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Temi di discussione

del Servizio Studi

Multifactor Productivity and Labour Quality in Italy, 1981-2000

by Andrea Brandolini and Piero Cipollone

Number 422 - October 2001

The purpose of the Temi di discussione *series is to promote the circulation of working papers prepared within the Bank of Italy or presented in Bank seminars by outside economists with the aim of stimulating comments and suggestions.*

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This paper is part of a research project on "Technological Innovation, Productivity, Growth: Towards a New Economy?" carried out at the Economic Research Department of the Bank of Italy. Like others that are part of the project, it was presented and discussed in a seminar.

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MULTIFACTOR PRODUCTIVITY AND LABOUR QUALITY IN ITALY, 1981-2000

by Andrea Brandolini* and Piero Cipollone*

Abstract

We investigate how the evidence for Italy from simple growth accounting exercises is modified by more accurate measurements of inputs. We describe the dynamics of total factor productivity in the last 20 years in Italy, and review theoretical and measurement issues that complicate the picture emerging from this simple exercise. We adjust the labour input for its composition and verify its impact on estimated multifactor productivity in the whole economy. We replicate the labour-quality adjustment for the industrial sector together with corrections for hours worked and capital utilisation. We find that a sizeable part of the observed growth of total factor productivity vanishes when these adjustments are applied. They are not sufficient, however, to overturn the evidence of a productivity slowdown in the Italian economy in the second half of the 1990s.

JEL classification: O47, I20, J24.

Keywords: growth accounting, Solow residual, quality-adjusted labour input.

Contents

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1. Introduction[1]

During the 1990s, the long-run increase of the educational level of the work force was accompanied by a spreading of the new information technologies, in Italy as in other industrialised countries. The likely positive impact on productivity would be neglected in the simplest growth accounting exercises *à la* Solow (1957) where labour input is measured solely in terms of physical units.[2] The measurement of labour and multifactor productivity can be improved by integrating the information on employment with an indicator of its quality, and the same holds for the capital stock. The need for adjusting inputs for their quality and composition has been long recognised in the literature, at least since Jorgenson and Griliches (1967) clarified that unmeasured variations in the quality of inputs show up spuriously in the growth of total factor productivity.

In this paper we carry out a growth accounting exercise for the Italian economy in the last two decades, and we investigate how the evidence derived from the simple model is modified by a more accurate measurement of inputs. The results from the basic growth decomposition into contributions of labour and capital and changes in total factor productivity are examined in Section 2, while the theoretical and measurement issues that underlie these results are reviewed in Section 3. In the two following sections, we focus on the adjustment of the labour input for its composition. Following a common practice, we construct quality-adjusted measures by partitioning employment according to relevant characteristics (e.g. schooling, experience, gender) and subsequently aggregating the groups with weights equal to the relative wage rates, taken to proxy the marginal product of labour. We also experiment with a different weighting scheme based on the minimum years of schooling to achieve a certain educational level. Because of data availability, we restrict our attention to the whole economy (Section 4) and to the industrial sector (Section 5). For the

1 We thank Marco Magnani and Fabiano Schivardi for helpful comments. We are indebted to Leandro D'Aurizio for having provided us with updated estimates on the number of hours worked per capita in manufacturing firms with 50 employees or more. The views expressed here are ours and do not necessarily reflect those of the Bank of Italy.

2 An account of the historical origins of the Solow residual is given by Griliches (1996).

latter, we also correct for changes in hours worked and capital utilisation. The main conclusions are drawn in Section 6.

2. The standard growth accounting exercise

We begin with the basic growth accounting exercise, using annual data for the period 1980-2000 drawn from the National Accounts (NA) computed by the Italian central statistical office (Istat) according to the new European System of Accounts (ESA 95). Let us indicate with Y the output as measured by the value added at factor cost at 1995 prices, with L the total labour input as measured by standard labour units (i.e. the number of full-time equivalent employed), and with K the net capital stock at 1995 prices; let small letters denote the logarithms of the corresponding variables. The rate of growth (as approximated by the logarithmic difference) of the real value added can be decomposed – under the hypotheses discussed in the next section – into the contributions of the capital stock and the labour input and the rise in total factor productivity, θ:

$$\Delta y = \alpha \Delta l + (1-\alpha)\Delta k + \theta , \qquad (1)$$

where α is the labour share in value added, i.e. $\alpha = wL / pY$ with w being the compensation of employees per standard labour unit and p the deflator of the value added. Notice that, in the computation of the labour share, we are following the conventional practice of attributing each self-employed labour unit the average per capita compensation of employees.

The results from applying (1) to the main sectors of the economy, shown in Table 1, submit the following considerations.

- From 1981 to 2000 the real value added at factor cost in the whole economy grew at an average annual rate of 1.9 per cent. Over half of this increase was accounted for by the growth of total factor productivity, a third by the accumulation of capital and only a tenth by the rise in labour input. Roughly the same pattern can be observed for the non-farm private sector.

- The highest contribution of total factor productivity is to be found in agriculture, industry, and transport and communications; the contribution of labour was particularly relevant in the financial intermediation and the other services (which include public administration, health and education services); capital stock was an important source of growth in all private services sectors.

- In the non-farm private sector, the rate of growth of real value added in the 1990s was two thirds of that in the 1980s (1.7 vis-à-vis 2.6 per cent). Relative to the expansion years 1986-1990, in the first half of the 1990s the deceleration was largely explained by the labour input – about two thirds of the fall in the growth rate – with total factor productivity accounting for most of the remaining part. In the second half of the 1990s, the slowdown was entirely attributable to the stagnation of total factor productivity: while inputs contributed to the growth of real value added for about 1.6 percentage points – about the same as in the second half of the 1980s – the contribution of total factor productivity was a mere 0.4 percentage points. The contribution of capital accumulation was very stable throughout the period, explaining around one percentage point of the growth rate of real value added (Figure 1).

3. An overview of theoretical and measurement issues in growth accounting

The simple exercise carried out in the previous section would lead us to attribute half of the growth in value added between 1981 and 2000 to the residual, while at the same time making us worrying about the slowdown of productivity growth in the second half of the 1990s. However, we would be too hasty in taking this evidence at its face value. The large body of research spurred by Solow's (1957) seminal paper has stressed many reasons why caution is utterly needed. They can be distinguished into (i) the theoretical underlying assumptions, and (ii) the problems arising in practical applications from the measurement of output, capital stock and labour input. Let us consider them in turn.

Theoretical assumptions. It is well-known that growth accounting in its simplest form assumes that:

- the production function shows constant returns to scale;
- factor markets are competitive, so that factors are paid their marginal product;
- firms have no market power in the output market.

