The decline in Italian productivity: new econometric evidence

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Abstract

This paper addresses the question of the source of the productivity slowdown experienced by the Italian economy in the last decade using panel cointegration methods. The preliminary results confirm that the decline in labour productivity in the past decade is largely due to a fall in TFP. Our estimates of TFP growth are consistent with those obtained by the traditional griowth accounting approach.

Keywords: Labour Productivity, Productivity Slowdown, Italy, Panel Cointegration.

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Very preliminary, please do not quote

1 Introduction[1]

As it is well documented (see Daveri and Jona-Lasinio, 2005, among others), the growth of labour productivity in Italy in the past decade has been abysmal, the poorest in Europe together with Spain[2]. From 1995 to 2004, per capita GDP growth was barely 1.3% per annum; from 2000 onward the pace declined to around 0.5%.

Such a poor performance raises a fundamental question: is the productivity slowdown due to a fall in capital intensity in the Italian economy, perhaps linked to a change in factor prices vis-à-vis the Eighties (a movement along the isoquant), or is it due to a decline in total factor productivity (a shift in the isoquant)? The answer to this question is a very important one from a policy perspective. In fact, if one concluded that the productivity slowdown follows a re-adjustment in the factor mix, consistent with the observed upsurge in employment in the last decade, many reasons of concern would wane, since the phenomenon could be seen as a market-driven reaction to an excessive capital intensity of the past. On the other hand, if the problem lies in total factor productivity (henceforth TFP), then two possibilities arise: either the slowdown reflects the exhaustion of the "quality adjustment" component, linked to reallocation across industries, labour skills or capital vintages (see the literature dating back to Denison, 1967, and Matthews *et al.*, 1982); or it reflects a decline in pure (disembodied) technological progress in the Italian economy, due, say, to fewer research, development and innovation. The latter hypothesis is of particular concern to policy-makers, as it would result in a prolonged competitiveness gap of the Italian industry vis-à-vis other countries, especially within the single currency area.

A number of studies have tackled the question: see for instance Bassanetti *et al.* (2004) and Daveri and Jona-Lasinio (2005). They conclude that most of the decline in productivity since 1995 is due to the decline in total factor productivity; indeed there has been some reduction in capital deepening in the period, but this has been compensated by an increase in the share of capital in the economiy-wide value added. For instance Daveri and Jona-Lasinio estimate that 1 out of the 1.2 percentage points reduction in labour productivity growth with respect to the period 1980-95 is accounted

[1]We would like to thank Riccardo Cristadoro for kindly providing the series of the Bank of Italy Capacity Utilisation Index. The first author acknowledges financial support from University of Rome "La Sapienza" and MIUR.

[2]For a very recent assessment based on the Groeningen dataset see Conference Board (2007).

for by the decline in TFP in the overall economy. The negative contribution of TFP to labour productivity growth is widespread: all industries, with the exception of utilities, displayed a slowdown of TFP since 1995 and an abrupt fall since 2000. This finding militates against the hypothesis that the decline in TFP is caused by a halt to the process of reallocation towards high productivity industries.

Although these findings are definitely plausible, more work is needed. First of all, standard growth accounting assumes constant returns to scale and perfect competition in both the products and factors markets: hypothesis respectively not guaranted and very unlikely to hold. Hence, as put by Stiroh (2002): "While growth accounting provides a valuable and well-tested means for understanding the proximates sources of growth, additional tests are needed to corroborate those results" (p. 1559). Second, to assess how widespread the declining productivy problem is we need to examine data at a fairly high disaggregation level. The aim of this paper can thus be described as follows: first of all, we will review the data evidence for individual industries at NACE Subsection level. Second, following a largely novel non-stationary panel approach, we will estimate models for labour productivity obtaining estimates of the underlying aggregate TFP trend for the entire set of industries included in the analysis. The non-stationary panel analysis delivers robust results, which allow us to circumvent the well-known shortcomings of the growth accounting methodology. Since the technique requires to estimate production functions for each industry (a linear approximation of a CES in our case), we also tested whether the elasticity of substitution between capital and labour is different from one. Such a test has some bearing on the discussion on the proximate causes of the productivity slowdown. Suppose that we discover that the elasticity is one: factor shares are constant, at least in the long-run. Then, if real wages increase at a slower pace than in earlier periods, as they did in the last decade in Italy, the slowdown in labour productivity is somewhat predetermined in order to maintain the constancy of the share. All in all we cannot reject the hypothesis of unit elasticity of substitution, although the power of the test turns out to be very low.

The paper is organises as follows: we shall first examine the data (section 1), then move to modelling issues (section 2, with the technical details of the bootstrap algorithms employed described in the Appendix). Some conclusions will finally be drawn (section 3).

