», 14, ISTAT, Roma.

Maddison, A. (1995), *Monitoring the World Economy, 1820-1992*, Development Centre of the Organisation for Economic Co-operation and Development, Paris.

Maddison, A. (1996)*, Macroeconomic Accounts for European Countries*, in Ark, Crafts (eds.).

Mazzoleni, R. (1999), *Innovation in the Machine Tool Industry: A Historical Perspective on the Dynamics of Comparative Advantage*, in Mowery, D.C., Nelson, R.R. (eds.), *Sources of Industrial Leadership: Studies of Seven Industries*, Cambridge University Press, Cambridge.

Malerba, F. (ed.) (2004), *Sectoral Systems of Innovations*, Cambridge University Press, Cambridge.

Nardozzi, G. (1974), *Struttura industriale e accumulazione del capitale in Italia*, in «L'Industria», 5-6.

Nelson, R.R. (ed.),1993 *National Innovation Systems. A Comparative Analysis*, Oxford University Press, Oxford.

O'Brien, P.K., Prados de La Escosura, L. (1992), *Agricultural Productivity and European Industrialization, 1890-1980*, in «The Economic History Review», 45, 3.

OECD (1992), *Technology and the Economy: The Key Relationships*, OECD, Paris.

OECD (1997a), *An Empirical Comparison of National Innovation Systems*, OECD, Paris.

OECD (1997b), *International Trade by Commodities Statistics: Historical Series 1961-1990, SITC Revision 2*, CD-ROM, OECD, Paris.

OECD (1999a), *Boosting Innovation: The Cluster Approach*, OECD, Paris.

OECD (1999b), *Managing National Innovation Systems*, OECD, Paris.

OECD (2002), *Dynamising National Innovation Systems*, OECD, Paris.

Oliner, D.S., Sichel, D.E. (2000), *The Resurgence of Growth in the Late 1990s: Is Information Technology the Story?*, in «The Journal of Economic Perspectives», 14, 4.

Onida, F. (1978), *Industria italiana e commercio internazionale*, il Mulino, Bologna.

Paci R., Saba A. (1997), *The empirics of regional economic growth in Italy 1951-93*, Rivista Internazionale di Scienze Economiche e Commerciali.

Paci R., Usai S (1999), *Technological Enclaves and Industrial Districts: an analysis of the regional distribution of innovative activity in Europe*, Regional Studies, vol 34.2 pp. 97-114.

Paci R., Pusceddu N. (2000), *Stima dello stock di capitale nelle regioni italiane*, Rassegna Economica, Quaderni di Ricerca, 97-118.

Patrucco, P.P. (2003), *Institutional Variety, Networking and Knowledge Exchange: Communication and Innovation in the Case of the Brianza Technological District*, in «Regional Studies», 37, 2.

Patrucco, P.P. (2005), *The Emergence of Technology Systems: Knowledge Production and Distribution in the Case of the Emilian Plastics District*, in «Cambridge Journal of Economics», 29, 1.

Prometeia (2003), Banca Dati Regionale, mimeo, Bologna, aprile.

Quatraro, F. (2006), *Technological Change and Productivity Growth in Italian Regions, 1982-2001*, in «Région et Développement», 24.

Rosenberg, N. (1963), *Technical Change in the Machine Tool Industry: 1840-1910*, in «The Journal of Economic History», 23, 4.

Rosenberg, N. (1982), *Inside the Black Box*, Cambridge University Press, Cambridge.

Rosenberg, N., Mowery, D.C. (1998), *Paths of Innovation: Technological Change in 20th Century America*, Cambridge University Press, Cambridge.

Rossi, N., Toniolo, G. (1992), *Un secolo di sviluppo economico*, in P. Ciocca (ed.), *Il progresso economico in Italia*, il Mulino, Bologna.

Rossi, N., Sorgato, A., Toniolo, G. (1993), *I conti economici italiani: una ricostruzione statistica, 1890-1990*, in «Rivista di Storia economica», X, 1.

Rossi, N., Toniolo, G. (1996), *Italy*, in Crafts, Toniolo (eds.).

Rossi, S. (2003), *La nuova economia. I fatti dietro il mito*, il Mulino, Bologna.

Solow, R.M. (1956), *A Contribution to the Theory of Economic Growth*, in «The Quarterly Journal of Economics», 70, 1.

Solow, R.M. (1957), *Technical Change and the Aggregate Production Function*, in «The Review of Economics and Statistics», 39, 3.

Svimez (1996), *La politica per l'unificazione economica dell'ultimo cinquantennio e i problemi di oggi*, Collana SVIMEZ, il Mulino, Bologna, dicembre.

Sylos Labini, P. (1972), *Investimenti, produttività e politica finanziaria*, in Id., *Sindacati, inflazione e produttività*, Laterza, Roma-Bari.

Vasta, M. (1999), *Capitale umano e ricerca scientifica e tecnologica*, in *Storia d'Italia. Annali*, vol. XV, *L'industria*, eds., F. Amatori, D. Bigazzi, R. Giannetti, L. Segreto, Einaudi, Torino.

Verspagen, B. (1996), *Technology Indicators and Economic Growth in the European Area: Some Empirical Evidence*, in Ark, Crafts (eds.).

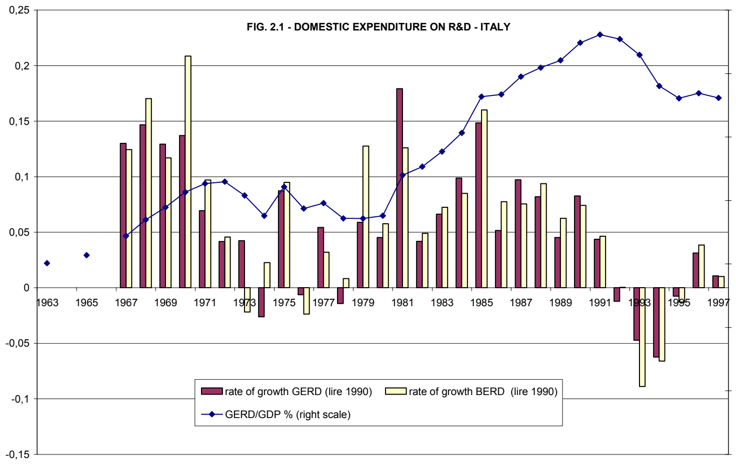
USPTO (2001), *Utility Patents in the TAF Database - PATSIC file*, CD-ROM.

Zamagni, V. (1990), *Dalla periferia al centro. La seconda rinascita economica dell'Italia, 1861-1990*, il Mulino, Bologna.

Zellner, A. (1962), *An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests for Aggregation Bias*, in «Journal of the American Statistical Association», 57, 298.

Wolff, E.N. (1996), *The Productivity Slowdown: The Culprit at Last? Follow-Up on Hulten and Wolff*, in «The American Economic Review», 86, 5.

Graphs and Tables



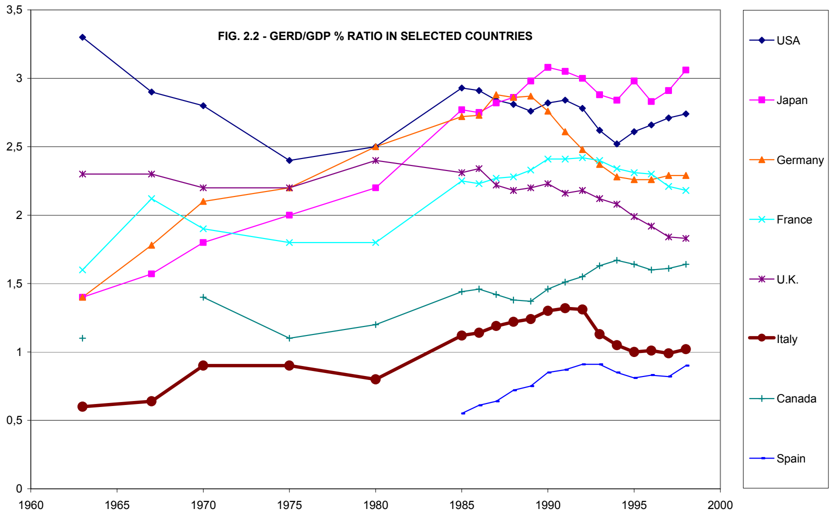


FIG. 2.2 - GERD/GDP % RATIO IN SELECTED COUNTRIES
USA
Japan
Germany
France
U.K.
Italy
Canada
Spain
0
0,5
1
1,5
2
2,5
3
3,5
1960
1965
1970
1975
1980
1985
1990
1995
2000

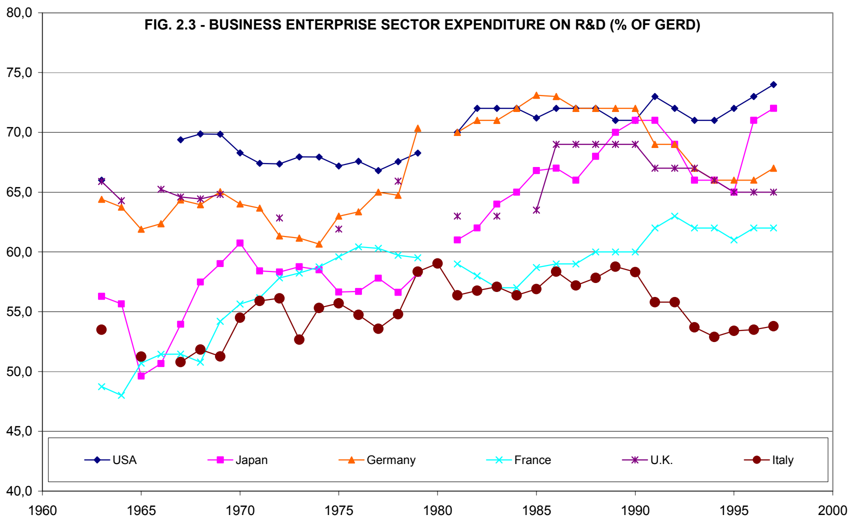


FIG. 2.3 - BUSINESS ENTERPRISE SECTOR EXPENDITURE ON R&D (% OF GERD)
USA
Japan
Germany
France
U.K.
Italy
40,0
45,0
50,0
55,0
60,0
65,0
70,0
75,0
80,0
1960
1965
1970
1975
1980
1985
1990
1995
2000