Table 1

CONTRIBUTIONS TO THE GROWTH OF REAL VALUE ADDED, 1983-1999
(percentage annualised values)

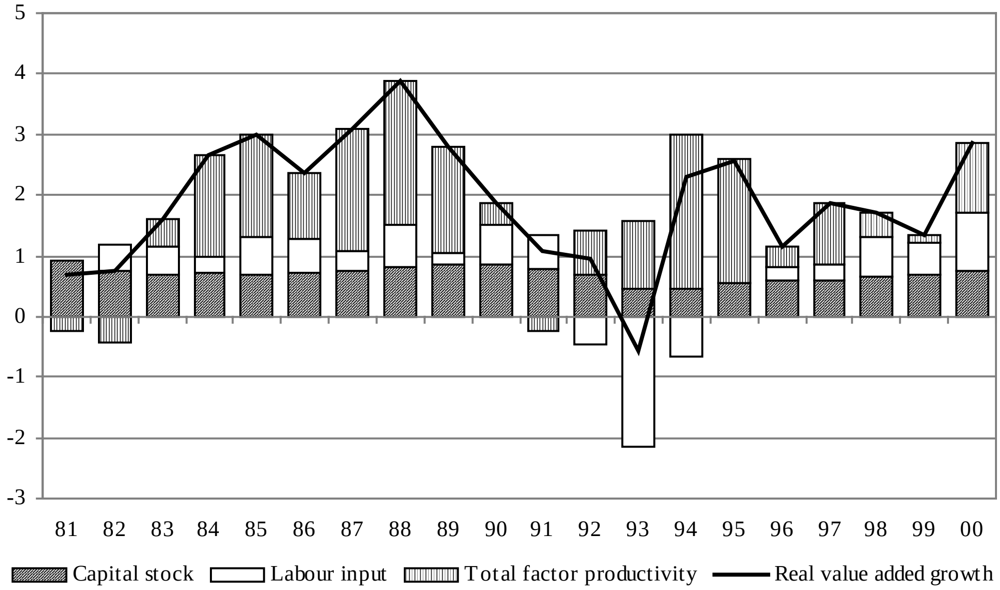
	1981-1985	1986-1990	1991-1995	1996-2000	1981-2000
All economy					
Rate of growth of real value added	1.7	2.8	1.3	1.8	1.9
Contribution of stock of capital	0.8	0.8	0.6	0.7	0.7
Contribution of labour	0.3	0.5	-0.5	0.5	0.2
Total factor productivity	0.6	1.5	1.2	0.6	1.0
Non-farm private sector					
Rate of growth of real value added	1.8	3.3	1.4	2.0	2.1
Contribution of stock of capital	1.0	1.0	0.8	0.8	0.9
Contribution of labour	0.3	0.7	-0.5	0.8	0.3
Total factor productivity	0.5	1.6	1.1	0.4	0.9
Agriculture and fishing					
Rate of growth of real value added	-1.0	-0.7	2.3	1.5	0.5
Contribution of stock of capital	0.0	0.1	0.0	0.4	0.1
Contribution of labour	-3.6	-3.5	-3.6	-2.5	-3.3
Total factor productivity	2.6	2.7	5.9	3.6	3.7
Industry					
Rate of growth of real value added	0.1	3.1	1.4	1.3	1.5
Contribution of stock of capital	0.7	0.9	0.5	0.7	0.7
Contribution of labour	-1.9	0.4	-1.2	0.1	-0.6
Total factor productivity	1.3	1.8	2.1	0.5	1.4
Construction					
Rate of growth of real value added	0.1	1.9	-1.3	1.1	0.4
Contribution of stock of capital	0.7	0.1	-0.2	0.9	0.4
Contribution of labour	-0.8	-0.3	-0.5	0.3	-0.3
Total factor productivity	0.2	2.1	-0.6	-0.1	0.3
Trade, hotels and restaurants					
Rate of growth of real value added	1.3	2.6	1.7	1.8	1.8
Contribution of stock of capital	0.8	1.2	1.0	1.4	1.1
Contribution of labour	2.0	0.3	-0.5	0.8	0.7
Total factor productivity	-1.5	1.1	1.2	-0.4	0.0
Transport and communications					
Rate of growth of real value added	2.7	4.3	2.7	2.8	3.2
Contribution of stock of capital	1.0	1.5	1.1	1.4	1.2
Contribution of labour	1.3	0.5	-0.8	1.1	0.5
Total factor productivity	0.4	2.3	2.4	0.3	1.5
Financial intermediation and business activities					
Rate of growth of real value added	4.7	4.0	1.3	2.9	3.2
Contribution of stock of capital	1.6	1.3	1.2	0.9	1.2
Contribution of labour	3.5	2.2	0.5	1.8	2.0
Total factor productivity	-0.4	0.5	-0.4	0.2	0.0
Other services					
Rate of growth of real value added	2.0	1.6	0.7	0.8	1.3
Contribution of stock of capital	0.3	0.4	0.2	0.2	0.3
Contribution of labour	2.5	1.4	0.4	0.3	1.2
Total factor productivity	-0.8	-0.2	0.1	0.3	-0.2

Source: authors' elaboration on data from Istat NA.

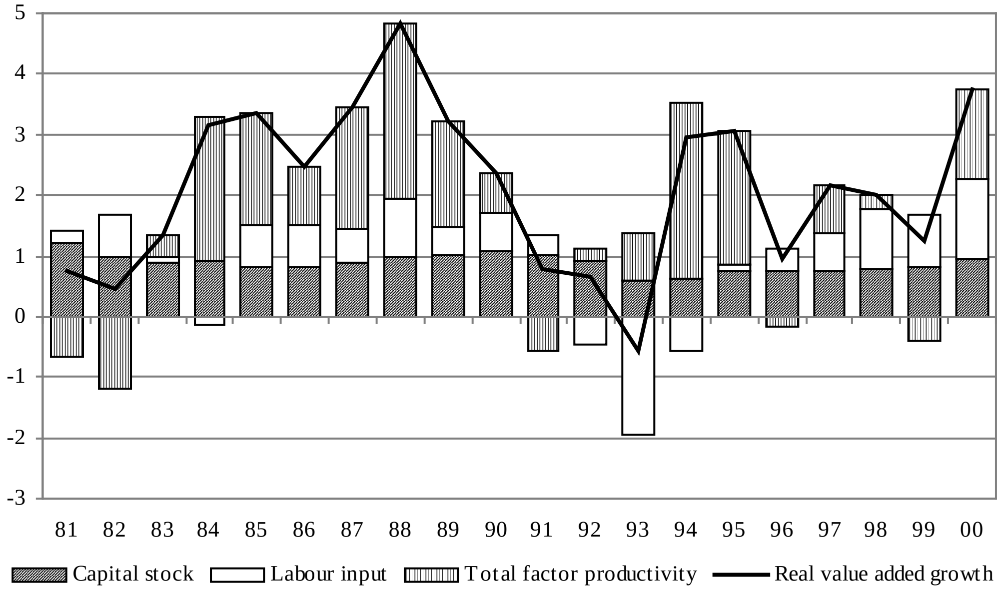
Figure 1

CONTRIBUTIONS TO THE GROWTH OF REAL VALUE ADDED, 1983-1999
(percentage values)

(a) Whole economy



(b) Non-farm private sector



Source: authors' elaboration on data from Istat NA.

