INTERNATIONAL TECHNOLOGICAL SPILLOVERS AND ECONOMIC GROWTH. THE ITALIAN CASE*

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Abstract:

This study moves along the recent research path started by Coe and Helpman (1995) which aims at unravelling the mechanics of spillovers in the economic growth of nations. Unlike many previous studies, which are mainly cross-sectional, our analysis focuses on the experience of Italy. The time-series analysis 1963-1995 shows that the Italian economic growth has been critically influenced by external technology funnelled by imports of investment goods. Moreover, empirical evidence suggests that Italian growth has been and still is more related to external rather than internal spillovers; moreover, the extent of external spillovers has shown some relevant changes throughout the years: aggregate (but not industrial) spillovers have slowed down since the eighties.

JEL: E23, F15, O33, O52.

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Introduction

The study of long run economic growth of nations is a classical theme which has known a revival of interest since the eighties. Recent developments in the theory of international trade and economic growth (Grossman and Helpman, 1991) have emphasised the importance of technology as the engine of both growth and trade. In particular, they suggest that, for latecomer countries, such an engine may be fuelled by technological spillovers which help them to reduce or to close up the gap vis-a-vis the advanced countries. The mechanics of this engine and the power of spillovers has been under empirical scrutiny by many important scholars[1]. Most of these studies are cross sectional (either among industries within a country or among countries) and look for significant relationships between several measures of productivity growth and different proxies for spillovers (see Mohnen, 1996, for a comprehensive review). In this study, on the contrary, we concentrate on the experience of one country: Italy. As a matter of fact, in the post-war period, Italy has been an example of a successful latecomer: it has significantly concurred to the convergence process which has characterised that period. Most importantly, its success has been attributed not only to its own ability to produce and export low cost and good quality merchandise but also to the exploitation of spillovers from more advanced countries[2]. Nonetheless, despite the fact this is a commonly shared belief among economic historians, previous studies of Italian economists[3] have not focussed on it[4]. On the contrary, the exam of the role of spillovers on the Italian economic growth is the aim of our study, which investigates the extent and the typology of spillovers through the years from 1963 to 1995.

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[1] See for example the seminal work by Coe and Helpman (1995). Other important studies are Bernstein and Mohnen (1998), Coe, Helpman and Hoffmaister (1997), Connelly (1997), Eaton and Kortum (1996), Engelbrecht (1997a, b), Keller (1996), Lichtenberg and van Pottelsberghe de la Potterie (1996), Sanna (1998). In the light of all these studies, there is sufficient evidence to claim that significant returns on outside R&D exist.
[2] For excellent accounts on the Italian economic miracle see Zamagni (1993) and Rossi and Toniolo (1996).
[3] See among the latest contributions Ardeni (1993), Orsi and Picci (1993), Rossi and Toniolo (1993, 1996), Mattana (1997), Picci (1997), Atella and Quintieri (1998).
[4] The only significant but partial exception being Rossi and Toniolo (1993) who consider non-energy imports among factors of production, but concentrate on economies of scale and other effects over a much longer period.

The paper is organised as follows. The following section presents a descriptive analysis to outline the main features of Italian growth, compared to other countries, and its dependence on the technological progress of other countries. The third section, after a brief account of the model to be estimated and of some econometric issues involved, presents the empirical evidence. The fourth section offers some conclusive remarks.

1. Some features of Italian economic growth, 1960-1995

In the aftermath of World War II there has been a general process of convergence among countries, a process characterised by high rates of growth of GDP per capita and productivity all over the world. As noted by Baumol (1994):

"the post-war period from 1950 to 1970 ('the golden age of growth') was one of unprecedented convergence in terms of homogenisation and catch-up to the leader, as well the size of the group of countries participating in the convergence process (the group numbering perhaps somewhere between 20 and 40 countries, depending on the criteria used). Finally after 1970 a trend of relatively mild convergence began" (p. 64).

Italy is an emblematic example of such a process and has followed the sequel of high fast growth at the beginning and a subsequent period of moderate growth as described in the quotation above. In table 1 some statistics are reported to summarise the Italian economic history from the sixties until 1995 in comparison with Canada, France, Germany, United Kingdom and USA[5]. Some peculiarities are worth highlighting.