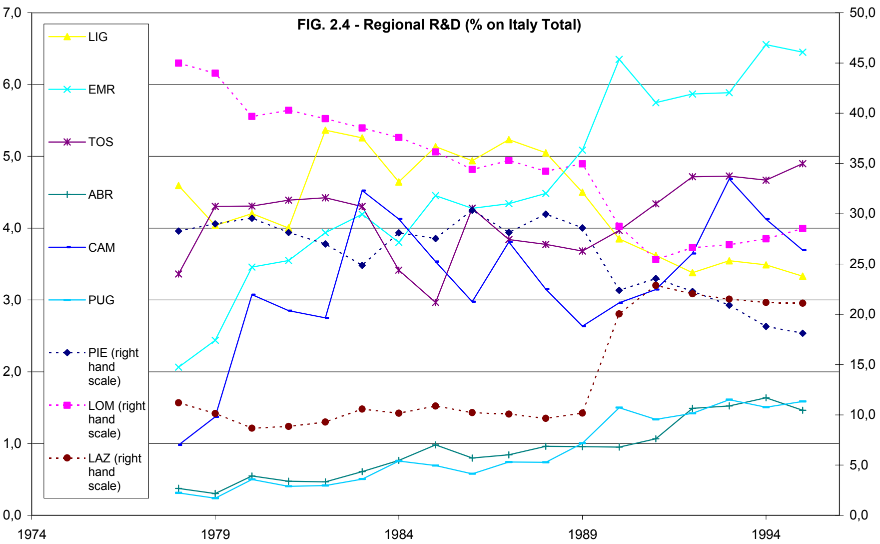


FIG. 2.4 - Regional R&D (% on Italy Total)
LIG
EMR
TOS
ABR
CAM
PUG
PIE (right hand scale)
LOM (right hand scale)
LAZ (right hand scale)
0,0
1,0
2,0
3,0
4,0
5,0
6,0
7,0
0,0
5,0
10,0
15,0
20,0
25,0
30,0
35,0
40,0
45,0
50,0
1974
1979
1984
1989
1994

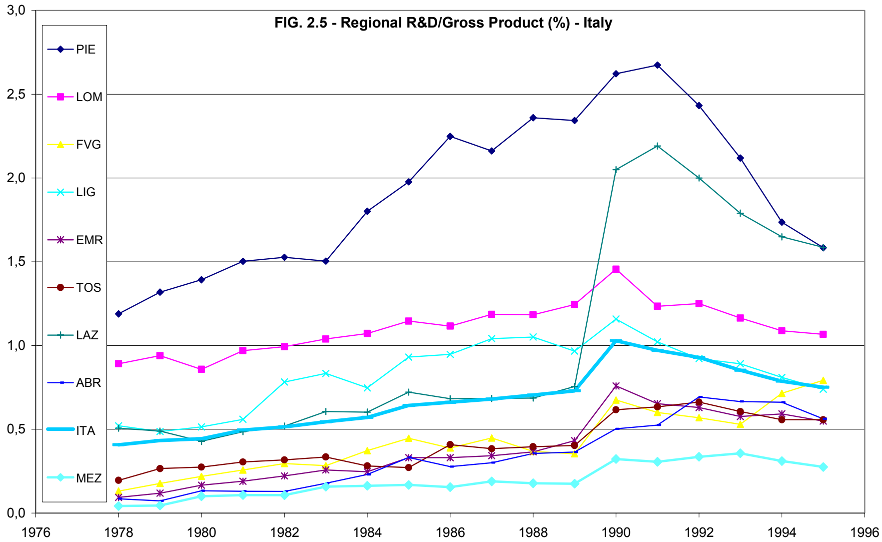


FIG. 2.5 - Regional R&D/Gross Product (%) - Italy
PIE
LOM
FVG
LIG
EMR
TOS
LAZ
ABR
ITA
MEZ

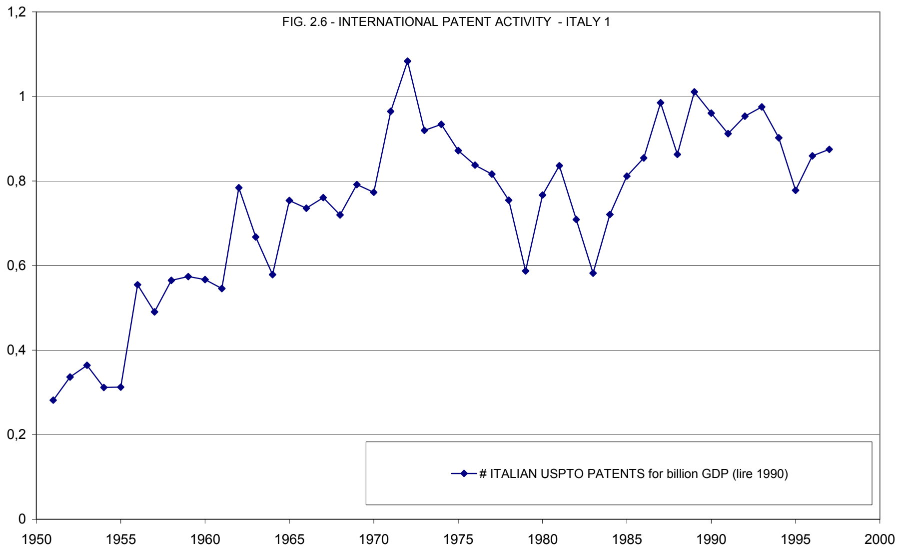


FIG. 2.6 - INTERNATIONAL PATENT ACTIVITY - ITALY 1
ITALIAN USPTO PATENTS for billion GDP (lire 1990)

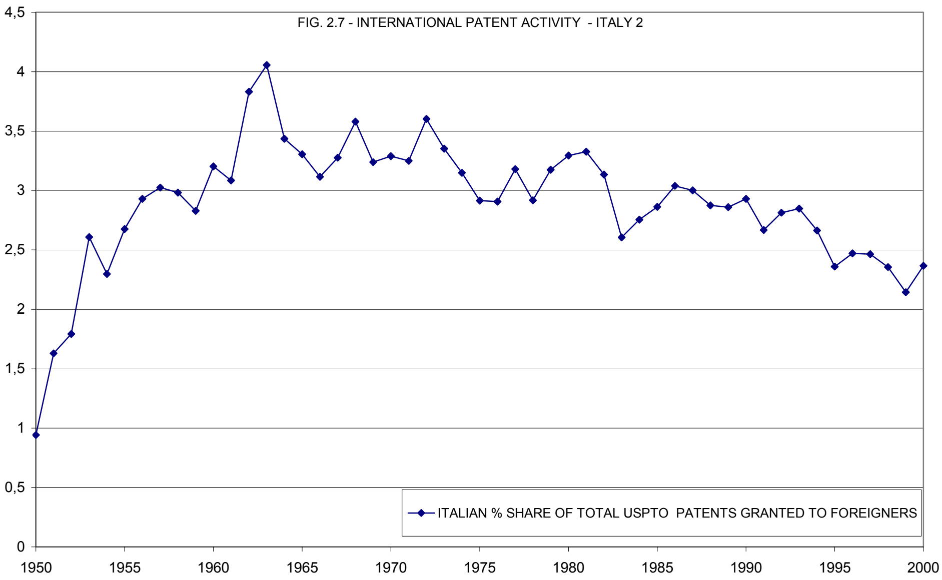


FIG. 2.7 - INTERNATIONAL PATENT ACTIVITY - ITALY 2
ITALIAN % SHARE OF TOTAL USPTO PATENTS GRANTED TO FOREIGNERS

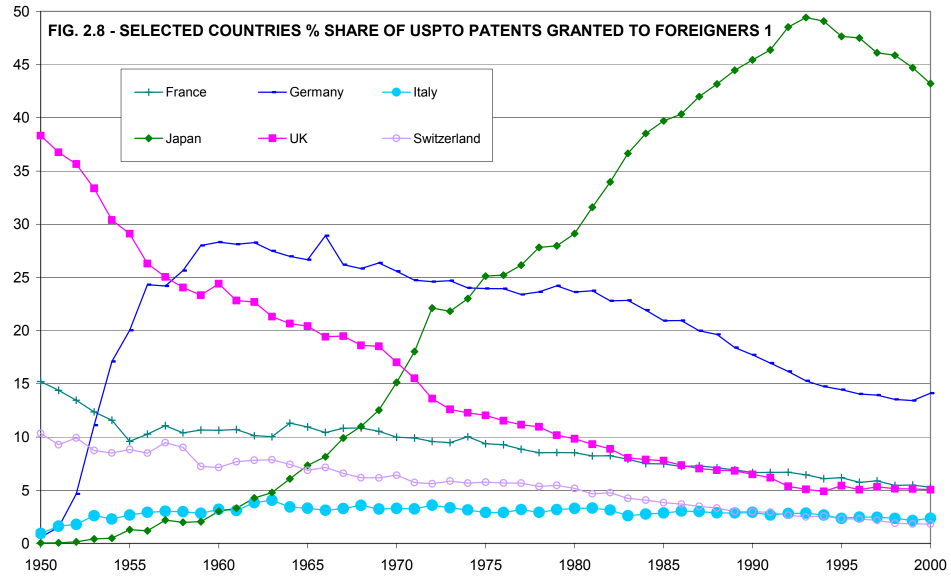


FIG. 2.8 - SELECTED COUNTRIES % SHARE OF USPTO PATENTS GRANTED TO FOREIGNERS 1
France
Germany
Italy
Japan
UK
Switzerland
50
45
40
35
30
25
20
15
10
5
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

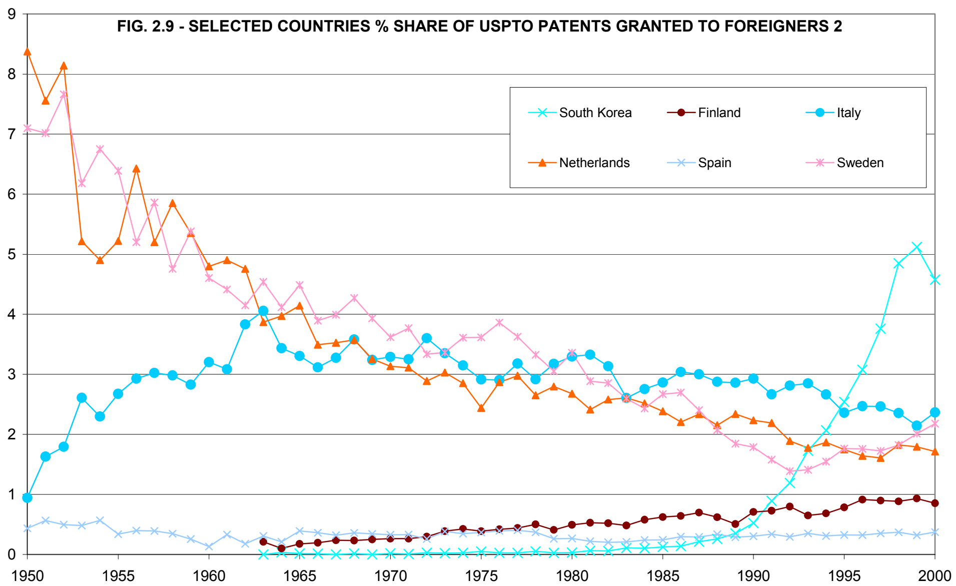


FIG. 2.9 - SELECTED COUNTRIES % SHARE OF USPTO PATENTS GRANTED TO FOREIGNERS 2
South Korea
Finland
Italy
Netherlands
Spain
Sweden
9
8
7
6
5
4
3
2
1
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