We can observe that equation (1) carries over to the case where the output market is not competitive, provided that α is replaced with the labour cost share in total factor cost $\tilde{\alpha}$, where $\tilde{\alpha} = wL/(wL + rK)$ and r is the rental price of capital (e.g. Hall, 1990). If firms have no market power, then the cost-based share $\tilde{\alpha}$ and the revenue-based share α coincide; however, "[w]hen revenue exceeds cost, because of pure monopoly profits, the revenue share of labor understates the elasticity of output with respect to labor input. When some exogenous event raises labor input relative to capital input, the revenue-based Solow residual fails to account for all of the increase in output, because it gives too little weight to labor" (Hall, 1990, p. 76).

Measurement of output. The measure of *output* underlying the estimates in Table 1 is the *value added at factor cost*. We followed the most common practice in literature, but a feasible alternative would have been to identify output with total production and to specify intermediate consumption as a third input along with capital and labour. For instance, the U.S. Bureau of Labor Statistics (BLS) publishes two sets of estimates of multifactor productivity for the United States: those for the aggregate sectors use value added at factor cost, while those for industrial sectors at the 2-digit SIC level are based on total output net of intrasectoral transactions. The latter estimates are known as KLEMS, because they are obtained after detailing 5 inputs: capital stock, labour input, energy inputs, nonenergy material inputs and business services. An important drawback of the specification based on value added is that it implies that "… intermediate inputs cannot be the source of productivity growth" (Gullickson, 1995, p. 17). However, the use of value added seems reasonable for aggregate analyses.[3]

Regardless of its definition, a crucial issue is the "degree of measurability" of output. This point was emphasised by Griliches (1994), who observed how the shift away from manufacturing and agriculture towards sectors such as finance and other services makes the

[3] Gullickson (1995, p. 17) suggests that ignoring intermediate inputs is more problematic for analyses at the industry level because of their large weight in total cost as well as because "… many modern manufacturing productivity enhancement techniques [such as just-in-time production, statistical process control, computer-aided design] are aimed at improving the efficiency with which both intermediate inputs and primary inputs are used". For a discussion of the alternative output measures see also Gullickson (1992) and Gullickson and Harper (1999).

measurement of aggregate output, and therefore productivity, increasingly less reliable (see also Dean, 1999). It is worth recalling, for instance, that government output is an input-based measure, for value added is defined as the sum of compensation of employees and capital depreciation (taken as the remuneration of the capital). This renders the estimated total factor productivity in Table 1 virtually meaningless, and undermines also the significance of the same measure for the whole economy. Problems also arise in other service sectors. In the retail trade sector, the value added of small firms – which represent a relevant proportion of the market – is corrected upward for the under-declaration of income from self-employment.[4] The definition of output in financial intermediation has typically been very controversial and has given rise to one of the most "elusive" item of the production account, "Financial intermediation services indirectly measured".[5]

Measurement of labour input. In the previous section, we approximated labour input with the number of "standard labour units", or full-time equivalent employed. There are three reasons why such an approximation is unsatisfactory:

- it is an imprecise measure of the actual number of hours worked per capita, as it does not take into account variations induced by the business cycle and structural changes;
- it is insensitive to changes in the effort put by workers;
- it ignores the quality of each hour of work, failing to reflect changes in the composition of the employed labour force.

Measurement of capital input. The capital stock underlying the estimates in Table 1 is the official series produced by Istat. It is obtained through the perpetual inventory method by assuming that retirements of capital goods occur around the predetermined average service life according to a truncated normal distribution, and that depreciation is linear (Lupi and

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[4] The basic assumption utilised by Italian national accountants is that the per capita income of a self-employed, adjusted for hours worked, cannot be lower than the average compensation of employees in the same economic sub-branch. See Istat (1990, p. 111).

[5] In Italy, the "Financial intermediation services indirectly measured" are allocated to a nominal sector and not to sectors and industries. If allocated to industries, their value added would be lower and their intermediate consumption higher. See Gobbi and Pellegrini (1997) for a discussion.

Mantegazza, 1994). As for the labour input, the net real capital stock is an imperfect measure of the *service* provided by capital.

- The standard assumption is that the service provided by capital goods is proportional to their stock. The hypothesis on depreciation allows for the efficiency of a capital good to deteriorate with age, but it does not account for the fact that utilisation varies over time. There are both important variations over the business cycle, and structural changes brought about by the re-organisation of the production. For instance, since the 1980s an increasing share of manufacturing firms has moved towards continuous production or production on multiple shifts. We have not enough information to control for this structural change, but we adjust for the cyclical effect by inserting into equation (1) an indicator of capacity utilisation.
- As for the labour input, the composition of the capital stock varies over time. The recent debate on productivity in the United States has focused on whether different types of capital goods were contributing differently to output growth, and in particular on the role of information and telecommunication (ITC) technologies (e.g. Hornstein, 1999, and the references cited therein). Unfortunately we are unable to explore this particular issue on Italian data, since investment in ITC capital goods started to be separately recorded only in 1995. The BLS distinguishes 63 classes of assets and 57 industries (e.g. U.S. Bureau of Labour Statistics, 1997, p. 92), while Dougherty and Jorgenson (1996, 1997) disaggregate the total capital stock by 9 asset types and 4 ownership sectors.

We show how revising some of the measurement hypotheses used in Section 2 affects growth accounting in the next two sections. We first introduce a quality-adjusted measure of the labour input for the whole economy. While this allows us to draw comparisons with other studies, we are fully aware that the inclusion of all service sectors make the results vulnerable to Griliches' criticism on output "measurability". Next, we focus on industry, for which we examine the importance of hours worked and capital utilisation in addition to labour composition.

4. Quality-adjusted labour input in the whole economy

Approximating the labour input by the number of employed standard labour units is a rather imprecise measure of the labour contribution in production because standard units are only a crude proxy of hours actually worked, and they are unaffected by variations over time of effort and quality. In this section, we focus on this last aspect. When the quality of the work improves, the accounting equation (1) should be modified accordingly:

$$\Delta y = \alpha(\Delta l + \Delta e) + (1-\alpha)\Delta k + \tilde{\theta}, \qquad (2)$$

where e is the efficiency of one (full-time equivalent) unit of labour. Failure to take into account this labour-augmenting factor leads to underestimate labour contribution and to overvalue total factor productivity. The Solow residual θ computed from (1) would be a biased measure of the true residual $\tilde{\theta}$:

$$\theta = \Delta y - \alpha\Delta l + (1-\alpha)\Delta k = \tilde{\theta} + \alpha\Delta e. \qquad (3)$$

The magnitude of the bias is proportional to the rate of change of efficiency units per worker and to the labour share, being zero when per capita efficiency is constant over time.