2 What do the Disaggregate Data Say? Productivity, Output, Labour and Capital Trends

Since we will estimate a single TFP trend we will limit the analysis to the Subsections included in the NACE Sections "Mining and Quarrying" (C), "Manufacturing" (D) and "Electricity, Gas and Water Supply" (E, henceforth "Utilities"; the NACE classification with all the abbreviations used as well as, for reference's sake, the average value added shares and capital/labour ratios of all industries, are reported in the Appendix). Agriculture and Market Services, technically far too heterogenous, and, as far as the latter is concerned, plagued by serious productivity measurement problems, have been excluded. As data on Capital are available from 1980, a peak year according to almost all dating methods (Bruno and Otranto, 2003), until 2001, we will examine the period 1981-2001.

First of all, let us review the main picture. The Labour Productivity, Value Added, Employment and Capital logs and rates of growth for the aggregate of the Mining, Manufacturing and Utilities over the period 1981-2001 are plotted in Fig. 1, with average rates of growth for the 1981-1995[3] and 1996-2001 subperiods in Table 1. Employment is measured in Standard Labour Units (henceforth "Labour Units"), Istat's implementation of the ESA95 concept of full time equivalent employed person; Labour Productivity is defined as Value Added per Labour Unit; finally, Capital is rescaled by the Bank of Italy Capacity Utilisation Index. Cyclical fluctuations are thus largely excluded from the picture.

The log plots (left column) tell an apparently rather clear story: Labour Productivity, Value Added and Capital/Labour ratio grew more or less steadily, while employment followed an opposite, declinining trend. However, looking at the plots in the right column we can notice that in fact both labour productivity and the capital/labour ratio growth kept falling throughout the period, while employment growth accelerated over the last years of the sample.

Let us now first examine the broad trends in the individual industries (Figs. 2A-2B and Table 1). The aggregate globally positive trend in labour productivity is mirrored in all industries except Energy Mining and Coke, where Value Added has been declining sharply both in absolute terms and per Labour Unit respectively since the beginning of the period and the mid'90's. Considering both the negligible size of these two industries (on the average, they account for 0.16% of the labour inputs used in the Italian

[3] According to all dating methods 1995 was a peak year (Bruno and Otranto, 2003).

economy, 0.7% of those used in the Mining, Manufacturing and Utilities aggregate) and that this pattern is completely anomalous we decided to exclude them from the main empirical analysis.

Partially different trends in Labour Productivity are also found in the "Other Manufacturing" and Utilities, where at the end of the 1980's a phase of growth followed a decade of stagnation. In fact, these two industries and the Transport industry are the only cases in which productivity growth was higher in the 1996-2001 period than in 1981-1995; in all the other cases it fell, sometimes substantially.

Capital endowments per Labour Unit grew in all industries[4]; contrary to productivity, average annual rates of growth have been higher in the second part of the sample in almost half of the industries. As a consequence, the partial correlation between the growth in the Capital/Labour ratio and that of Labour Productivity over the entire period is ambiguous and not robust to the cluster of industries examined. Looking at Fig. 3, we can see that if we exclude the Chemical and Energy Mining industries, outliers for opposite reasons, the correlation is clearly positive. On the other hand, if we treat the Electrical and Transport Equipment industries (which lay at the upper right corner of the plot, with strong positive growth of both Capital/Labour ratio and Labour Productivity) as outliers the impression is of no correlation: an entire range of Labour Productivity growth rates (from slightly negative to strongly positive) is compatible with approximately similar rates of growth of Capital/Labour ratios.

Globally positive trends are found for Value Added in most industries as well, except the cases already mentioned above and that of the Leather Industry, where from 1995 until the end of the period Value Added fell at a 3% annual rate in real terms; in this case as well the cause is a negative Output trend. In a few cases some some strong cyclical swings took place (for instance, in the Transport equipment industry after the 1992 depreciation crisis).

Finally, Employment trends are more varied. In one case only (Rubber) a positive trend spanned the entire period; in four more industries (Food, Paper, Non-metals, Other Manufacturing) 2001 levels are close to the 1981 ones; in two cases (Other Manufacturing and Utilities) a positive trend in the 1980's was followed by a sharp decline, mirroring the pattern of Labour Productivity. Finally, in the remaining nine industries (Textiles, Leather,

[4]Because of the lower detail of the Capacity Utilisation Index the following approximations have been introduced: (i) the index for "Leather and Textiles" has been used for both the Textile and the Leather industries; (ii) the economy-wide index has been used for the Non metals and the Utilities.

Wood, Coke, Chemicals, Basic Metals, Machinery, Electrical Equipment) there is an overall negative trend, although in last three cases a short cycle of positive growth towards the end of the period resulted in final levels of Employment only marginally lower than the initial ones. Growth in the late 1990's has almost in all cases faster (or decline slower) than in the 1980's, with the only exception of the three industries where productivity growth did not fall between the two periods. In fact, a negative partial correlation bewteen Labour Productivity and Employment growth is clear, with the plot (Fig. 4) closely matching that for the EU reported by Daveri (2004).