The Italian growth rate in the thirty-five years under exam, both measured by GDP per head and productivity is second only to Japan's. In particular, as regards GDP growth Italy outperformed all the other countries, but for Japan, during the sixties and all countries during the seventies[6]. Later, its performance has been less clearly outstanding but nevertheless conspicuous. As far as the productivity is concerned, Italy's success has been even more exceptional; its productivity growth has been always higher than that of the other countries under exam (but for Japan for the whole period and for Germany for the post oil shock period).

According to the usual growth accounting exercise based on the neo-classical model, such a remarkable performance should be, first of all, ascribed to capital accumulation. However, although it is undeniable that Italy's capital accumulation has been essential in its economic growth especially in the immediate aftermath of World War II, according to

[5] The thirtyfive years under exam have been conveniently divided into three periods (1960-73, 1974-1980, 1981-90, 1991-95) for the sake of comparison with other previous studies.

[6] In those years, Italy's policy response to the first oil shock was "a peculiar blend of supply side measures, inflation and exchange rate depreciation" (Giavazzi and Spaventa, 1989) which facilitated a quicker recovery of output.

the indicators referred to the period under exam, Italy has not shown any exceptional behaviour in terms of investment on GDP. Italy has again lagged behind Japan, which has invested a quota of GDP on average 37% higher than Italy. Furthermore, Italy has clearly outperformed the United States and the United Kingdom (especially before the first oil shock), but it has been in line with Germany, Canada and France. More importantly, in Italy the investment volume relative to GDP has clearly deteriorated in the nineties when it fell behind Canada, Germany and France, not to mention Japan, whose quota has relatively increased and in the period 1991-1995 it is 62% higher than the Italian one.

The endogenous growth theory suggests another possible account for Italy's growth: the process of accumulation of knowledge and technological change. If, we approximate such a process by using research and development expenditure over GDP, however, we find that Italy, since 1963, has been the country with the lowest R&D quota on GDP among industrialised countries. Moreover, for such an indicator of performance there has been no unambiguous signal of convergence. Italy has reduced the gap with respect to the United Kingdom, which invested in R&D more than three times than Italy in the sixties and it has invested less than twice in the nineties; and to the United States, whose relative quota of R&D expenditure with respect to Italy fell from 462% before 1974 to 255% after 1990. Some progress has been achieved also with respect to Canada and France. Nevertheless, Italy's performance has not changed significantly with respect to Japan and Germany[7], the countries which are commonly recognised, together with the United States, as the vanguard of the technological frontier. Furthermore, it is worth noting that the other industrialised countries, except Canada, still spend on R&D an almost double quota of GDP than Italy. It should not be forgotten, however, that there are several reasons which may explain this bad performance by Italy in terms of R&D expenditure (see Malerba, 1993, and Sassu, Paci and Usai, 1996). In a nutshell, we may say that Italian small and medium firms which still form the bulk of Italian industrial system are not involved in formal R&D as other bigger firms. Moreover, as far as such big firms are concerned, that they are just a small number and mostly concentrated in sectors which are not at the frontier of technological advance. Most importantly such firms have renounced to enter new sectors. For all these reason even big firms have a relative low R&D intensity. In

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[7] Actually, Italy has got closer to Germany in the last five years under exam, probably due to the process of reunification which has negatively affected the performance of the latter.

this perspective, we may say that Italian specialisation pattern and low propensity to R&D expenditure are clearly two intertwined phenomena.

Such a controversial picture, which comprises high GDP growth without similar performances of the usual causing factors, is corroborated by the analysis of the whole dynamics of Italy's economic growth detailed in figure 1. It can be noted that the growth of GDP per capita is constant for the whole period but for 1975 and 1993 and that such a growth almost came to a standstill in the early eighties. Along similar lines is the trend of productivity. On the contrary, the performance of gross capital formation (measured as a quota of GDP) has not been particularly brilliant but for some limited periods (in the early sixties and before the first oil shock, for example). On the whole its trend has been negative and, as a result, the quota of investment on GDP has decreased of more than one third, from around 26% in 1960 to 16% in 1995. As far as R&D expenditure is concerned, this has increased more than GDP during the sixties and later in the eighties when there has been a remarkable accelerated growth. After 1985, such a growth has been relatively more modest and came to a halt in 1990. Afterwards, the R&D quota of GDP has declined back to the 1986 levels.