Are there reasons to suppose that the quality of the labour input has varied over time? One rough indicator is provided by the average educational achievement of the Italian employed. According to the Istat Labour Force Survey (LFS), in 1977 little more than 40 per cent of the employed had completed at least middle school, and persons with a university degree were only 4 per cent of the total. By 2000 the share of persons who had completed middle school had risen to 87 per cent, that of persons with a diploma from high secondary school had become the modal group (40 per cent), and the proportion of people with a university degree had tripled to 12 per cent (Figure 2). As a result, there has been a steady rise of the mean number of years of schooling by employed persons, from 7 years in 1977 to almost 11 in 2000, or an increase by 54 per cent (Figure 3).[6]

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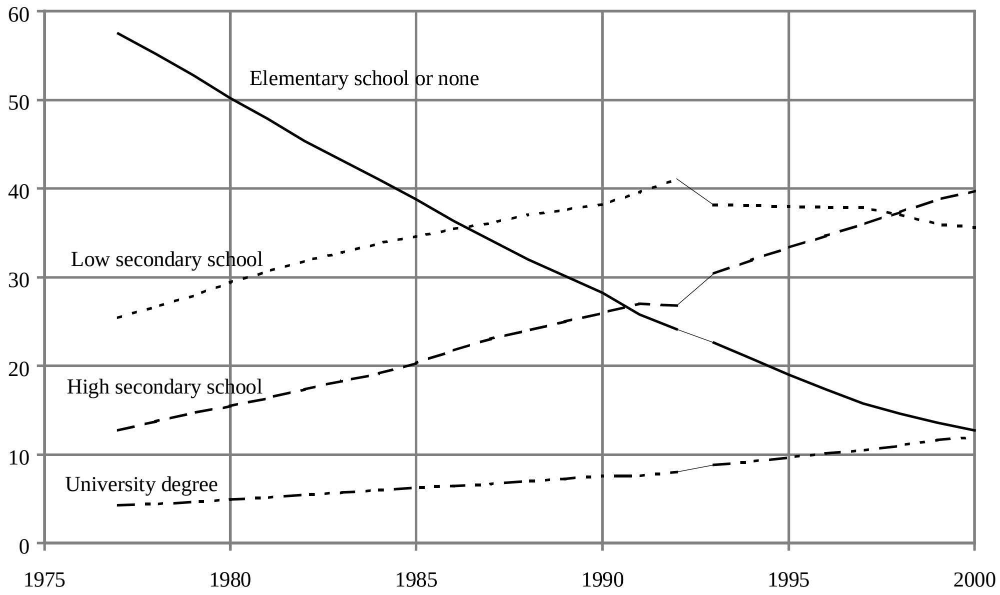
[6] We assigned 5 years to elementary school, 8 to low secondary (or middle) school, 13 to high secondary school, and 18 to university degree. These values are just proxies. First, they tend to represent lower bounds since it may take longer to complete each school level. Second, high secondary school includes vocational courses that frequently last 3 years or less, while university degrees range from short university diploma obtained after a 3-year course to doctorate degrees which imply a total of at least 7 years of university courses.

Figure 2

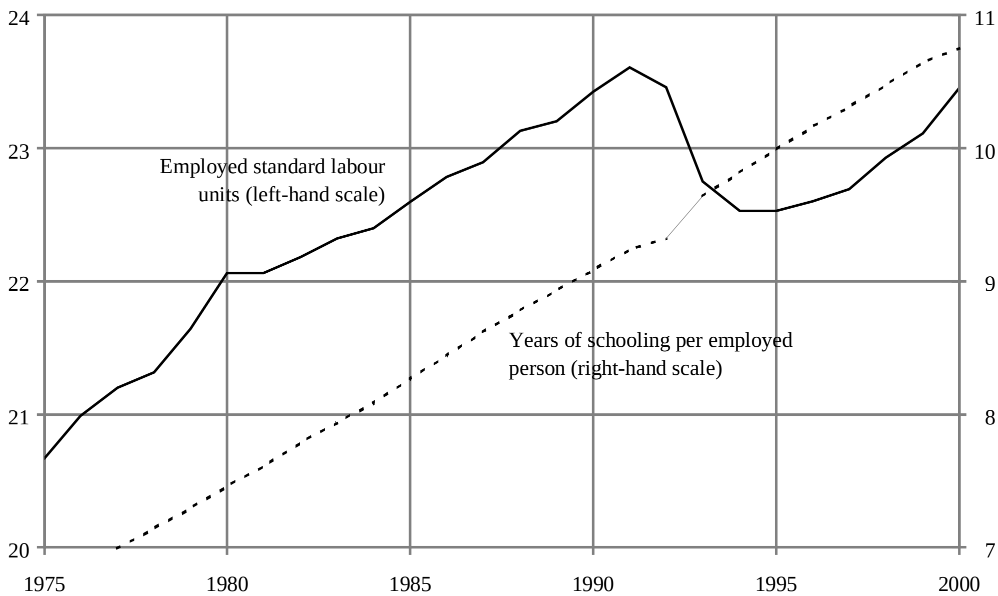
EDUCATIONAL ATTAINMENT OF EMPLOYED PERSONS, 1977-2000
(percentage values)



Source and notes: authors' elaboration on data from Istat LFS. The interruption of the lines between 1992 and 1993 signals the discontinuity introduced by a major methodological revision of the survey.

Figure 3

TOTAL EMPLOYMENT AND AVERAGE LEVEL OF SCHOOLING IN ITALY
(millions and number of years)



Source: authors' elaboration on data from Istat NA and LFS. The interruption of the dotted line between 1992 and 1993 signals the discontinuity introduced by a major methodological revision of the survey.

If the efficiency of one unit of labour is related to the educational achievement of the worker, this evidence suggests that efficiency cannot be taken as constant over time. To obtain an indicator of the quality of labour input, we can compute – as appropriate in growth accounting (e.g. U.S. Bureau of Labor Statistics, 1993, p. 13) – a Törnqvist index, whereby the annual rate of growth of the quality of the labour input Δe_t is defined as:

$$\Delta e_t = \sum_{i=1}^{n} \frac{1}{2} \left(\frac{w_{i,t} E_{i,t}}{\sum_{j=1}^{n} w_{j,t} E_{j,t}} + \frac{w_{i,t-1} E_{i,t-1}}{\sum_{j=1}^{n} w_{j,t-1} E_{j,t-1}} \right) (\Delta e_{it} - \Delta l_t), \tag{4}$$

where $E_{i,t}$ is the number of persons with school level *i* in year *t*, $\Delta e_{i,t} = \Delta \log E_{i,t}$ is its rate of growth, and $w_{i,t}$ is the quality valuation of school level *i* in year *t*. The index is derived by chaining subsequent rates of growth.

The first indicator is obtained by valuing the quality of each school level by the minimum years (as detailed in footnote 6) required to obtain the certificate; this means that $w_{i,t}$ is time-invariant. This method of controlling for labour quality is rather extreme, since it assumes that efficiency differentials between educational levels are substantial: for instance, a university graduate is presumed to be twice more productive than somebody who attended only middle school (18 vis-à-vis 8 years at school). These values are much higher than the estimated returns to education, which during the 1990s were in the order of 5-6 per cent per year at school. So long as wages reflect productivity, the differential between a graduate and a person with only a middle school certificate should vary from 50 to 60 per cent. In brief, approximating skill with years at school may tend to overestimate the contribution of the quality-adjusted labour input at the expense of that of total factor productivity.