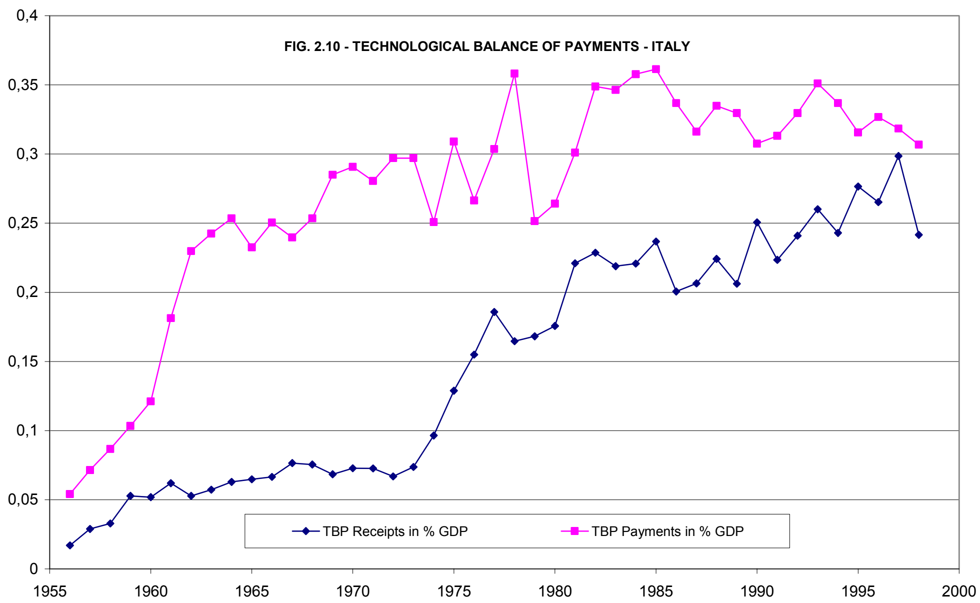


FIG. 2.10 - TECHNOLOGICAL BALANCE OF PAYMENTS - ITALY
TBP Receipts in % GDP
TBP Payments in % GDP
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

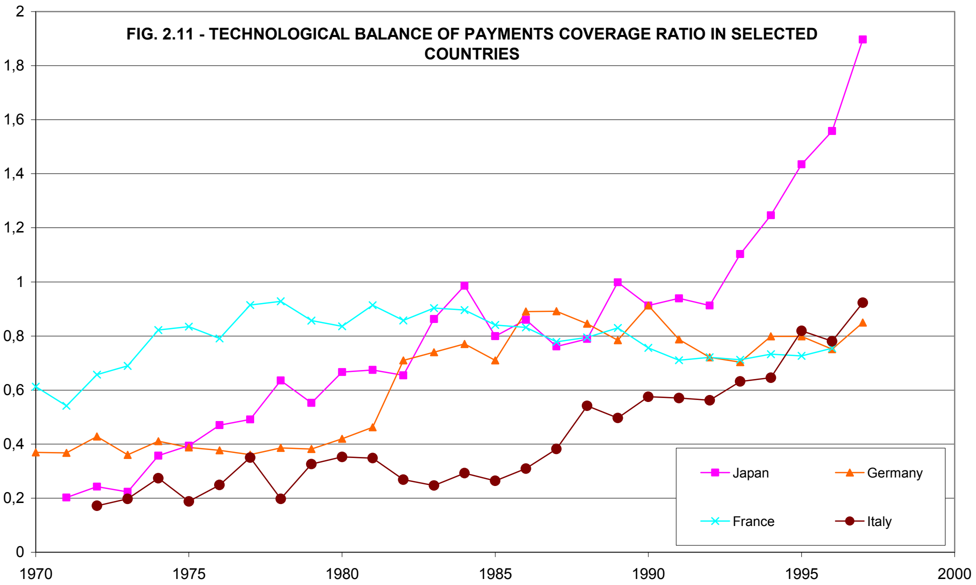


FIG. 2.11 - TECHNOLOGICAL BALANCE OF PAYMENTS COVERAGE RATIO IN SELECTED COUNTRIES

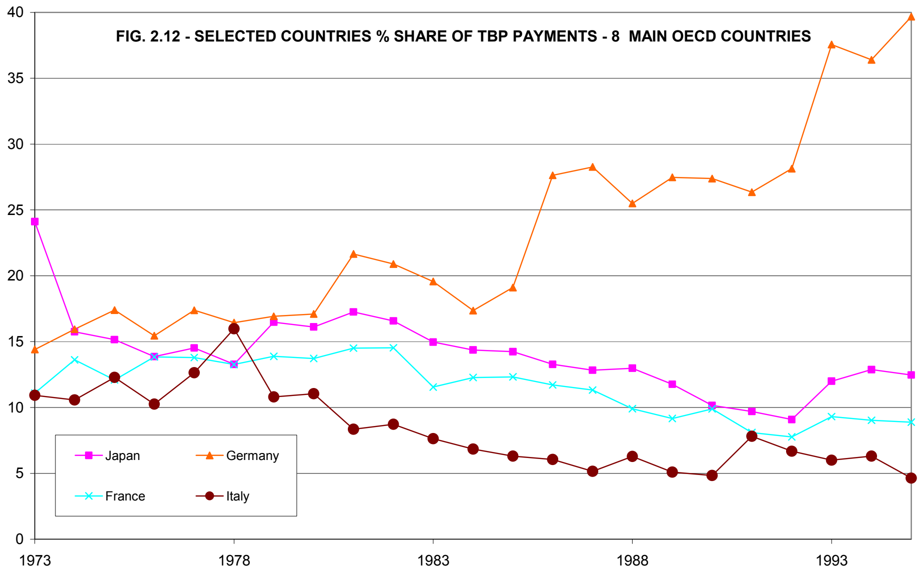


FIG. 2.12 - SELECTED COUNTRIES % SHARE OF TBP PAYMENTS - 8 MAIN OECD COUNTRIES

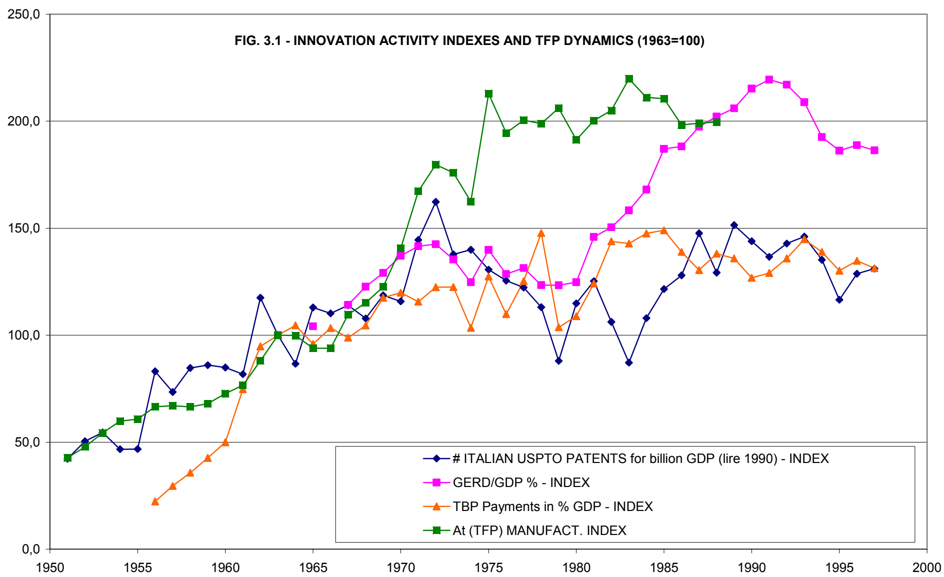


FIG. 3.1 - INNOVATION ACTIVITY INDEXES AND TFP DYNAMICS (1963=100)

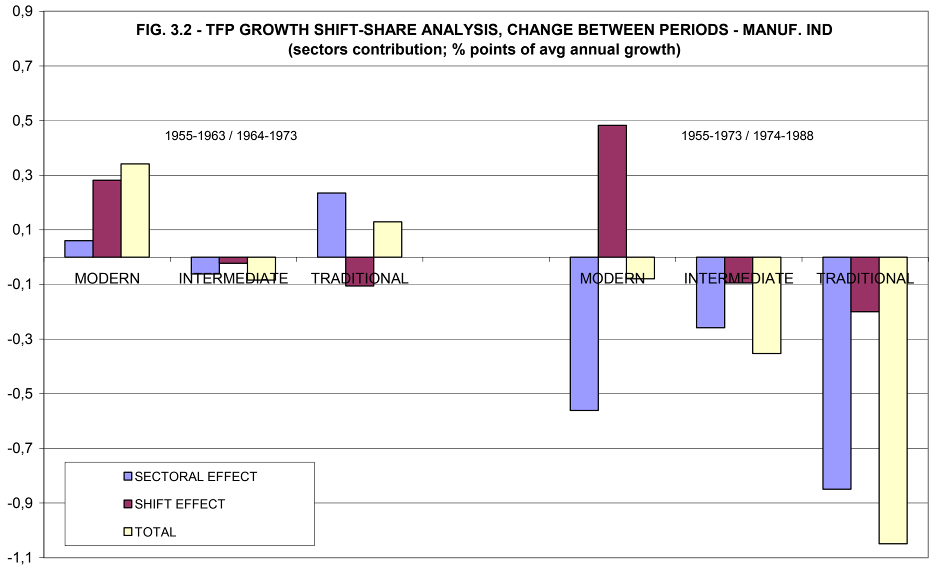


FIG. 3.2 - TFP GROWTH SHIFT-SHARE ANALYSIS, CHANGE BETWEEN PERIODS - MANUF. IND
(sectors contribution; % points of avg annual growth)
1955-1963 / 1964-1973
1955-1973 / 1974-1988
MODERN
INTERMEDIATE
TRADITIONAL
SECTORAL EFFECT
SHIFT EFFECT
TOTAL
0,9
0,7
0,5
0,3
0,1
-0,1
-0,3
-0,5
-0,7
-0,9
-1,1