In conclusion, Italy's catch up on other more advanced countries can not be easily explained by referring just to capital accumulation or to internal R&D. This does not, actually, come as any surprise since many other factors have been mentioned in the literature in order to justify Italy's performance: the reallocation of man power from agriculture to manufacturing, the exploitation of static economies of scale, the mild dynamics of labour costs. However, even though they have been certainly crucial in the early period of the Italian post-war growth (in the 50's and 60's), these factors are not able to explain the persistency of the performance of Italian economy in the long run. Persistence, which, in our reading, is more related to another commonly mentioned factor, that is the ability of Italian firms as imitators. In other words, Italy has constantly exploited the typical externalities associated with technological progress and knowledge as public goods. Since the pioneering study by Fuà (1969), as a matter of fact, it has been emphasised that large productivity gains were obtained from the implementation of imported technology in a relatively easy way thanks to the country's endowment of well-qualified engineers and of a fairly disciplined and educated labour force.

Imported technology can be conveyed from one country to another through several channels: trade (especially of capital goods), foreign direct investment, joint ventures, patent and licence exchange, migration flows and several other means of communication. Obviously these channels are not necessarily alternative, actually they can easily coexist and integrate and reinforce each other. Nevertheless some channels may prove relatively more important than others. For a preliminary appraisal of such relative importance, we may look at some of these phenomena associated with the Italian case reported in table 2.

First of all, we examine the relative value of the imports of investment goods (and of its main component, that is machinery and instruments) over total GDP[8] reported in the first two columns. Most scholars, as a matter of fact, agree that Italy's spillovers have been channelled mostly thanks to the inflow of investment goods which embodied the new technologies developed abroad. According to the data, imports of investment goods have become more and more important relative to GDP from 1960 to 1990. Total imports on GDP increased from 1.69 to 2.24 whilst the imports of machinery and instruments stayed rather constant along the years. Both indicators dropped only after 1991, probably as a result of the ongoing process of import substitution as we know that early imports of machinery have been instrumental for the creation of an increasingly competitive internal machinery industry.

Concerning the indicators referred to the technology balance of payments, displayed in the following three columns, they show that Italy's global performance improved during the eighties and afterwards (the quota of payments on the sum of payments and receipts was 83.7% in the first period and dropped 20 points below in the nineties at 63.5%). Such a good performance is, however, not to be associated with Italy being no longer in need of patents and licences from abroad, rather with the fact that Italy is selling more and more technology abroad (the quota of receipts on GDP having increased from 0.04% to 0.11%). In fact, the quota of imports of technologies on GDP has slightly increased throughout the period under exam moving from 0.18% to 0.19%.

Finally, the last two columns refer to direct investment inflows and outflows as measured by their quota over GDP. Again, some interesting features are worth noting. Italy's inflows are declining (from 0.49% to 0.33%, even though it reached its minimum in the late

[8] The analysis of the Italian case proves interesting also because the series of imports of investment goods (and among them machinery and instruments) are available. For most countries only imports classified by sector of production (and not by destination) are available.

seventies at 0.22% mainly for macroeconomic factors). This implies that this channel of technology transfer is slowly loosing importance probably as a result of a declining interest by foreign firms in investing in Italy due to many factors. Some of these factors are exogenous in nature as it is the crowding out by other new industrialised countries; others are more related to internal phenomena such as the well known problems related to the lack of infrastructure and the uncertainties due to bureaucracy. In contrast with this negative result, the other channel of spillovers, represented by outflows, has substantially increased since the capacity to invest abroad (measured by the quota of outflows on GDP) is now 0.65% while it was 0.19% in the first four years of the seventies.

In conclusion, it is apparent that different channels of externalities have operated throughout the years, even though they have gone under a notable process of remodelling. As a result, our aim is twofold: firstly, we wish to assess the relative importance of such channels in inducing economic growth; secondly, we look for any significant statistical evidence of the remodelling suggested by descriptive data.