A reasonable alternative to using the number of years is weighting different types of labour by their relative wage. This is the procedure followed by the BLS, which classifies workers by potential work experience (defined as age minus years of completed schooling minus 6), educational attainment and gender (U.S. Bureau of Labor Statistics, 1993, 1997, 2001) and compute the wage rates by estimating annual wage equations on data from the March Supplement of the Current Population Survey (labour input is expressed in terms of hours of work rather than persons employed). Jorgenson and Griliches (1995) and Dougherty and Jorgenson (1996, 1997) partition the employed into 20 groups according to sex, 2 employment statuses and 5 categories of educational attainment. Bassanini, Scarpetta and Visco (2000) and Scarpetta, Bassanini, Pilat and Scheyer (2000) distinguish 6 types of workers by gender and 3 level of educational achievement, but assume that the rate of growth of hours worked is constant across groups; relative wages are held constant over time, because of data constraints.

Following this second approach, we have elaborated two further quality adjustments of the labour input, by identifying the weight $w_{i,t}$ with either a fixed wage differential, or a time-varying wage differential. The mean after-tax monthly wages for 10 categories of full-time employees, distinct by sex and 5 educational levels, were computed from microdata from the Bank of Italy's Survey of Households' Income and Wealth (SHIW) for 15 years in the period 1977-1998.[7]

The indicators draw two rather different pictures: between 1977 and 2000, the quality of the labour input rises by 54 per cent weighting by years of schooling, as opposed to 10 per cent with either measure of wage differentials (Figure 4). The results from replicating the growth accounting exercise by using the three constant-quality indexes of labour input, i.e. by estimating (2) instead of (1), are reported in Table 2. The contribution of total factor productivity to output growth diminishes when the labour input is adjusted for quality, which in turn becomes a more important source of growth. As obvious from Figure 4, the magnitude of the adjustment is highly sensitive to the index used.

Between 1981 and 2000, the correction based on years of schooling contributes 1.3 percentage points (1.5-0.2) of the 1.9 per cent annual growth of the output. This contribution remains quite stable over time around 1.4 percentage points until 1995, but it drops to 1.0 in the last three years. This deceleration is a consequence of a less rapid rise of average years of schooling caused by a slowdown in population growth, and by a weakening of catching up in educational levels of subsequent cohorts. Correcting for years of schooling cancels the contribution of multifactor productivity, which becomes negative over the entire period and

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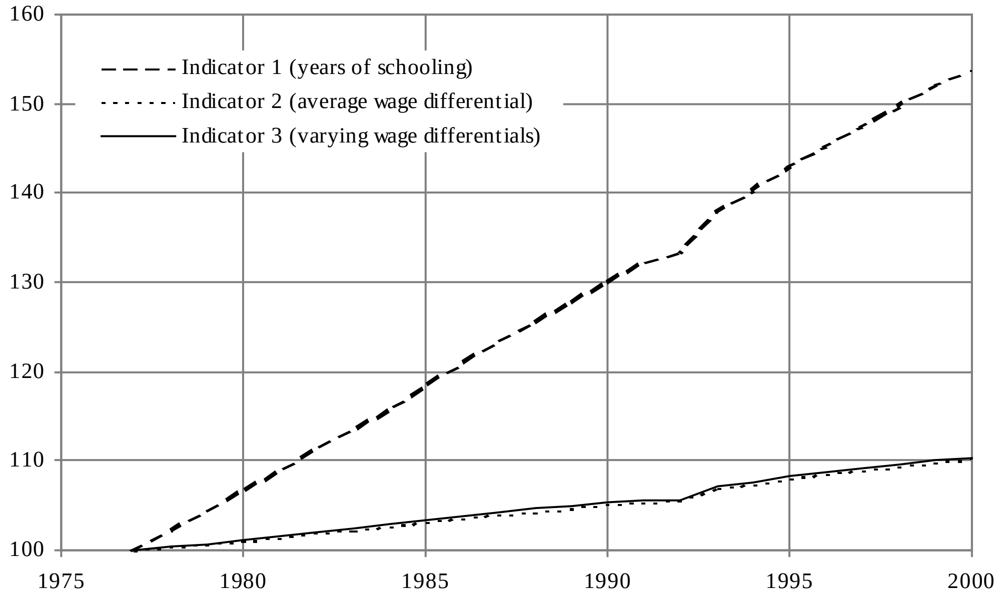
[7] Values for missing years were obtained by interpolation. Notice that data refer to job positions rather than employees and that gross incomes, that would be more appropriate for the exercise, are not available in the survey. For a detailed description of the data used see Brandolini, Cipollone and Sestito (2000, Appendix A).

reaches its lowest in the last three years. Adjusting for years of schooling makes labour the single most important factor, accounting for about three quarters of value added growth.

Figure 4

QUALITY INDICATORS OF THE LABOUR INPUT
(index 1977=100)



Source: authors' elaboration on data from Istat NA and LFS, and Bank of Italy SHIW.

Table 2

CONTRIBUTIONS TO THE GROWTH OF REAL VALUE ADDED, ALL ECONOMY 1983-1999
(percentage annualised values)

	1981-1985	1986-1990	1991-1995	1996-2000	1981-2000
Rate of growth of real value added	1.7	2.8	1.3	1.8	1.9
Contribution of stock of capital	0.8	0.8	0.6	0.7	0.7
Contribution of labour					
Unadjusted	0.3	0.5	-0.5	0.5	0.2
Quality-adjusted (years of schooling)	1.8	1.8	0.8	1.5	1.5
Quality-adjusted (average wage differentials)	0.6	0.8	-0.2	0.8	0.5
Quality-adjusted (varying wage differentials)	0.6	0.7	-0.2	0.8	0.5
Total factor productivity					
Unadjusted	0.6	1.5	1.2	0.6	1.0
Quality-adjusted (years of schooling)	-0.9	0.2	-0.1	-0.4	-0.3
Quality-adjusted (average wage differentials)	0.3	1.2	0.9	0.3	0.7
Quality-adjusted (varying wage differentials)	0.3	1.3	0.9	0.3	0.7

Source: authors' elaboration on data from various sources as described in the text.

The results obtained using relative wages as a proxy for differential efficiency confirm that approximating skill with years at school may lead to overestimate the contribution of the quality-adjusted labour input. With the wage-based corrections, the contribution of total factor productivity remains positive and sizeable, albeit reduced; the improvement of labour quality accounts for about one sixth of the overall output growth in the period 1981-2000. This contribution remains stable throughout the period, except for a peak around the 1993 recession, possibly due to a firms' tendency to fire low-skilled workers first in bad times. The specification of the wage differentials used in the Törnqvist index (varying year by year, or equal to averages over the entire period) makes virtually no difference to the results.

When the labour input is adjusted for quality on the basis of relative wages, multifactor productivity still gives a significant contribution, around a third, to output growth; however, its slowdown turns out to be more accentuated. Comparing the second half of the 1990s with the same period of the 1980s, the smaller output growth was partly attributable to slower human capital accumulation if we use the schooling year correction; with the relative wage correction, however, the decline mostly depends on the weaker increase of total factor productivity, which falls to 0.3 per cent in the second half of the 1990s.

5. Adjusted growth accounting for industry

Data availability for the industrial sector allows us to study two further adjustments, besides that for labour composition: hours worked and capital utilisation. To take into account changes in labour quality, we construct for industry the three Törnqvist indicators discussed before. Because of the lack of more detailed information, we are forced to approximate the distribution of workers by educational level with the distribution in industry plus construction. All other variables, however, relate to industry alone.