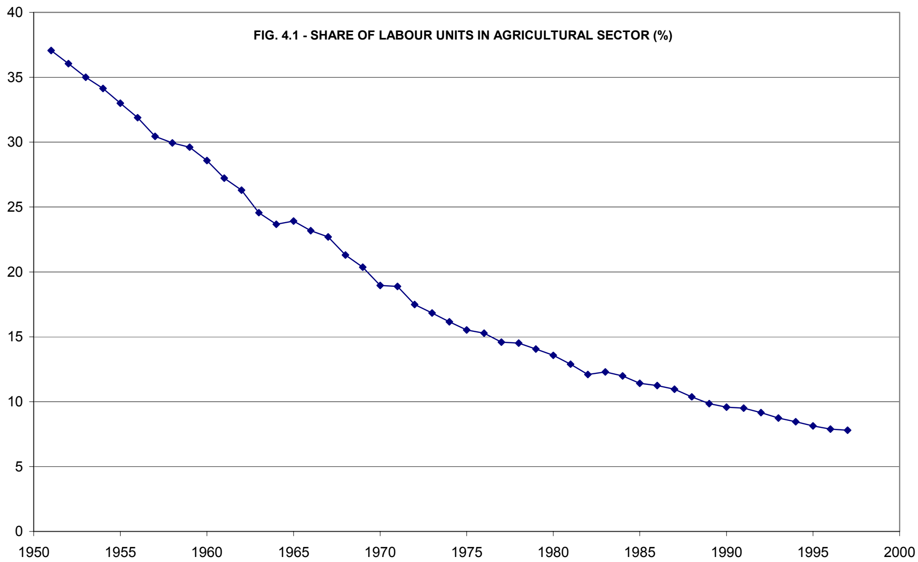


FIG. 4.1 - SHARE OF LABOUR UNITS IN AGRICULTURAL SECTOR (%)
40
35
30
25
20
15
10
5
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

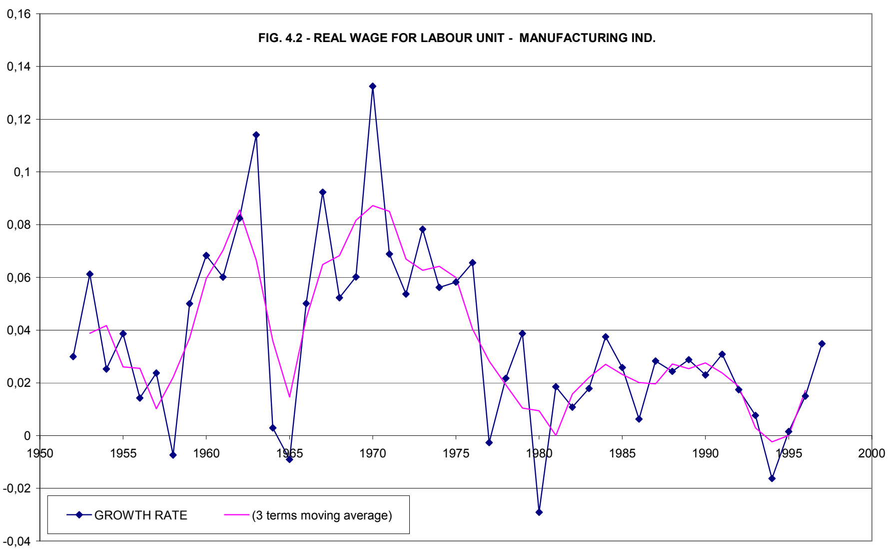


FIG. 4.2 - REAL WAGE FOR LABOUR UNIT - MANUFACTURING IND.
GROWTH RATE
(3 terms moving average)
0,16
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
-0,02
-0,04
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

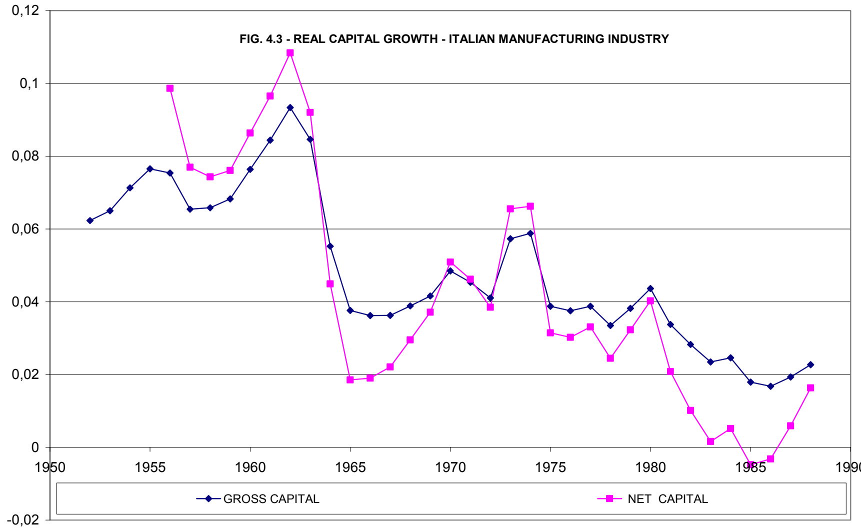


FIG. 4.3 - REAL CAPITAL GROWTH - ITALIAN MANUFACTURING INDUSTRY
GROSS CAPITAL
NET CAPITAL
0,12
0,1
0,08
0,06
0,04
0,02
0
-0,02
1950
1955
1960
1965
1970
1975
1980
1985
1990

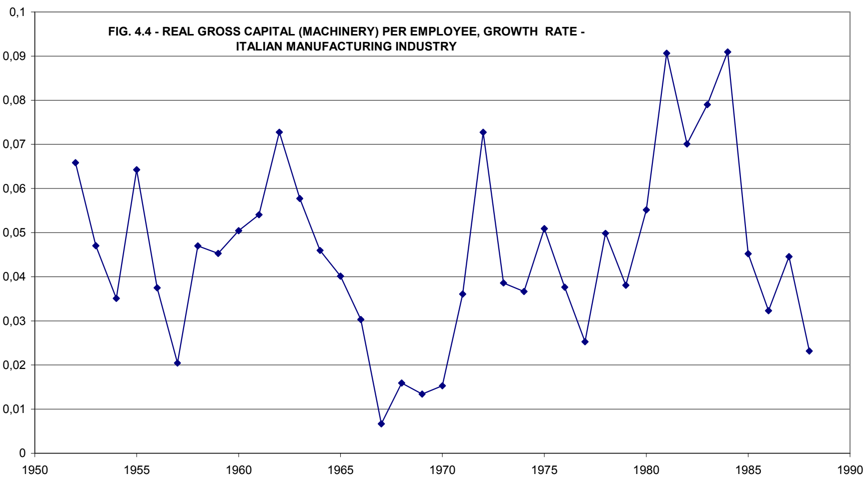


FIG. 4.4 - REAL GROSS CAPITAL (MACHINERY) PER EMPLOYEE, GROWTH RATE - ITALIAN MANUFACTURING INDUSTRY
0,1
0,09
0,08
0,07
0,06
0,05
0,04
0,03
0,02
0,01
0
1950
1955
1960
1965
1970
1975
1980
1985
1990

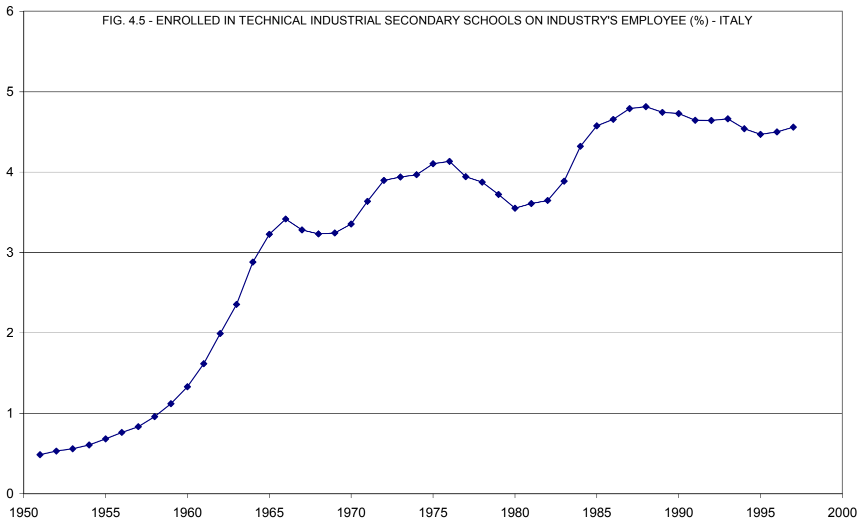


FIG. 4.5 - ENROLLED IN TECHNICAL INDUSTRIAL SECONDARY SCHOOLS ON INDUSTRY'S EMPLOYEE (%) - ITALY
6
5
4
3
2
1
0
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

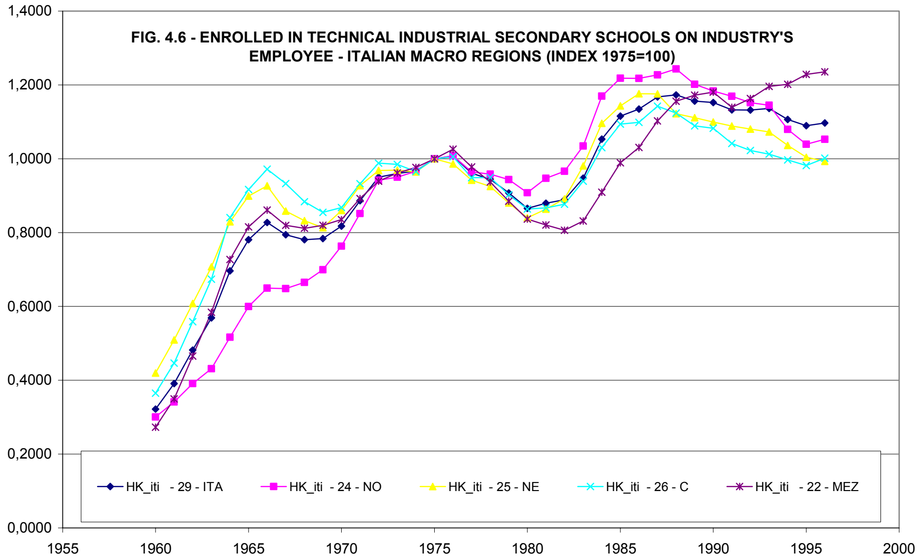


FIG. 4.6 - ENROLLED IN TECHNICAL INDUSTRIAL SECONDARY SCHOOLS ON INDUSTRY'S EMPLOYEE - ITALIAN MACRO REGIONS (INDEX 1975=100)
HK_iti - 29 - ITA
HK_iti - 24 - NO
HK_iti - 25 - NE
HK_iti - 26 - C
HK_iti - 22 - MEZ
1,4000
1,2000
1,0000
0,8000
0,6000
0,4000
0,2000
0,0000
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000