2. Empirical analysis

2.1. Methodological notes

We estimate a Cobb-Douglas-type production function augmented to include R&D capital as a distinct factor of production[9] and to allow for spillovers from abroad. Following Coe and Moghadan (1993), unlike most similar studies (for example, Coe and Helpman, 1995), we do not implement standard TFP analysis, based on coefficients on capital and labour constrained to equal their factor shares. This has a twofold motivation: on the one hand, the inclusion of two more inputs make the calculation of shares more ambiguous; on the other hand we try to impose as less constraints as possible and to test them directly. On this point, it is worth reminding that the estimation of a Cobb-Douglas function (the so called primal approach) imposes some constraints itself that are not verified in actual long-run process (as those relating to perfect competition). On this issue, some relevant progress has been achieved since Morrison (1988) suggested to follow the dual approach by estimating

[9] For a similar framework see, for example, Coe and Moghadan (1993) who studied French productivity growth and Mattana (1997) who analyses the Italian case. However, they both use quarterly data which allow them to estimate a cointegrating function.

a Generalised Leontief form cost function (see Rossi and Toniolo 1996, Bernstein and Mohnen, 1998 and Atella and Quintieri, 1998). However, this procedure requires data on input prices which are not available for our spillover variable for the whole period from 1963 to 1995. Therefore, the production function to be estimated is simply:

$$Y = AL^{\alpha}K^{\beta}HK^{\chi}SP^{\delta} \qquad (1)$$

Where Y represents production; A is a productivity parameter depending on unmeasurable phenomena (such as those which shape the institutional setting), while L, K, HK and SP are labour, physical capital, human capital and spillovers respectively.

Taking the natural logs (1) becomes:

$$y = a + \alpha l + \beta k + \chi h + \delta s \qquad (2)$$

Although this formula is usually considered suitable for estimation[10], some problems arise from the application of Ordinary Least Squares. It is, as a matter of fact, well known that most of the macroeconomic time series are nonstationary and that by using simple OLS estimation one risks to highlight spurious relationships. The series under exam are no exception. However, there is no agreement among econometricians on the appropriate method to get rid of nonstationary components from the series[11]. In this paper, given that cointegration analysis is problematic due to the small number of degrees of freedom, first differences on natural log variables are used to detrend series. Some attempts to estimate either an error correction model or regressions with linear detrended variables have been applied too. The main evidence, which highlights a significant relationship between external spillovers and economic growth, is not invalidated by the estimation using such different methodologies.[12] The use of first differences may be subject to criticisms, given that, contrary to the error correction model which includes both short and long run analysis, it takes into account just the short term. Nonetheless, this is a minor fault in our

[10] See for example Picci (1997).
[11] Different suggestions on this issue are given in the forum hosted by the *Economic Journal* on this controversy, Taylor and Dixon (1997).
[12] Such estimates are available upon request.

case, since the objective of this analysis is not only to reveal a relationship between spillovers and growth but also to highlight potential changes in its short term dynamics along the years under exam.

As far as the proxies to be used to measure human capital and spillovers, most previous empirical analyses have suggested the use of the stock of internal or external R&D for the former whilst the debate is still ongoing about the best proxy for the latter. In particular there is no agreement concerning the right measure of proximity, that is the right indicator of the spillover channel, to accompany the chosen indicator for foreign knowledge (usually the stock of R&D in another group of countries[13]). Within a cross-sectional framework Coe and Helpman (1995) use foreign R&D expenditure weighted by quota of imports[14]; Coe, Helpman and Hoffmaister (1997) suggest the use of the same measure but weighted by means of quotas of import of machinery instead of total imports; finally, Bernstein and Moehnen (1998), in their interesting study on knowledge flows between Japan and US from 1962 to 1986, suggest the utilisation of foreign R&D stock without any specification of the transfer channel (i.e. without any weighting procedure) because no international transaction is a necessary condition for spillovers to flow from one country to other ones. In this study we follow the literature as for the measure of internal and external human capital by using R&D stocks of Italy and of the six most industrialised countries (Canada, Germany, France, Japan, United Kingdom and United States) respectively; on the contrary, for the proxy of the channel of spillovers we try to proceed without any strong pre-commitment to any of the suggested measures given that, since we refer to just one country, data availability and homogeneity is not a main issue. This allows us to attempt an empirical assessment of the relative importance of different channels.

2.2. Empirical evidence

First of all, we have compared a number of proxies which are meant to denote different channels of spillovers. All such proxies are used as a weight of the foreign stock of R&D expenditure[15] associated to the six most industrialised countries as an indicator of the pool

[13] One notable exception being Eaton and Kortum (1996) who use patent data.