5.1 Worked hours

Standard labour units in national accounts express the labour input in full-time equivalent terms by correcting for part-time and employees receiving benefits from the Wage Supplementation Fund (WSF) (the latter are not at work but remain in firms' payrolls). This correction does not take into account that the average number of hours worked per capita may change over time. Unfortunately, data on hours worked are scarce in Italy, even for industry. Istat collects this information only for the largest companies (with 500 employees or more) in the Survey on Large Firms (SLF) conducted in industry and market services.[8] An alternative source is the database of the Bank of Italy Survey of Investment in Manufacturing (SIM), which is conducted on a representative sample of firms with 50 employees or more. This survey was used by Casadio and D'Aurizio (2000) to estimate hours actually worked per capita, with workers receiving WSF benefits either included (SIM unadjusted for WSF) or excluded (SIM adjusted for WSF).

The SLF indicator and the SIM indicator adjusted for WSF exhibit similar time patterns, except in the second half of the 1980s (Figure 5). The SIM unadjusted indicator grew faster until 1995, apart from a drop in 1993 when the recession led to a large rise of the share of employees receiving WSF benefit. The broad picture is that a substantial increase in the number of hours worked per capita took place between early 1980s and mid-1990s, in the order of 7 to 12 per cent depending on the indicator used. This means that the labour input associated with the average full-time worker (the concept used in national accounts) has varied over time and that this effect should be corrected for in growth accounting. The index used in the following exercise is the SIM indicator adjusted for WSF, retropolated by the SLF indicator.

5.2 Capacity utilisation

It is well-known that the utilisation of the stock of capital varies over the cycle. To get a better measure of the contribution of capital service to output growth, it is appropriate to correct the value of the capital stock for the degree of capacity utilisation. In the following estimates, the ISAE index of capacity utilisation was used.

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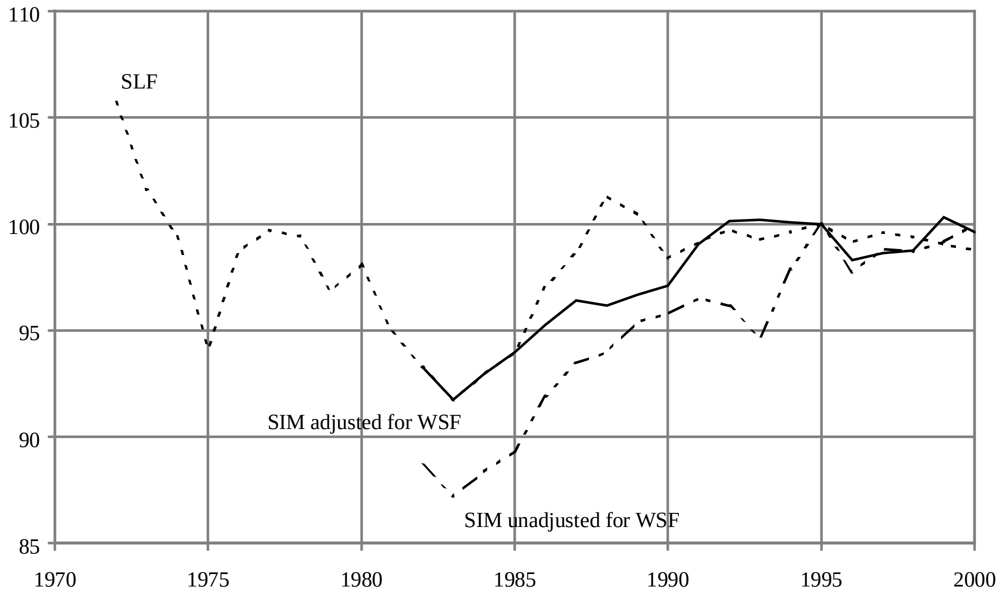
[8] There are at least two reasons why the SLF indicator of hours worked has to be treated with caution. First, sectors where large firms dominate, e.g. energy and transportation, are over-represented at the expense of sectors characterised by smaller firm sizes, such as textile and retail trade. Second, the traditionally low size of Italian firms coupled with a long-run tendency to downsizing means that the SLF covers a small and declining proportion of employees. According to the 1996 Census, the shares of employees of large firms were 21 and 29 per cent in industry and market services, respectively. In the last four years, the number of employees went up by about 16 per cent in market services and remained almost constant in industry, but it declined by 3.4 and 10 per cent, respectively, in large firms.

Figure 5

INDICATORS OF NUMBER OF HOURS WORKED PER CAPITA IN INDUSTRY
(index 1995 = 100)



Source: authors' elaboration on data from Istat SLF and from Bank of Italy SIM as elaborated by Casadio and D'Aurizio (2001). In the "SIM adjusted for WSF" series the total number of hours worked is divided by the total number of employees *excluding* those not at work and receiving benefits from the Wage Supplementation Fund (WSF); in the "SIM unadjusted for WSF" series the denominator is the total number of employees *including* those not at work and receiving benefits from the WSF.

5.3 Adjusted multifactor productivity

Over the period 1981-2000, the rate of growth of total factor productivity in industry – as measured in equation (1) without any adjustment for labour quality, hours worked, and capacity utilisation – has shown large variations around a flat trend (top panel of Figure 6). In this section we examine how this average tendency is affected by a better measurement of inputs. Accordingly, we modify equation (1) to improve our input measures by allowing for changes in labour quality, hours worked per capita, and capacity utilisation. This gives the new growth accounting equation

$$\Delta y = \alpha(\Delta l + \Delta e + \Delta h) + (1-\alpha)(\Delta k + \Delta u) + \hat{\theta}, \tag{5}$$