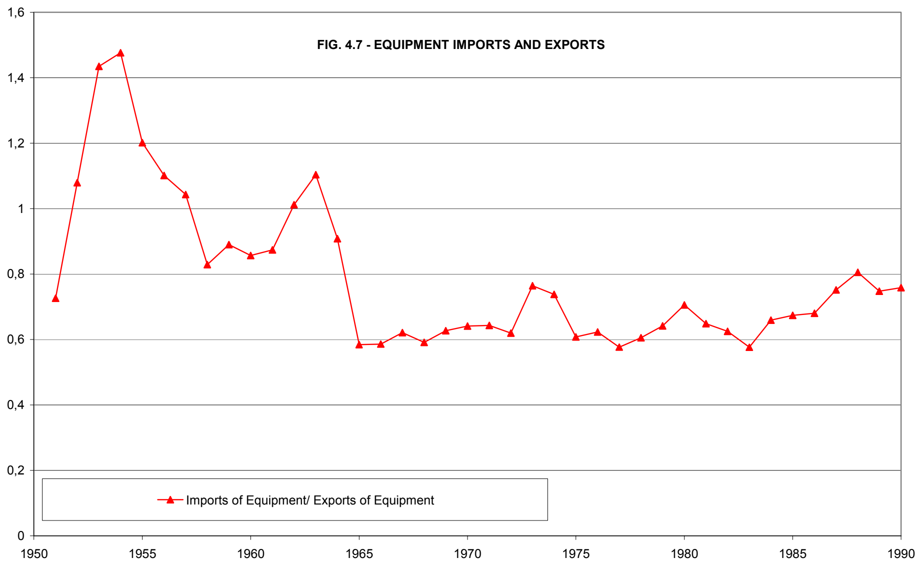


FIG. 4.7 - EQUIPMENT IMPORTS AND EXPORTS
Imports of Equipment/ Exports of Equipment
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1950
1955
1960
1965
1970
1975
1980
1985
1990

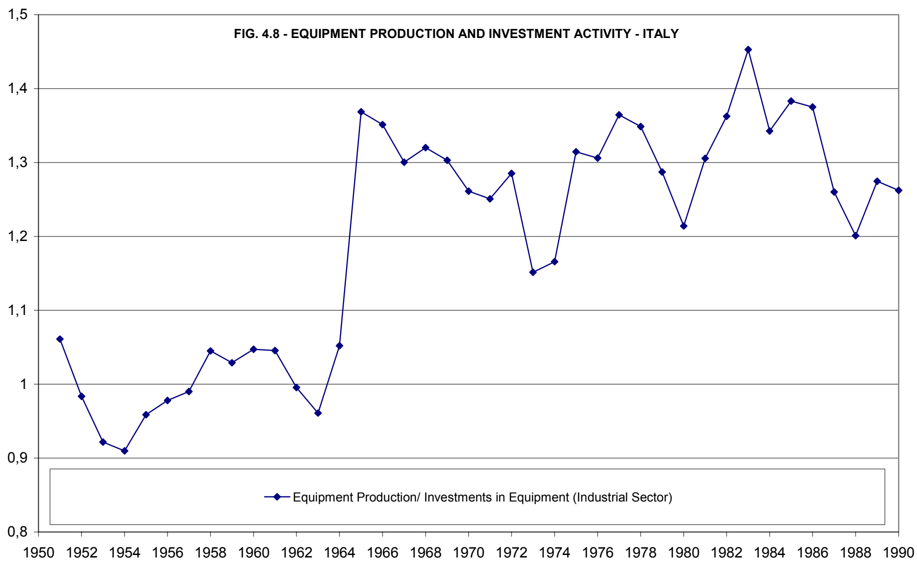


FIG. 4.8 - EQUIPMENT PRODUCTION AND INVESTMENT ACTIVITY - ITALY
Equipment Production/ Investments in Equipment (Industrial Sector)
1,5
1,4
1,3
1,2
1,1
1
0,9
0,8
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990

TAB 2.1 - Patents granted by the European patent Office to Italian residents	1980	1985	1990
PIEMONTE	**14,5**	**17,9**	**15,3**
VALLE D'AOSTA	0,0	0,0	0,1
LIGURIA	**3,4**	**2,2**	**2,2**
LOMBARDIA	**41,4**	**37,1**	**37,2**
TRENTINO-ALTO ADIGE	0,3	0,7	1,1
VENETO	**7,1**	**10,1**	**10,1**
FRIULI-VENEZIA GIULIA	**4,0**	**3,5**	**4,4**
EMILIA-ROMAGNA	**13,7**	**10,8**	**11,6**
TOSCANA	**4,0**	**5,7**	**6,1**
UMBRIA	1,8	0,8	0,7
MARCHE	**0,8**	**0,7**	**2,0**
LAZIO	**4,5**	**7,2**	**6,2**
CAMPANIA	1,3	0,7	0,6
ABRUZZI	0,8	0,5	0,7
MOLISE	0,3	0,0	0,0
PUGLIA	0,5	0,7	0,3
BASILICATA	0,0	0,1	0,0
CALABRIA	0,3	0,1	0,1
SICILIA	0,8	0,9	1,0
SARDEGNA	0,5	0,2	0,4
TOTAL	100,0	100,0	100,0
Source: our calculations on CRENOS DATA BANK ON EUROPEAN PATENTS.			

TAB. 2.2 - INDEX OF REVEALED TECHNOLOGICAL ADVANTAGE - ITALY (USPTO PATENTS)					
USPTO PRODUCT FIELD	**1950-1963**	**1964-1973**	**1974-1988**	**1989-2000**	**1950-2000**
FOOD AND KINDRED PRODUCTS	1,13	0,65	0,88	1,09	0,96
TEXTILE MILL PRODUCTS	1,69	1,03	0,72	1,03	0,96
CHEMICALS AND ALLIED PRODUCTS	1,03	1,43	1,33	1,57	1,43
PETROLEUM AND NATURAL GAS EXTRACTION AND REFINING	0,33	0,79	0,34	0,89	0,60
RUBBER AND MISCELLANEOUS PLASTICS PRODUCTS	2,56	1,35	1,07	1,19	1,20
STONE, CLAY, GLASS AND CONCRETE PRODUCTS	0,87	0,79	0,78	0,79	0,80
PRIMARY METALS	0,69	0,76	0,77	0,62	0,72
FABRICATED METAL PRODUCTS	1,22	0,80	0,91	1,10	1,00
MACHINERY, EXCEPT ELECTRICAL	1,10	1,07	1,22	1,28	1,22
ELECTRICAL AND ELECTRONIC MACHINERY, EQUIPMENT AND SUPPLIES	0,60	0,77	0,74	0,63	0,67
TRANSPORTATION EQUIPMENT	1,32	0,82	0,81	0,76	0,83
PROFESSIONAL AND SCIENTIFIC INSTRUMENTS	0,90	0,63	0,62	0,61	0,63
ALL OTHER SIC'S	1,23	1,11	1,19	1,29	1,22
Source: our calculations on USPTO (2001), Cantwell (2003).					

TAB. 3.1 - LABOUR PRODUCTIVITY LEVELS (GDP PER EMPLOYEE, USA =100)							
	ITALY	FRANCE	GERMANY	JAPAN	UK	NETHERLANDS	USA
1950	**30,1**	37,1	33,9	15,6	53,8	49,5	100,0
1973	**54,4**	65,1	62,1	50,3	59,2	71,6	100,0
1987	**69,6**	81,8	75,0	70,9	67,6	73,6	100,0
% change							
1950-1973	**80,8**	75,5	83,4	222,6	10,1	44,8	
1973-1987	**27,8**	25,6	20,7	41,1	14,2	2,9	
1950-1987	**131,2**	120,4	121,4	355,0	25,7	48,9	
Source: our calculations on data by Broadberry (1996).							

TAB. 3.2 - ECONOMIC GROWTH & TFP (average annual growth rates)

	ITALY*	FRANCE	GERMANY	JAPAN*	UK°	USA
1951-1973						
Real Product	5,2	5,6	6,3	9,8	3,7	3,7
Total Factor Productivity	3,4	3,1	3,5	4,1	1,9	1,2
TFP contribution to real product growth	64,3	56,1	55,1	41,4	51,4	31,5
1960-1990						
Real Product	4,1	3,5	3,2	6,8	2,5	3,1
Total Factor Productivity	2,0	1,5	1,6	2,0	1,3	0,4
TFP contribution to real product growth	47,9	41,4	49,4	28,8	51,9	13,2

Source: our calculations on data by Christensen, Cummings e Jorgenson (1980); Dougherty (1991).
* first figure of 1952 ° first figure of 1955.

TAB. 3.3 - LABOUR PRODUCTIVITY LEVELS (GDP PER EMPLOYEE, USA =100) - MANUFACTURING INDUSTRY

	ITALY	FRANCE	GERMANY	JAPAN	UK	NETHERLANDS	USA
1950	**26**	32	37	8	38	33	100
1973	**45**	53	55	44	47	62	100
1987	**63**	65	59	81	56	72	100
% change							
1950-1973	**72,7**	66,0	51,6	481,0	22,3	84,9	
1973-1987	**40,4**	22,5	7,2	82,8	21,5	16,9	
1950-1987	**142,5**	103,4	62,5	962,4	48,6	116,1	

Source: our calculations on data by Broadberry (1996).

TAB. 3.4 - TOTAL FACTOR PRODUCTIVITY IN ITALY (average annual growth rates) - MAIN SECTORS

	AGRIC.	ENERG.	**MANUFACT. IND.**	CONSTR.	INDUSTRY	SERVICES SAL. * §	PRIV. SECT. * §	PRIV. SECT. WITHOUT AGRIC. * §
1955-1973	2,5	4,1	**4,7**	0,8	3,4			
1955-1963	2,6	4,9	**4,4**	0,9	3,5			
1964-1973	2,5	3,5	**4,9**	0,7	3,3	4,2	4,0	3,7
1974-1988	2,7	-3,1	**3,3**	-0,3	1,8	0,2	1,5	1,2
1955-1988	2,6	0,8	**4,1**	0,3	2,7	2,1	2,7	2,3

* data available since 1961. § Without real estate renting and other services.
Source: our calculations on data by Antonelli e Barbiellini Amidei (2005).