[14] Keller (1996) has criticised this method by showing that similar results can be achieved by using random figures instead of the actual quota of imports.

[15] Foreign R&D is considered with a two-year lag given that the process of innovation is a

of knowledge and technological progress available in the world. Moreover, we use GDP and industrial production as proxies for economic growth. The comparison is based on simple correlation coefficients (but it is confirmed by simple and multiple regression analysis) which are reported in table 3. It is clear that neither the balance of payments indicators nor the foreign direct investment have played a major role in directing economic growth in Italy, as they display a negative coefficient. On the contrary, according to our previous account, the channel represented by imports of either investment goods or, within them, of machinery and instruments is positively correlated with economic growth[16]. The best results are obtained when the foreign stock of R&D is weighted by means of the index of volume of either imports of investment goods or imports of instruments and machinery. However, such a variable is available only until 1987 and its use in the following regression analysis would penalise our objective of studying the dynamics of spillovers until nowadays. For this reason, and also because the correlation coefficient is anyhow rather high, we choose the quota of imports of investment goods on GDP.

In table 4 the results of the estimation of (2) are reported in column (a), with *y* represented by GDP per capita growth rate and *k* and *l* given by the stock of gross capital and by total employees, respectively. Let us focus on spillovers and human capital effects. The former has apparently a significant effect on productivity (its elasticity being 0.07), whilst the latter is negative even though it is not significant. Despite the fact this may appear as a peculiar result[17], it is not unexpected in the light of the empirical evidence shown in the previous section. Italy's economic growth, as a result, appears more related to external rather than internal technological progress.

In the light of this piece of evidence we can now turn on the second objective, that is to see if there have been changes throughout time in the magnitude of externalities. The analysis of recursive coefficients is, on this extent, quite suggestive. In particular, there appear two structural breaks on spillovers coefficients (in 1981 and in 1988) and another one on the

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lengthy one. The choice of the best lag is left to the estimation procedure but results do not change if the lags are increased. The same applies to the regression analysis below.

[16] Correlation coefficients for different proxies referred to the same channel of spillovers are shown in the table in order to test for the robustness of the coefficients themselves. This is to avoid typical errors involved in data mining procedures when a number of candidate regressors are available to represent the phenomenon under study.

[17] Note that within a different empirical framework, Mattana (1997) finds that R&D has a relevant role in long run equilibrium growth.

human capital coefficient (in 1988)[18]. To test for the statistical significance we use multiplicative dummies on the coefficients of spillovers and human capital. Results are reported in columns (b)-(d) and confirm, at least partially, these suggestions. As a matter of fact, spillovers slowed down during the eighties: in column (c) the interaction terms are negative and significant driving the elasticity from 0.17 in the period from 1963 to 1980 to 0.05 in 1981 and even negative (-0.02) after 1988. In other words, imports of investment goods are becoming less crucial for Italian growth. This has happened particularly in the late eighties, when the process of restructuring and reorganisation of Italian industry, which started in the early eighties[19], was near to conclusion.

No role, at least not significant from a statistical point of view, can be, conversely, attributed to internal human capital, even when its impact is split into two periods (before and after 1988). Actually, its negative coefficient seems to increase after 1988 (from -0.3 to -0.2) but it remains negative and most of all not significantly different from zero (see column (b)).

Results for industrial production reported in table 5 confirm the main evidence provided in the regression analysis for GDP per worker growth rate. However, some interesting peculiarities are still worth remarking. Firstly, the elasticity for spillovers for the whole period is slightly (but not significantly) bigger than in the GDP regression. (0,09 instead of 0.07). Secondly, despite the analysis of recursive coefficient still suggests a break in 1988 for the spillover coefficient (and none before), such a break is not fully confirmed by the regression analysis. The interaction term with the dummy for the years from 1988 to 1995, reported in column (c) has, in fact, a negative sign but it is not significant. As for the human capital coefficient, again, this is not significantly different from zero and does not change significantly along the years.

The last column (e) both in table 4 and in table 5 confirm that main results do not change if a two stages least procedure is implemented in order to take into account for potential problems of endogeneity.[20]

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[18] There seems to be also a break for the coefficient of the labour force in 1993 in coincidence with a big slump in employment but there is no statistical support for it. The other coefficient on physical capital appears rather stable along time.