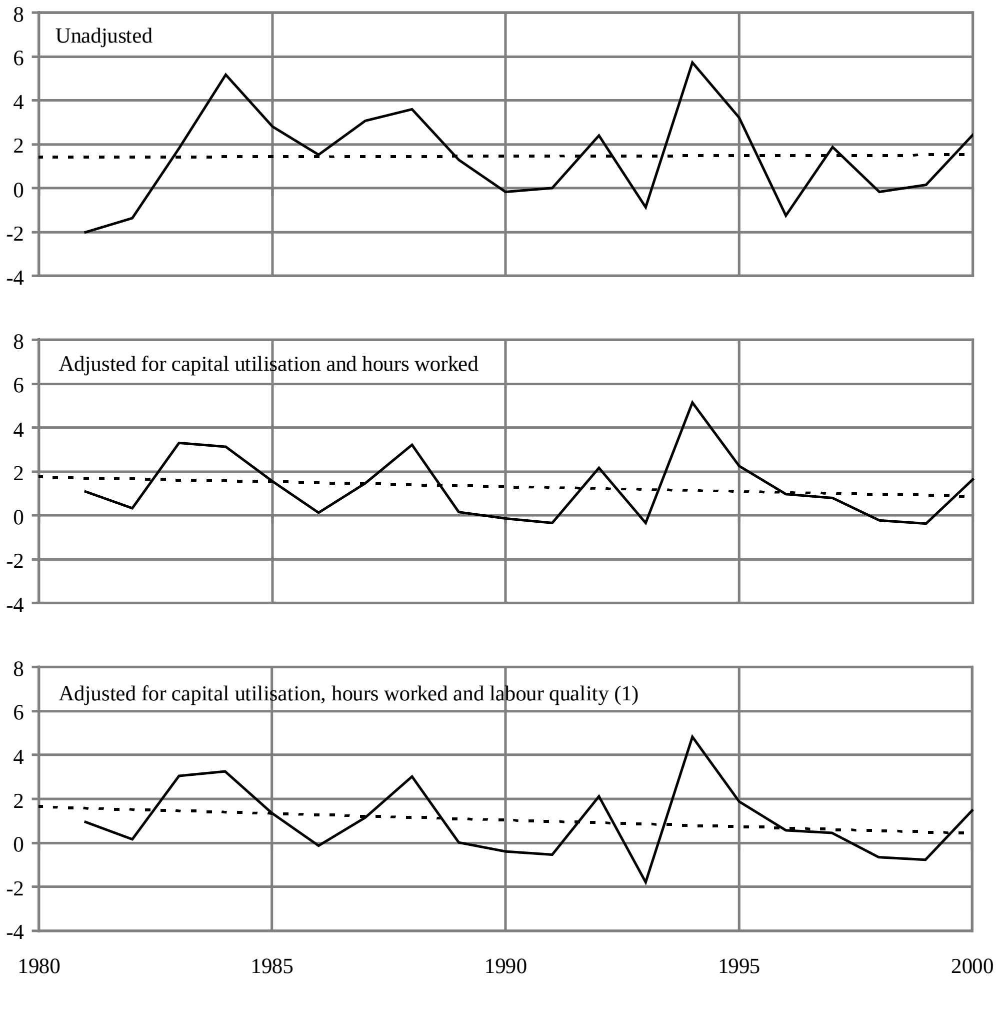
where variables are defined as before and h and u denote the logarithms of the index of hours worked and the degree of capacity utilisation, respectively. The Solow residual θ computed from (1) is related to the new estimate of multifactor productivity $\hat{\theta}$ as follows:

$$\theta = \Delta y - \alpha\Delta l + (1-\alpha)\Delta k = \hat{\theta} + \alpha(\Delta e + \Delta h) + (1-\alpha)\Delta u \,. \tag{6}$$

When labour quality, hours worked per capita or capacity utilisation rise, the residual computed from (1) over-estimates total factor productivity. The results from decomposing the rate of growth of real value added in industry using (5) are reported in Table 3.

Figure 6

GROWTH OF TOTAL FACTOR PRODUCTIVITY IN INDUSTRY
(percentage values)



Source: authors' elaboration on data from various sources as described in the text. (1) Labour input is adjusted for quality by using average wage differentials.

Table 3

CONTRIBUTIONS TO THE GROWTH OF REAL VALUE ADDED, INDUSTRY 1983-1999
(percentage annualised values)

	1981-1985	1986-1990	1991-1995	1996-2000	1981-2000
Rate of growth of real value added	0.1	3.1	1.4	1.3	1.5
Contribution of stock of capital					
Unadjusted	0.7	0.9	0.5	0.7	0.7
Adjusted for utilisation	0.7	1.4	0.4	0.8	0.8
Contribution of labour input					
Unadjusted	-1.9	0.4	-1.2	0.1	-0.6
Adjusted for hours worked	-2.4	0.8	-0.8	0.0	-0.6
+ quality-adjusted (years of schooling)	-1.5	2.0	0.6	1.0	0.5
+ quality-adjusted (average wage differentials)	-2.3	1.0	-0.3	0.3	-0.3
+ quality-adjusted (varying wage differentials)	-2.3	1.0	-0.3	0.2	-0.3
Total factor productivity					
Unadjusted	1.3	1.8	2.1	0.5	1.4
Adjusted for capital utilisation	1.3	1.3	2.2	0.4	1.3
Adjusted for hours worked	1.8	1.4	1.7	0.6	1.4
Adjusted for capital utilisation and hours worked	1.8	0.9	1.8	0.5	1.3
+ quality-adjusted (years of schooling)	0.9	-0.3	0.4	-0.5	0.2
+ quality-adjusted (average wage differentials)	1.7	0.7	1.3	0.2	1.0
+ quality-adjusted (varying wage differentials)	1.7	0.7	1.3	0.3	1.0

Source: authors' elaboration on data from various sources as described in the text.

On average, using the index of hours worked and the degree of capacity utilisation has virtually no effect on the rate of growth of total factor productivity, although it tends to turn its flat trend into a slightly declining one (central panel of Figure 6). The small effect of this correction on the mean rate over the entire period derives from averaging out different episodes. In particular, during the economic expansion of the late 1980s, Italian industrial firms undertook an intense reorganisation that led to a more efficient utilisation of manpower and plants: the better use of inputs shows up in a cumulative contribution to output growth that is almost twice that provided by the sole increase in employed units and physical capital (2.2 against 1.3 percentage points).[9] This process came to a halt in the 1990s, and in the second half of the decade improvements in the use of inputs did not sustain growth, suggesting that the margins for expanding output without hiring additional staff or employing more capital had progressively diminished.

[9] The more intensive use of the work force since 1986 is discussed by Casadio and D'Aurizio (2001).

The higher quality of the labour input has the effect of reducing the estimated increase of total factor productivity: the adjustment based on relative wages cuts its average rate of growth between 1981 and 2000 (after correcting for capital utilisation and hours worked) by about a fourth, while the adjustment based on years of schooling would almost wipe it off. When all corrections are implemented, the temporal profile of the growth in total factor productivity is somewhat less variable, and its linear trend is slightly negative (bottom panel of Figure 6). On average, after adjusting for capital utilisation, hours worked and changes in labour quality, the rate of growth of total factor productivity appears to diminish by 0.05 percentage points per year, or one percentage point every 20 years.

To sum up, the more accurate – but far from exhaustive – measurement of inputs leads us to revise downwards the rise in total factor productivity in industry since 1981. We find that such rise still accounts for two thirds of the growth of real value added. Also, we confirm that a productivity slowdown occurred in recent years.