TAB. 3.5 - TFP GROWTH IN ITALY (average annual growth rates) - MANUFACTURING INDUSTRY

	MODERN SECTORS °	**TRADITIONAL SECTORS °°**	**INTERMEDIATE SECTORS °°°**	**MANUFACT. INDUSTRY**	FERR. & NON MIN.	NON MET. MIN.	CHEM. PHARM.	MECH.	TRANSP. EQUIP.	FOOD BEV. TOB.	TEXT. APP. FOOT.	WOOD FURN.	PAPER	RUBBER
1955-1973	**5,0**	**5,0**	**3,5**	**4,7**	1,5	4,9	7,1	4,6	5,9	3,3	6,3	4,7	4,7	4,3
1955-1963	**4,7**	**4,8**	**3,8**	**4,4**	3,5	3,3	10,4	3,9	8,4	2,0	6,9	3,5	4,3	-0,6
1964-1973	**5,2**	**5,2**	**3,2**	**4,9**	-0,1	6,1	4,4	5,2	3,8	4,4	5,9	5,7	5,0	8,1
1974-1988	**4,2**	**2,9**	**2,4**	**3,3**	1,9	1,9	10,8	3,8	1,4	2,6	2,8	4,1	4,0	3,7
1955-1988	**4,6**	**4,1**	**3,0**	**4,1**	1,7	3,5	8,8	4,2	3,8	3,0	4,7	4,4	4,4	4,0

° chemical, mechanical, transp. equipment, rubber °° food, textile, wood °°° ferrous min., non metal. min., paper.
Source: our calculations on data by Antonelli e Barbiellini Amidei (2005).

TAB. 3.6 - SECTORAL CONTRIBUTION (%) TO TFP GROWTH (average annual growth rates) - MANUFACTURING INDUSTRY

	TFP GROWTH - MANIF.	**MODERN SECTORS** ° (%)	v.a. share (avg.)	**TRADITIONAL SECTORS °°** (%)	v.a. share (avg.)	**INTERMEDIATE SECTORS °°°** (%)	v.a. share (avg.)
1955-1973	4,7	40,9	38,1	41,5	37,8	17,6	24,1
1974-1988	3,3	57,4	47,2	28,7	33,8	13,9	19,0
1955-1988	4,1	46,9	42,2	36,6	36,0	16,4	21,8

° chemical, mechanical, transp. equipment, rubber °° food, textile, wood °°° ferrous min., non metal. min., paper.

Source: our calculations on data by Antonelli e Barbiellini Amidei (2005).

TAB. 3.7 - TFP GROWTH CHANGE SHIFT-SHARE ANALYSIS (% sectors contribution; average annual growth rates) - MANUFACTURING INDUSTRY

	TFP GROWTH - MANIF.		**ALL MANUFACT. SECTORS**	**MODERN SECTORS °** (%)	% points of avg annual growth	v.a. share (avg.)	**TRADITIONAL SECTORS °° (%)**	% points of avg annual growth	v.a. share (avg.)	**INTERMEDIATE SECTORS °°° (%)**	% points of avg annual growth	v.a. share (avg.)
1955-1963	4,4	SECTORAL EFFECT	60,2	15,5	0,1	36,2	60,6	0,2	39,4	-16,0	-0,1	24,4
1964-1973	4,9	SHIFT EFFECT	39,8	72,7	0,3	39,6	-27,2	-0,1	36,6	-5,7	0,0	23,8
Δ	0,4	*TOTAL*	*100,0*	*88,2*	*0,3*		*33,4*	*0,1*		*-21,6*	*-0,1*	
1955-1973	4,7	SECTORAL EFFECT	112,7	37,9	-0,6	38,1	57,4	-0,8	37,8	17,4	-0,3	24,1
1974-1988	3,3	SHIFT EFFECT	-12,7	-32,6	0,5	47,2	13,5	-0,2	33,8	6,4	-0,1	19,0
Δ	-1,4	*TOTAL*	*100,0*	*5,3*	*-0,1*		*70,8*	*-1,0*		*23,8*	*-0,4*	

° chemical, mechanical, transp. equipment, rubber °° food, textile, wood °°° ferrous min., non metal. min., paper.

Source: our calculations on data by Antonelli e Barbiellini Amidei (2005).

TAB. 3.8 - TOTAL FACTOR PRODUCTIVITY IN ITALIAN MACROREGIONS (Y/Y* levels) - INDUSTRY

	NORTHWEST	NORTHEAST	CENTER	SOUTH	SOUTHEAST	SOUTHWEST	ITALY
1963 -1969	6,2	5,6	5,6	2,3	2,0	2,5	5,0
1970-1979	8,3	*8,1*	8,0	4,8	3,6	5,4	7,4
1980-1989	8,3	*7,6*	7,7	4,8	4,4	5,0	7,3
1990-1994	10,8	*9,4*	9,6	6,1	5,7	6,4	9,2
1963-1994	8,2	7,6	7,7	4,5	3,8	4,8	7,1
1963-1988	7,7	7,3	7,3	4,1	3,5	4,5	6,7

Source: our calculations on data by Antonelli e Barbiellini Amidei (2007); Crenos (2000); Svimez (2000).

TAB. 3.9 - TOTAL FACTOR PRODUCTIVITY IN ITALIAN MACROREGIONS (average annual growth rates) - INDUSTRY

	NORTHWEST	NORTHEAST	CENTER	SOUTH	SOUTHEAST	SOUTHWEST	ITALY
1963 -1969	2,5	3,8	3,1	5,2	6,3	4,9	3,5
1970-1979	1,4	2,7	1,4	0,9	1,4	0,7	1,6
1980-1989	2,2	*0,9*	*1,1*	1,5	1,6	1,5	1,6
1990-1994	0,8	1,7	0,8	0,0	0,4	-0,2	0,8
1963-1994	1,7	2,3	1,5	1,8	2,3	1,7	1,9

Source: our calculations on data by Antonelli e Barbiellini Amidei (2007); Crenos (2000); Svimez (2000).

TAB. 3.10 - MACROREGIONAL CONTRIBUTION (%) TO ITALIAN TFP LEVELS (Y/Y*) - INDUSTRY

	TFP LEVEL - IND.	**NORTHWEST (%)**	v.a. share (avg.)	**NORTHEAST (%)**	v.a. share (avg.)	**CENTER (%)**	v.a. share (avg.)	**SOUTH (%)**	v.a. share (avg.)
1963 -1969	5,0	53,0	44,8	20,4	19,1	18,0	16,9	8,6	19,2
1970-1979	7,4	45,9	41,4	23,1	21,5	18,6	17,4	12,5	19,7
1980 -1989	7,3	44,6	39,7	24,5	23,6	18,6	17,8	12,3	18,9
1990-1994	9,2	45,6	39,5	24,2	24,4	18,2	17,7	12,0	18,3
1963-1994	7,1	46,8	41,3	23,1	22,1	18,4	17,5	11,7	19,1

Source: our calculations on data by Antonelli e Barbiellini Amidei (2007); Crenos (2000); Svimez (2000).

Tab. 4.2 - Italian manufacturing industries TFP dynamics, 1955-1988.

Dependent variable: TFP, annual rate of growth; constant values. Equation (1). Seemingly Unrelated Regression Equations, SURE.

Seemingly unrelated regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
TFPmfe	33	5	.0880709	0.1578	8.04	0.1542
TFPmnm	33	5	.0582129	0.2052	10.41	0.0644
TFPchi	33	5	.0594073	0.2423	16.70	0.0051
TFPmec	33	5	.0440767	0.4117	45.18	0.0000
TFPmtr	33	5	.0729912	0.2391	28.50	0.0000
TFPali	33	5	.0446434	0.1600	11.18	0.0479
TFPtes	33	5	.0261728	0.5340	55.58	0.0000
TFPleg	33	5	.0480087	0.2517	11.80	0.0376
TFPcar	33	5	.0759818	0.2250	18.38	0.0025
TFPgom	33	5	.0570116	0.4699	27.74	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
TFPmfe | FERR. & NON MIN.						
tcKmac/L	-.5074883	.3248683	-1.56	0.118	-1.144218	.1292418
tcW/L	-.4007757	.3329604	-1.20	0.229	-1.053366	.2518147
W/L	-.0011566	.001679	-0.69	0.491	-.0044474	.0021342
TFPchi	-.0432156	.2333369	-0.19	0.853	-.5005475	.4141163
TFPmec	**.4999751***	.3112829	1.61	0.100	-.1101281	1.110078
_cons	.0697459	.0556448	1.25	0.210	-.0393159	.1788077
TFPmnm | NON MET. MIN.						
tcKmac/L	-.2212502	.1955632	-1.13	0.258	-.604547	.1620465
tcW/L	-.2427115	.2853151	-0.85	0.395	-.8019188	.3164958
W/L	-.0017691	.0012288	-1.44	0.150	-.0041774	.0006393
TFPchi	.1249794	.1544833	0.81	0.419	-.1778022	.4277611
TFPmec	**.4906266****	.1957281	2.51	0.012	.1070066	.8742466
_cons	.0669132	.037306	1.79	0.073	-.0062052	.1400316
TFPchi | CHEM. PHARM.						
tcKmac/L	1.123461**	.3631387	3.09	0.002	.4117223	1.8352
tcW/L	-.0405987	.2654573	-0.15	0.878	-.5608855	.4796881
W/L	.0041125**	.0011969	3.44	0.001	.0017667	.0064583
tcVAmtr	**.2272278***	.1338736	1.70	0.090	-.0351596	.4896152
tcVAtes	.3726568	.311282	1.20	0.231	-.2374447	.9827582
_cons	-.1231147	.0554077	-2.22	0.026	-.2317117	-.0145177
TFPmec | MECH.						
tcKmac/L	-.457987	.3074955	-1.49	0.136	-1.060667	.144693
tcW/L	.057621	.1964972	0.29	0.769	-.3275064	.4427483
W/L	.0038608**	.0010455	3.69	0.000	.0018116	.00591
tcVAmtr	**.2674444****	.0886949	3.02	0.003	.0936055	.4412832
tcVAtes	**.6523931****	.2037169	3.20	0.001	.2531154	1.051671
_cons	-.0846734	.0322491	-2.63	0.009	-.1478804	-.0214664
TFPmtr | TRANSP. EQUIP.						
tcKmac/L	.4427494*	.2409904	1.84	0.066	-.029583	.9150818
tcW/L	.421055*	.2343398	1.80	0.072	-.0382425	.8803524
W/L	-.0021132*	.0012488	-1.69	0.091	-.0045609	.0003344
TFPchi	.064262	.1843826	0.35	0.727	-.2971213	.4256454
TFPmec	**.8760041****	.2173619	4.03	0.000	.4499826	1.302026
_cons	.0056735	.0368306	0.15	0.878	-.0665132	.0778602
TFPali | FOOD BEV. TOB.						
tcKmac/L	-.7870202**	.3286094	-2.40	0.017	-1.431083	-.1429576
tcW/L	.5152357**	.1979349	2.60	0.009	.1272904	.9031809
W/L	.0014993	.0009513	1.58	0.115	-.0003652	.0033638
TFPchi	.0942999	.1250248	0.75	0.451	-.1507442	.339344
TFPmec	-.0285528	.1346655	-0.21	0.832	-.2924923	.2353868
cons	.0056993	.0268594	0.21	0.832	-.0469441	.0583427
TFPtes | TEXT. APP. FOOT.						
tcKmac/L	.1145053	.1547922	0.74	0.459	-.1888819	.4178925
tcW/L	.0985268	.0888805	1.11	0.268	-.0756757	.2727294
W/L	-.0029591**	.0006923	-4.27	0.000	-.0043161	-.0016021
TFPchi	**.1780527****	.0701171	2.54	0.011	.0406257	.3154797
TFPmec	**.3421085****	.0765625	4.47	0.000	.1920488	.4921682
_cons	.059504	.0130826	4.55	0.000	.0338627	.0851454
TFPleg | WOOD FURN.						
tcKmac/L	-.7348158**	.3174364	-2.31	0.021	-1.35698	-.1126518
tcW/L	.1429529	.2146654	0.67	0.505	-.2777835	.5636893
W/L	-.000691	.0011762	-0.59	0.557	-.0029963	.0016143
TFPchi	**.3712456****	.1385057	2.68	0.007	.0997794	.6427118
TFPmec	.2045246	.1529566	1.34	0.181	-.0952648	.504314
_cons	.0511948	.0284422	1.80	0.072	-.0045509	.1069405
TFPcar | PAPER						
tcKmac/L	-.1858884	.3568117	-0.52	0.602	-.8852264	.5134497
tcW/L	.2225228	.2788376	0.80	0.425	-.3239889	.7690345
W/L	.0000621**	.0014065	0.04	0.965	-.0026946	.0028187
TFPchi	**.47016****	.1964648	2.39	0.017	.0850961	.8552239
TFPmec	**.6704068****	.2297124	2.92	0.004	.2201787	1.120635
cons	-.0300039	.0423341	-0.71	0.478	-.1129772	.0529695
TFPgom | RUBBER						
tcKmac/L	-.1116269	.2806602	-0.40	0.691	-.6617108	.438457
tcW/L	.0689105	.2553305	0.27	0.787	-.431528	.5693491
W/L	.0009726	.0011028	0.88	0.378	-.0011888	.003134
TFPchi	-.1248049	.1549382	-0.81	0.421	-.4284782	.1788683
TFPmec	**.8613311****	.178418	4.83	0.000	.5116382	1.211024
_cons	-.0103341	.0314924	-0.33	0.743	-.0720581	.0513899