[19] Such a process was characterised by the dismissal of large parts of employment, the implementation of labour saving technologies, smaller units of production, deverticalisation and a thorough process of reorganisation of industrial relations.

[20] Obviously the applied solution is not a first best one, which would be the estimation of a system of demand equation for fixed and quasi fixed inputs. Data availability, as already said, precludes

Conclusive remarks

This study moves along the recent research path started by Coe and Helpman (1995) which aims at unravelling the mechanics of spillovers in the economic growth of nations. Unlike many previous studies, which are mainly cross-sectional, our analysis focuses on the experience of just one country: Italy. As a matter of fact, Italy is an example of a successful latecomer, whose success has been related to the exploitation of spillovers from more advanced countries.

The time-series analysis 1960-1995 shows that the Italian economic growth has been critically influenced by external technology through the spillover channel represented by imports of investment goods. Moreover, empirical evidence suggests two notable peculiarities of such a process. Firstly, Italian growth has been and still is more related to external rather than internal spillovers; secondly, the extent of external spillovers has shown some relevant changes throughout the years: aggregate (but not industrial) spillovers have slowed down since the eighties.

How should we interpret these results ? First of all, we could hypothesise that the Italian economy has come to the end of the usual latecomer development path and becoming less dependent on the technological lead of the others countries. There is no doubt that Italy has become structurally able to produce many investment goods which were previously imported (essentially in the so-called mature industries). However, its technological gap is still indisputable, as it has been shown in many analyses[21] and evidenced by the data presented in this study. We could then suppose that Italy's technological dependence is changing its nature, and spillovers are going through different channels than in the past. In the light of empirical evidence, one may suggest that other less tangible mechanisms are overtaking the role of investment goods in conveying externalities towards Italy. Mechanisms which are not, anyhow, able to ensure growth rates as high as in the past. This interpretation is strictly connected to another fact to be considered: Italian specialisation, as it is well known, is in traditional industrial sectors, where spillovers from abroad are still relevant, but probably at a diminishing rate. These facts could explain the slowing

such a solution.

[21] Malerba (1993) and Paci, Sassu and Usai (1996) among others.

down of aggregate external technological spillovers. At the same time, another by-product of the fact that Italy's convergence process in growth rates has not been followed by a modification in its specialisation pattern along the lines followed by other industrialised countries is that Italy is still not able to exploit *internal* R&D spillovers. Italian economy, as a matter of fact, do not invest in those high tech sectors, with high R&D propensity, which can create new and larger externalities for a country which has almost concluded its catching up process.

On the basis of our empirical analysis it is not possible to provide conclusive confirmation of our interpretation. Only a disaggregate analysis, which distinguishes different channels of externalities and inter-industry and intra-industry spillovers, will be able to detail the mechanics of the externalities-growth relationship that our analysis have revealed. But this is left to a future research.

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Figure1. Italy's economic performance (1963=100)