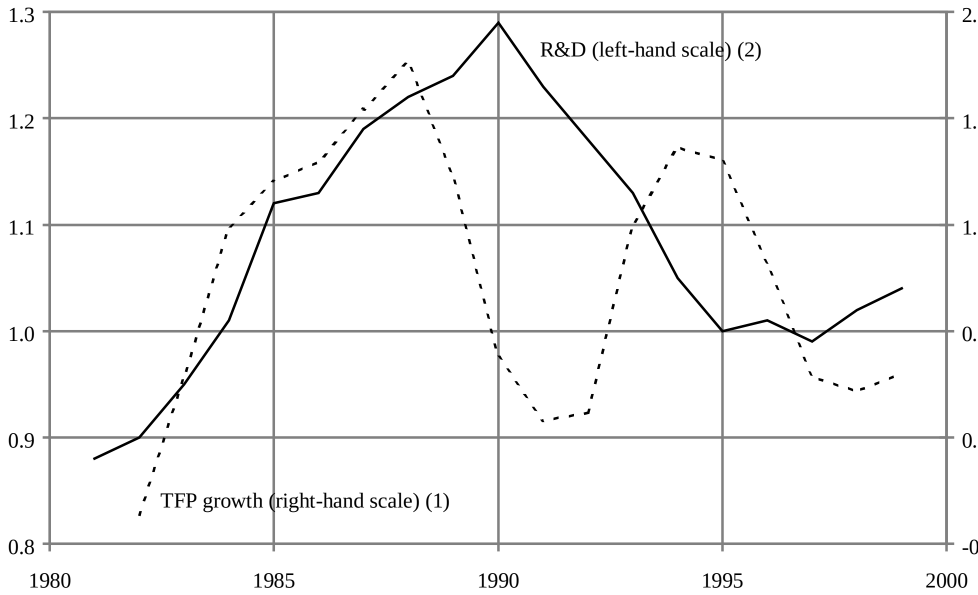
6. Conclusions

In this paper we have examined how the evidence for Italy from a growth accounting exercise is modified by a more accurate measurement of inputs. We have followed on Jorgenson and Griliches's (1967) suggestion that "… if real product and real factor input are accurately accounted for, the observed growth in total factor productivity is negligible" (p. 249), and we have indeed found that a sizeable part of this observed growth vanishes when changes in the quality of labour input and, for industry, in hours worked and capital utilisation are corrected for. Once these adjustment are made, in the years 1981-2000 the increase in total factor productivity accounts for over a third of the annual growth of real value added in the whole economy, and for about two thirds in industry. These adjustments are not sufficient, however, to overturn the evidence of a productivity slowdown in the Italian economy in the second half of the 1990s.

In addition to refining the measures proposed in the paper and carrying the analysis backwards to the early 1970s, two extensions seem worth pursuing in future work. First, the issue of firms' market power in the output markets might be tackled by relying on cost-based rather than revenue-based shares, taking advantage of the estimates of the rental price of capital due to Ganoulis, Parigi and Staderini (1998). Second, the relationship between the adjusted Solow residual and indicators of R&D could be studied. Figure 7 suggests that the association may be positive, but accurate testing is evidently needed.

Figure 7

TOTAL FACTOR PRODUCTIVITY AND EXPENDITURE ON R&D
(percentage values)



Source: (1) authors' elaboration on data from various sources as described in the text. 3-year centred moving average. Labour input is adjusted for quality by using average wage differentials. (2) OECD (2000). Gross domestic expenditure on R&D, as a percentage of GDP.

References

Bassanini, A., S. Scarpetta and I. Visco (2000). "Knowledge, Technology and Economic Growth: Recent Evidence from OECD Countries". Paper presented at the 150th Anniversary Conference of the National Bank of Belgium, Brussels,11-12 May 2000.

Brandolini, A., P. Cipollone and P. Sestito (2000). "Earnings Dispersion, Low Pay and Household Poverty in Italy, 1977-1998". In D. Cohen, T. Piketty and G. Saint-Paul (eds.), *The New Economics of Rising Inequalities*. Oxford: Oxford University Press, forthcoming.

Casadio, P. and L. D'Aurizio (2000). "Orari di lavoro pro capite, flessibilità e efficienza produttiva dell'industria manifatturiera italiana tra il 1985 e il 1998". *Rivista italiana degli economisti*, 5(3), pp. 413-447.

Dean, E. R. (1999). "The Accuracy of the BLS Productivity Measures". *Monthly Labor Review*, February, pp. 24-34.

Dougherty, C. and D. W. Jorgenson (1996). "International Comparisons of the Sources of Economic Growth ". *American Economic Review Papers and Proceedings*, 86(2), pp. 25-29.

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

Ganoulis, I., G. Parigi and A. Staderini (1998). "Taxation and the User Cost of Capital in Italy", mimeo.

Gobbi, G. and G. Pellegrini (1997). "La misurazione del prodotto bancario". In *Ricerche quantitative per la politica economica 1995*, vol. II, pp. 783-818. Rome: Banca d'Italia.

Griliches, Z. (1994). "Productivity, R&D, and the Data Constraint". *American Economic Review*, 84(1), pp. 1-23.

Griliches, Z. (1996). "The Discovery of the Residual: A Historical Note". *Journal of Economic Literature*, 34(3), pp. 1324-1330.

Gullickson, W. (1992). "Multifactor Productivity in Manufacturing Industries". *Monthly Labor Review*, October, pp. 20-32.

Gullickson, W. (1995). "Measurement of Productivity Growth in U.S. Manufacturing". *Monthly Labor Review*, July, pp. 13-28.

Gullickson, W. and M. J Harper (1999). "Possible Measurement Bias in Aggregate Productivity Growth". *Monthly Labor Review*, February, pp. 47-67.

Hall, R. E. (1990). "Invariance Properties of Solow's Productivity Residual". In P. Diamond (ed.), *Growth/Productivity/Unemployment. Essays to Celebrate Bob Solow's Birthday*, pp. 71-112. Cambridge, MA: MIT Press.

Hornstein, A. (1999). "Growth Accounting with Technological Revolutions". *Federal Reserve Bank of Richmond Economic Quarterly*, 85(3), pp. 1-22.

Istat (1990). “Nuova contabilità nazionale”. *Annali di statistica*, year 119, series IX, vol. 9.

Jorgenson, D. W. and Z. Griliches (1967). “The Explanation of Productivity Change”. *Review of Economic Studies*, 34(3), pp. 249-283.

Jorgenson, D. W. and Z. Griliches (1995). “The Explanation of Productivity Change”. In D. W. Jorgenson (ed.), *Postwar U.S. Economic Growth*, pp. 51-98. Cambridge, MA: MIT Press.

Lupi, C. and S. Mantegazza (1994). “Ricostruzione delle serie degli investimenti per branca utilizzatrice, per branca proprietaria e calcolo dello stock di capitale”. Istat, *Quaderni di ricerca*, No. 14.

OECD (2000). *Main Science & Technology Indicators*. Paris: OECD.

Scarpetta, S., A. Bassanini, D. Pilat and P. Scheyer (2000). “Economic Growth in the OECD Area: Recent Trends at the Aggregate and Sectoral Level” *OECD Economic Department Working Papers*, No. 21.

Solow, R. M. (1957). “Technical Change and the Aggregate Production Function”. *Review of Economics and Statistics*, 39(3), pp. 312-320.

U.S. Bureau of Labor Statistics (1993). *Labor Composition and U.S. Productivity Growth, 1948-90*, Bulletin 2426, December.

U.S. Bureau of Labor Statistics (1997). “Chapter 10. Productivity Measures: Business Sector an Major Subsectors”. In U.S. Department of Labor, Bureau of Labor Statistics, *BLS Handbook of Methods*, at: http://stats.bls.gov/hom/homch10.pdf.

U.S. Bureau of Labor Statistics (2001). *Changes in the Composition of Labor for BLS Multifactor Productivity Measures, 1999*, mimeo, April, at: http://stats.bls.gov/mprlabor.pdf>.

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