Correlation matrix of residuals:

TFP	mfe	mnm	chi	mec	mtr	ali	tes	leg	car	gom
mfe	1.0000									
mnm	-0.0414	1.0000								
chi	-0.0066	-0.0382	1.0000							
mec	-0.1029	-0.0174	0.1471	1.0000						
mtr	0.4884	-0.0897	-0.0918	-0.3495	1.0000					
ali	0.3498	0.2580	-0.0919	-0.0620	0.1737	1.0000				
tes	0.1290	0.2706	-0.1777	-0.2920	0.1217	0.3085	1.0000			
leg	-0.1230	0.1314	-0.0514	0.0634	-0.3160	0.0970	0.2719	1.0000		
car	0.3098	0.4883	-0.1497	-0.1855	0.4828	0.2920	0.1111	-0.0448	1.0000	
gom	0.1107	0.1288	-0.0572	0.0350	0.2363	0.1822	0.0251	-0.0290	0.3581	1.0000

Breusch-Pagan test of independence: chi2(45) = 71.255, Pr = 0.0076

Skewness/Kurtosis tests for Normality

Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2) (joint)	Prob>chi2 (joint)
res0	0.269	0.867	1.33	0.5135

Levels of significance: **95%; *90%.

Calculations on data by Antonelli e Barbiellini Amidei (2007).

Tab. 4.3 - Italian Regions' industry TFP dynamics, 1961-1994.

Dependent variable: TFP, annual rate of growth; constant values. Equation (1). Seemingly Unrelated Regression Equations, SURE.

Seemingly unrelated regression

Equation	Obs	Parms	RMSE	"R-sq"	chi2	P
piey1a	34	5	.0253804	0.7243	102.95	0.0000
vday1a	34	5	.067263	0.3712	31.73	0.0000
lomy1a	34	5	.017865	0.6552	89.51	0.0000
taay1a	34	5	.0403077	0.3336	48.36	0.0000
veny1a	34	5	.0229932	0.5618	81.10	0.0000
fvgy1a	34	5	.0317245	0.4126	33.67	0.0000
ligy1a	34	5	.0416907	0.3322	33.56	0.0000
emry1a	34	5	.0207014	0.7484	113.71	0.0000
tosy1a	34	5	.0185195	0.6293	102.87	0.0000
umby1a	34	5	.0354915	0.1283	17.81	0.0032
mary1a	34	5	.0366457	0.4665	42.34	0.0000
lazy1a	34	5	.0308942	0.3275	79.65	0.0000
abry1a	34	5	.0495071	0.3741	48.89	0.0000
moly1a	34	5	.0726649	0.3146	24.22	0.0002
camy1a	34	5	.0411156	0.2055	13.47	0.0194
pugy1a	34	5	.0453583	0.2371	13.43	0.0197
basy1a	34	5	.0862946	0.2310	15.27	0.0093
caly1a	34	5	.0614994	0.3494	20.07	0.0012
sicy1a	34	5	.0376492	0.4699	57.40	0.0000
sary1a	34	5	.0452247	0.2757	31.49	0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
pieTFP						
pie g K/L	.0795039	.1256678	0.63	0.527	-.1668005	.3258084
pie g W/L	**.4378093**	**.1233403**	**3.55**	**0.000**	**.1960667**	**.6795519**
itamech TFP	**.3490868**	**.1292908**	**2.70**	**0.007**	**.0956814**	**.6024922**
ita g Gdp	**.9773811**	**.382792**	**2.55**	**0.011**	**.2271227**	**1.72764**
pie THK/L	**1.341277**	**.4371688**	**3.07**	**0.002**	**.4844415**	**2.198112**
_cons	-.0888557	.025682	-3.46	0.001	-.1391915	-.0385199
vda TFP						
vda g K/L	-.0627269	.1662029	-0.38	0.706	-.3884787	.2630248
vda g W/L	**.9723384**	**.2055419**	**4.73**	**0.000**	**.5694836**	**1.375193**
itamech TFP	**.8480828**	**.3127829**	**2.71**	**0.007**	**.2350395**	**1.461126**
ita g Gdp	-.6706935	.7019155	-0.96	0.339	-2.046422	.7050356
vda THK/L	1.927494	1.233731	1.56	0.118	-.4905733	4.345562
_cons	-.0474981	.0251788	-1.89	0.059	-.0968476	.0018514
lom TFP						
lom g K/L	**-.1917587**	**.0649076**	**-2.95**	**0.003**	**-.3189752**	**-.0645422**
lom g W/L	.1186956	.0919739	1.29	0.197	-.06157	.2989612
itamech TFP	.1172109	.0808704	1.45	0.147	-.0412922	.2757141
ita g Gdp	**.8499452**	**.2052198**	**4.14**	**0.000**	**.4477219**	**1.252169**
lom THK/L	**1.609206**	**.3888093**	**4.14**	**0.000**	**.8471542**	**2.371259**
_cons	-.0509098	.015791	-3.22	0.001	-.0818596	-.01996
taa TFP						
taa g K/L	**.3065515**	**.0699694**	**4.38**	**0.000**	**.169414**	**.4436891**
taa g W/L	**.5177988**	**.1667617**	**3.11**	**0.002**	**.1909518**	**.8446457**
itamech TFP	.2215798	.1744831	1.27	0.204	-.1204007	.5635603
ita g Gdp	.3680395	.4305657	0.85	0.393	-.4758539	1.211933
taa THK/L	1.007084	.7999208	1.26	0.208	-.5607323	2.5749
_cons	-.0718311	.0272769	-2.63	0.008	-.1252928	-.0183694
ven TFP						
ven g K/L	**.1816022**	**.0628748**	**2.89**	**0.004**	**.05837**	**.3048345**
ven g W/L	**.3656768**	**.0951198**	**3.84**	**0.000**	**.1792455**	**.5521081**
itamech TFP	**.1823844**	**.1019377**	**1.79**	**0.074**	**-.0174098**	**.3821786**
ita g Gdp	**.7994283**	**.2478457**	**3.23**	**0.001**	**.3136596**	**1.285197**
ven THK/L	**1.729059**	**.518201**	**3.34**	**0.001**	**.7134042**	**2.744715**
_cons	-.0778146	.0189555	-4.11	0.000	-.1149666	-.0406625
fvg TFP						
fvg g K/L	**-.2417374**	**.1118446**	**-2.16**	**0.031**	**-.4609489**	**-.022526**
fvg g W/L	**.3444433**	**.1521456**	**2.26**	**0.024**	**.0462434**	**.6426433**
itamech TFP	.1401364	.1409952	0.99	0.320	-.1362092	.4164819
ita g Gdp	**.8093993**	**.3493899**	**2.32**	**0.021**	**.1246078**	**1.494191**
fvg THK/L	.4937439	.619793	0.80	0.426	-.721028	1.708516
_cons	-.0204346	.0310409	-0.66	0.510	-.0812738	.0404045