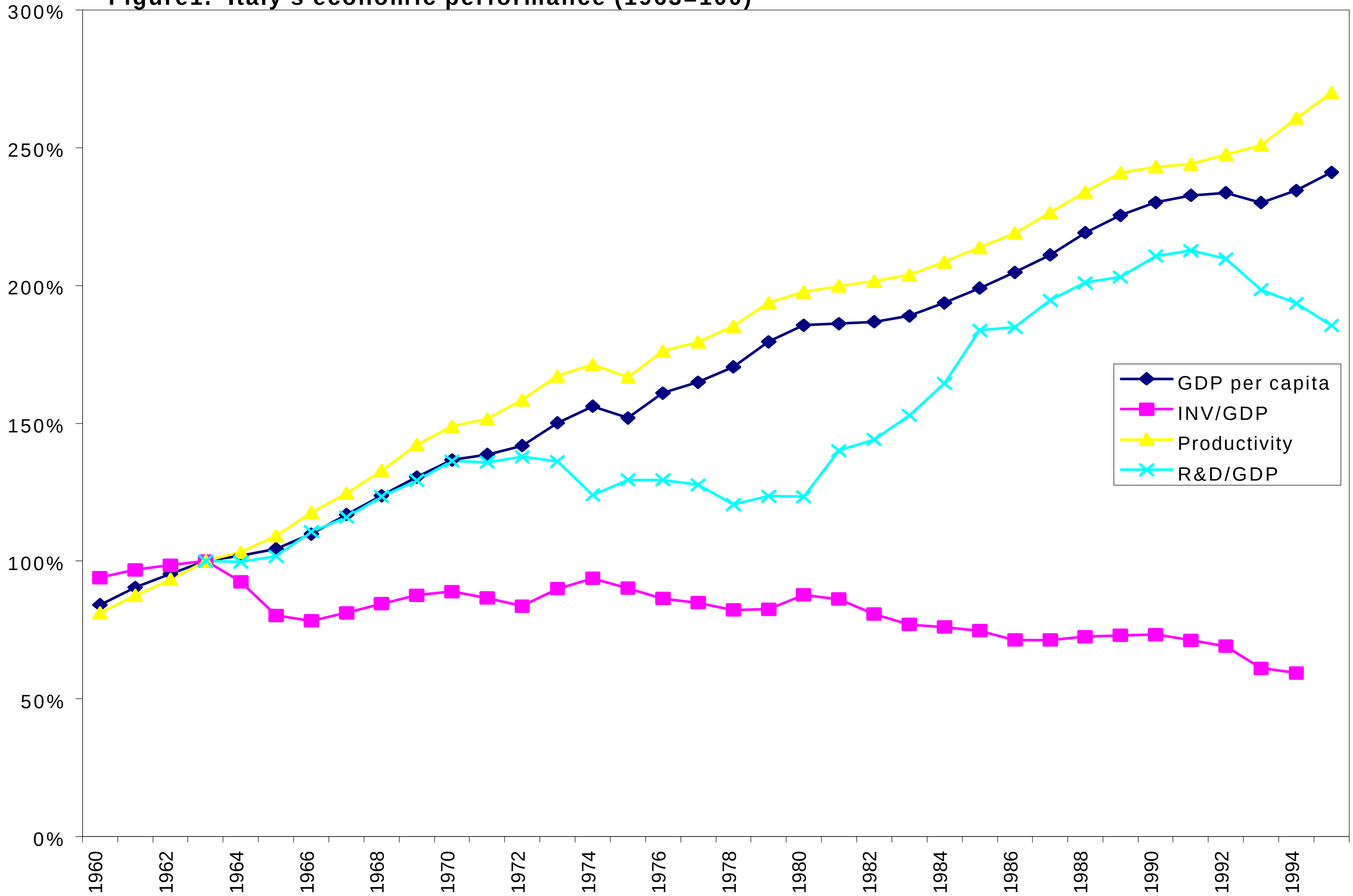

Table 1 - Indicators of economic performance (Italy=100)

	CANADA	FRANCE	GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES
	GDP per head growth rate					
1961-73	78.43	95.20	80.72	183.69	56.42	58.14
1974-80	81.62	64.43	74.38	75.41	34.18	33.46
1981-90	106.38	68.14	91.69	148.74	133.01	93.41
1991-95	0.61	69.09	119.80	141.47	61.24	95.79
1961-95	76.47	83.68	84.04	152.91	64.43	61.16
	Productivity growth rate					
	CANADA	FRANCE	GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES
1961-73	34.86	77.30	70.34	140.40	45.96	39.38
1974-80	62.93	91.91	102.53	127.15	67.73	29.12
1981-90	43.04	87.84	59.92	116.35	86.19	36.88
1991-95	34.26	98.78	7.39	117.43	63.44	53.74
1961-95	40.97	75.09	67.76	131.24	60.00	38.16
	Gross capital formation on GDP					
	CANADA	FRANCE	GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES
1961-73	91.33	96.91	107.59	132.71	74.57	74.98
1974-80	98.04	97.91	91.67	132.23	79.79	80.83
1975-80	99.80	96.74	94.46	133.80	80.37	86.41
1991-95	106.16	107.16	108.15	161.89	91.41	88.03
1961-95	96.76	98.38	101.87	137.33	79.44	81.25
	Gross R&D expenditure on GDP					
	CANADA	FRANCE	GERMANY	JAPAN	UNITED KINGDOM	UNITED STATES
1961-73	173.91	251.90	208.08	208.16	334.02	462.54
1974-80	152.17	218.90	242.35	227.04	298.20	344.90
1975-80	135.51	196.19	201.96	219.51	228.70	294.75
1991-95	133.07	189.11	183.99	208.66	194.39	254.68
1961-95	150.28	217.15	211.13	218.04	269.51	350.96

Source: our calculations on OECD

table 2 - Indicators of spillovers

	Imports of investment goods			*Technological Balance of Payments**			*Direct investment*	
	Total imports on GDP	Imports of machinery and instruments on GDP		Payments/ (Receipts+Payme nts)	Payments on GDP	Receipts on GDP	Inflows on GDP	Outflows on GDP
1961-73	1.69%	1.41%	**1970-73**	83.71%	0.18%	0.04%	0.49%	0.19%
1974-80	2.16%	1.44%	**1974-80**	78.53%	0.17%	0.05%	0.22%	0.13%
1981-90	2.24%	1.33%	**1981-90**	73.58%	0.13%	0.05%	0.35%	0.41%
1991-95	1.88%	1.10%	**1991-95**	63.54%	0.19%	0.11%	0.33%	0.65%

Source: our calculations on ISTAT, ICE and OECD

Table 3 - Correlation coefficients of growth rates

*Channels of spillovers**		GDP	Industrial Production	Period
Technology balance of payments				
	Payments/GDP	-0.35	-0.40	1970-95
	Payments/(Payments+Receipts)	-0.53	-0.50	1970-95
Imports of investment goods				
	index of volume	0.64	0.61	1963-87
	quota on GDP	0.55	0.53	1963-95
Imports of machinery and instruments				
	index of volume	0.70	0.68	1963-87
	quota on GDP	0.55	0.52	1963-95
Foreign direct investment				
	Outflows/GDP	-0.23	-0.29	1970-95
	Inflows/GDP	-0.27	-0.26	1970-95

* Each channel is multiplied by the foreign stock of R&D associated to the six most industrialised countries

Source: our calculations on ISTAT, ICE, OECD

Table 4 - dependent variable: gdp growth rate (dy) - 1963-1995

	(a)	(b)	(c)	(d)	(e) 2SLS
c	0.01	0.01	0.02	0.02	0.00
	0.68	*0.41*	*1.74*	*1.40*	*0.31*
dk	0.88	1.01	0.53	0.66	0.70
	3.80	*3.65*	*2.28*	*2.31*	*2.72*
dl	-0.79	-0.78	-0.59	-0.58	-0.68
	-4.15	*-4.04*	*-3.38*	*-3.26*	*-1.92*
dsp	0.07	0.08	0.17	0.17	0.09
	2.73	*2.83*	*4.43*	*4.37*	*2.30*
dsp*d81-87			-0.12	-0.11	
			-2.14	*-1.85*	
dsp*d88			-0.19	-0.19	
			-3.28	*-3.24*	
dhk	-0.25	-0.31	-0.27	-0.33	-0.09
	-1.19	*-1.41*	*-1.48*	*-1.66*	*-0.33*
dhk*d88		0.12		0.10	
		0.88		*0.79*	
Adjusted R-squared	0.53	0.53	0.66	0.65	0.45
Durbin-Watson	1.96	1.95	1.73	1.81	2.08

Table 5 - dependent variable: industrial production growth rate (dyind) - 1963-1995

	(a)	(b)	(c)	(d)	(e) 2TLS
c	0.01	0.00	0.01	0.01	0.00
	0.45	*0.17*	*0.82*	*0.04*	*-0.11*
dk	0.89	1.04	0.77	0.92	0.86
	2.69	*2.34*	*2.26*	*2.05*	*1.90*
dlind	-0.80	-0.85	-0.72	-0.78	-0.94
	-3.17	*-3.05*	*-2.81*	*-2.75*	*-2.11*
dsp	0.09	0.10	0.13	0.13	0.12
	3.01	*3.01*	*3.20*	*3.20*	*3.11*
dsp*d88			-0.09	-0.09	
			-1.31	*-1.28*	
dhk	-0.21	-0.27	-0.27	-0.33	-0.06
	-0.95	*-1.00*	*-1.11*	*-1.21*	*-0.23*
dhk*d88		0.10		0.09	
		0.54		*0.52*	
Adjusted R-squared	0.42	0.40	0.44	0.42	0.33
Durbin-Watson	2.26	2.17	2.22	2.21	2.27