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
lig TFP						
lig g K/L	**.4329777**	**.1418386**	**3.05**	**0.002**	**.1549791**	**.7109762**
lig g W/L	-.1009248	.1508239	-0.67	0.503	-.3965342	.1946846
itamech TFP	-.0222176	.1928421	-0.12	0.908	-.4001811	.355746
ita g Gdp	**1.423595**	**.493493**	**2.88**	**0.004**	**.4563663**	**2.390824**
lig THK/L	**3.143535**	**.6069622**	**5.18**	**0.000**	**1.953911**	**4.333159**
_cons	-.1864306	.0374093	-4.98	0.000	-.2597515	-.1131098
emr TFP						
emr g K/L	-.1058665	.0682448	-1.55	0.121	-.2396239	.0278909
emr g W/L	.0699263	.0936576	0.75	0.455	-.1136393	.2534919
itamech TFP	**.2946781**	**.0926785**	**3.18**	**0.001**	**.1130315**	**.4763247**
ita g Gdp	**.9802203**	**.2194989**	**4.47**	**0.000**	**.5500104**	**1.41043**
emr THK/L	**1.183542**	**.3564366**	**3.32**	**0.001**	**.4849392**	**1.882145**
_cons	-.0536721	.0155085	-3.46	0.001	-.0840682	-.0232761
tos TFP						
tos g K/L	-.1360761	.0831553	-1.64	0.102	-.2990575	.0269053
tos g W/L	**.6577001**	**.1014193**	**6.48**	**0.000**	**.458922**	**.8564782**
itamech TFP	.1080332	.0827752	1.31	0.192	-.0542032	.2702696
ita g Gdp	**.5552551**	**.1950262**	**2.85**	**0.004**	**.1730107**	**.9374994**
tos THK/L	**1.74973**	**.4647117**	**3.77**	**0.000**	**.8389114**	**2.660548**
_cons	-.0695658	.0168159	-4.14	0.000	-.1025243	-.0366073
umb TFP						
umb g K/L	-.1375281	.0958322	-1.44	0.151	-.3253557	.0502995
umb g W/L	**.3591672**	**.1267241**	**2.83**	**0.005**	**.1107926**	**.6075419**
itamech TFP	.2088225	.1575398	1.33	0.185	-.0999499	.5175948
ita g Gdp	.1230248	.3337575	0.37	0.712	-.5311279	.7771776
umb THK/L	**.7820779**	**.4387791**	**1.78**	**0.075**	**-.0779133**	**1.642069**
_cons	-.039108	.0211166	-1.85	0.064	-.0804957	.0022797
mar TFP						
mar g K/L	-.0980633	.1163557	-0.84	0.399	-.3261163	.1299897
mar g W/L	**.5244631**	**.1511147**	**3.47**	**0.001**	**.2282837**	**.8206425**
itamech TFP	**.3297331**	**.1550285**	**2.13**	**0.033**	**.0258828**	**.6335835**
ita g Gdp	.3569558	.3425307	1.04	0.297	-.3143921	1.028304
mar THK/L	**.9575087**	**.552713**	**1.73**	**0.083**	**-.1257889**	**2.040806**
_cons	-.05026	.0220576	-2.28	0.023	-.0934921	-.007028
laz TFP						
laz g K/L	**.3254337**	**.0729789**	**4.46**	**0.000**	**.1823978**	**.4684696**
laz g W/L	-.0341197	.103896	-0.33	0.743	-.2377522	.1695127
itamech TFP	-.1400608	.1379689	-1.02	0.310	-.4104748	.1303533
ita g Gdp	**1.340132**	**.331288**	**4.05**	**0.000**	**.6908192**	**1.989444**
laz THK/L	**1.541922**	**.1954231**	**7.89**	**0.000**	**1.1589**	**1.924944**
_cons	-.1530165	.0199001	-7.69	0.000	-.19202	-.114013
abr TFP						
abr g K/L	**.3218193**	**.1044364**	**3.08**	**0.002**	**.1171278**	**.5265109**
abr g W/L	.244174	.1582413	1.54	0.123	-.0659733	.5543214
itamech TFP	-.2702954	.2144368	-1.26	0.207	-.6905838	.1499931
ita g Gdp	**1.471101**	**.4774604**	**3.08**	**0.002**	**.5352957**	**2.406906**
abr THK/L	**1.756637**	**.4075988**	**4.31**	**0.000**	**.9577578**	**2.555516**
_cons	-.1461024	.0263308	-5.55	0.000	-.1977098	-.094495
mol TFP						
mol g K/L	.1330318	.1635484	0.81	0.416	-.1875172	.4535807
mol g W/L	**.8830961**	**.2857525**	**3.09**	**0.002**	**.3230316**	**1.443161**
itamech TFP	**1.105727**	**.3263983**	**3.39**	**0.001**	**.4659983**	**1.745456**
ita g Gdp	**-2.007714**	**.7364242**	**-2.73**	**0.006**	**-3.451079**	**-.5643488**
mol THK/L	**-2.101184**	**.8253678**	**-2.55**	**0.011**	**-3.718875**	**-.4834923**
_cons	.0717572	.044527	1.61	0.107	-.0155142	.1590285
cam TFP						
cam g K/L	-.0945888	.1815322	-0.52	0.602	-.4503853	.2612078
cam g W/L	**.3271347**	**.1814454**	**1.80**	**0.071**	**-.0284917**	**.6827611**
itamech TFP	-.0696219	.1927953	-0.36	0.718	-.4474938	.3082501
ita g Gdp	**.8711822**	**.4787544**	**1.82**	**0.069**	**-.0671591**	**1.809524**
cam THK/L	.2598755	.3704576	0.70	0.483	-.4662081	.9859591
_cons	-.0402858	.0338203	-1.19	0.234	-.1065725	.0260008

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
pug TFP						
pug g K/L	-.1638276	.1568548	-1.04	0.296	-.4712573	.1436022
pug g W/L	**.29678**	**.1713375**	**1.73**	**0.083**	**-.0390352**	**.6325953**
itamech TFP	.0836711	.2137188	0.39	0.695	-.33521	.5025522
ita g Gdp	.5157015	.4914767	1.05	0.294	-.4475752	1.478978
pug THK/L	-.4000158	.5092448	-0.79	0.432	-1.398117	.5980858
_cons	.0185917	.0341242	0.54	0.586	-.0482905	.085474
bas TFP						
bas g K/L	**-.4114052**	**.1528873**	**-2.69**	**0.007**	**-.7110588**	**-.1117516**
bas g W/L	.5565611	.3522751	1.58	0.114	-.1338855	1.247008
itamech TFP	**.8784936**	**.4064665**	**2.16**	**0.031**	**.0818338**	**1.675153**
ita g Gdp	-1.124368	.9522648	-1.18	0.238	-2.990773	.7420366
bas THK/L	-1.364726	.935569	-1.46	0.145	-3.198407	.4689558
_cons	.0689189	.0518155	1.33	0.183	-.0326377	.1704754
cal TFP						
cal g K/L	.0041955	.0846966	0.05	0.960	-.1618067	.1701978
cal g W/L	.2503473	.181765	1.38	0.168	-.1059056	.6066002
itamech TFP	.3630149	.2792828	1.30	0.194	-.1843694	.9103992
ita g Gdp	.9114082	.6595415	1.38	0.167	-.3812695	2.204086
cal THK/L	-.1655477	.4979158	-0.33	0.740	-1.141445	.8103493
_cons	-.0188416	.0390289	-0.48	0.629	-.0953367	.0576536
sic TFP						
sic g K/L	**.8425506**	**.1733487**	**4.86**	**0.000**	**.5027934**	**1.182308**
sic g W/L	**.2461392**	**.1381666**	**1.78**	**0.075**	**-.0246624**	**.5169407**
itamech TFP	-.2922304	.1833712	-1.59	0.111	-.6516314	.0671705
ita g Gdp	**1.340217**	**.4819003**	**2.78**	**0.005**	**.39571**	**2.284724**
sic THK/L	.1567904	.4541422	0.35	0.730	-.7333119	1.046893
_cons	-.0623247	.0303287	-2.05	0.040	-.121768	-.0028815
sar TFP						
sar g K/L	.0225559	.1127743	0.20	0.841	-.1984778	.2435895
sar g W/L	**.6070658**	**.1462588**	**4.15**	**0.000**	**.3204039**	**.8937278**
itamech TFP	.0687021	.2134062	0.32	0.748	-.3495664	.4869707
ita g Gdp	-.0315865	.5336714	-0.06	0.953	-1.077563	1.01439
sar THK/L	-.3534926	.3510002	-1.01	0.314	-1.04144	.3344551
_cons	.0143534	.0256797	0.56	0.576	-.035978	.0646848

Correlation matrix of residuals:

	piey1a	vday1a	lomy1a	taay1a	veny1a	fvgy1a	ligy1a	emry1a	tosy1a	umby1a	mary1a	lazy1a	abry1a	moly1a	camy1a	pugy1a	basy1a	caly1a	sicy1a	sary1a
piey1a	1.0000																			
vday1a	0.2250	1.0000																		
lomy1a	0.2168	-0.3058	1.0000																	
taay1a	0.2441	-0.0832	0.1949	1.0000																
veny1a	0.3898	-0.1148	0.3111	0.6050	1.0000															
fvgy1a	0.3804	-0.0927	0.1994	0.5618	0.4192	1.0000														
ligy1a	0.2696	0.0917	0.3282	0.3629	0.4069	0.3099	1.0000													
emry1a	0.0689	-0.2087	0.4556	0.5725	0.5306	0.4296	0.3331	1.0000												
tosy1a	0.3101	-0.1961	0.2745	0.2340	0.4789	0.3412	0.2137	0.2175	1.0000											
umby1a	0.2169	0.3357	-0.1584	-0.0870	-0.2720	0.0236	-0.0641	-0.4403	0.0254	1.0000										
mary1a	0.1566	0.2971	-0.2229	-0.1569	0.1687	0.0322	0.0244	-0.0850	0.2766	0.1408	1.0000									
lazy1a	0.0785	-0.1903	0.5283	0.2548	0.5565	0.2474	0.6037	0.6154	0.1495	-0.6171	-0.0555	1.0000								
abry1a	0.0269	0.1164	-0.0276	0.2245	0.2916	-0.1523	0.2117	-0.1483	0.0825	0.0236	-0.0577	0.1836	1.0000							
moly1a	0.2394	0.0814	-0.0790	-0.0860	0.0674	0.1372	0.1439	-0.0687	-0.0023	0.2886	0.2485	-0.0910	0.0588	1.0000						
camy1a	0.1172	0.1798	0.2244	0.3264	0.1433	0.0995	0.0524	0.0141	0.1382	0.1167	-0.2009	-0.0803	0.0915	-0.2810	1.0000					
pugy1a	0.3100	-0.0181	0.1312	0.1086	0.3340	0.2059	0.0957	-0.1484	0.0810	0.1990	0.0810	0.0481	0.4451	0.3271	0.0510	1.0000				
basy1a	-0.0094	0.0933	-0.1618	0.2380	0.2620	-0.2088	0.2462	-0.0281	0.1626	-0.0567	0.1529	0.0881	0.5443	0.1164	-0.1062	0.1767	1.0000			
caly1a	0.1714	0.2096	0.1362	-0.1134	0.2251	-0.1672	-0.0211	-0.0410	0.0154	0.1883	0.4681	-0.0412	0.0913	0.2274	0.1732	0.2972	0.1784	1.0000		
sicy1a	-0.0856	-0.0124	-0.0287	0.1020	0.1958	0.0734	0.0587	-0.0264	-0.1472	-0.2065	-0.1263	0.1390	0.3846	0.1726	0.0514	0.2791	0.0531	0.2190	1.0000	
sary1a	0.0420	0.1329	-0.1734	0.2425	0.2699	-0.1319	-0.0398	-0.1707	-0.0882	0.0246	0.2213	0.0078	0.5211	-0.0346	0.2843	0.0926	0.2574	0.4091	0.2213	1.0000

Breusch-Pagan test of independence: chi2(190) = 378.386, Pr = 0.0000

Skewness/Kurtosis tests for Normality

			------- joint ------	
Variable	Pr(Skewness)	Pr(Kurtosis)	adj chi2(2)	Prob>chi2
res0	0.551	0.460	0.95	0.6223

Levels of significance: **95%; *90%.

Calculations on data by Antonelli e Barbiellini Amidei (2007) , Crenos (2000), Svimez (2000), Istat (1949-1998).