Before moving to the modelling issue, let us discuss the time series properties of the series. The general impression is obviously of non-stationarity; given the small time sample in order to run a formal test we need to use a panel unit root test, and since the units are obviously not independent it must be robust to cross-correlation. A procedure which appears to be both simple and powerful is Pesaran (2005) CIPS test, which is essentially an average of the Dickey-Fuller tests computed for the individual units (*i.e.*, the popular test by Im, Pesaran and Shin, 2003) augmented with the cross-section means. The results, reported in Table 3, are largely in favour of the unit root hypothesis thus confirming the graphical evidence.

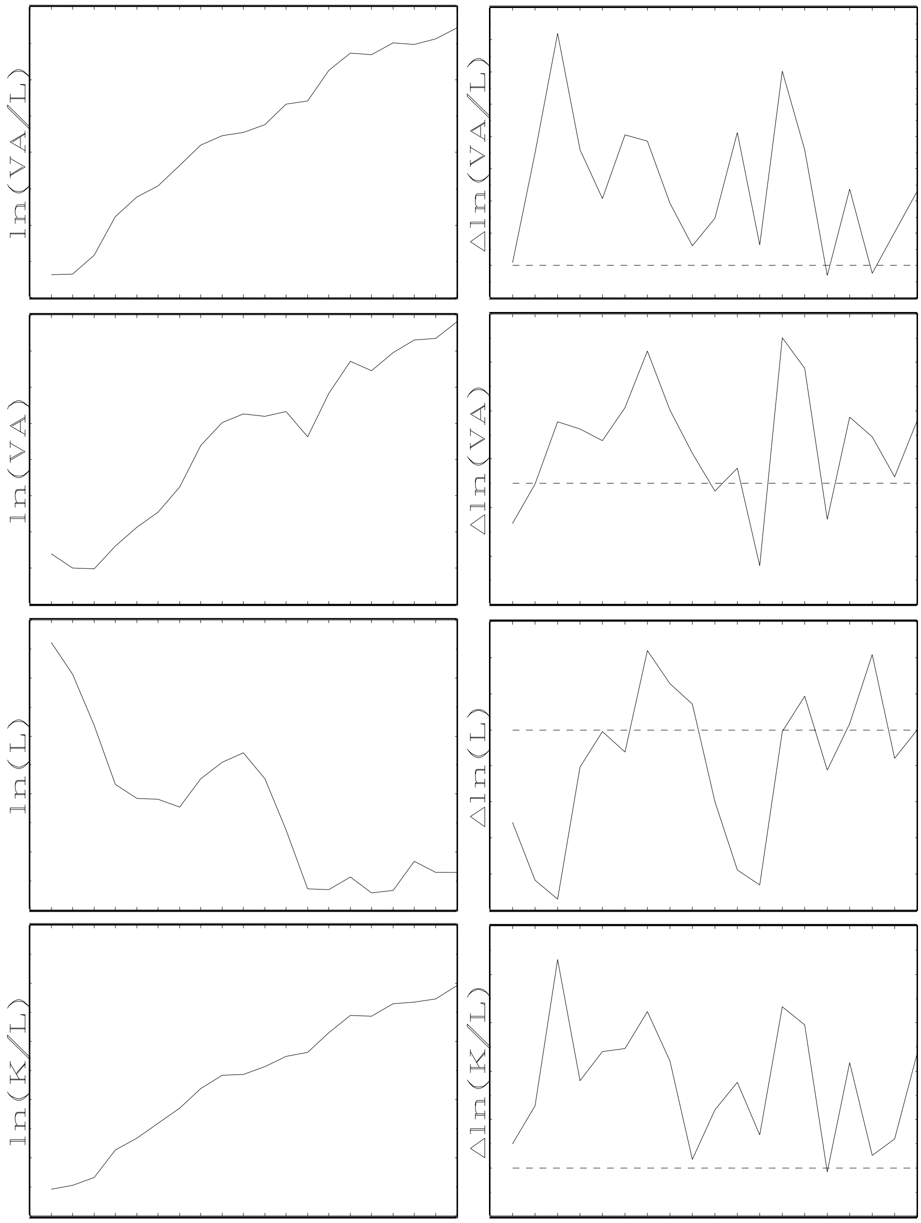

Fig. 1. Mining, Manufacturing and Utilities, 1981-2001. Top to bottom: Value Added per Labour Unit, Value Added, Employment in Labour Units, Gross Capital per Labour Unit. Left: logs; right: $\Delta \log$. Value Added at 1995 prices; Capital at 1995 prices rescaled by the Bank of Italy Capacity Utilisation Index .

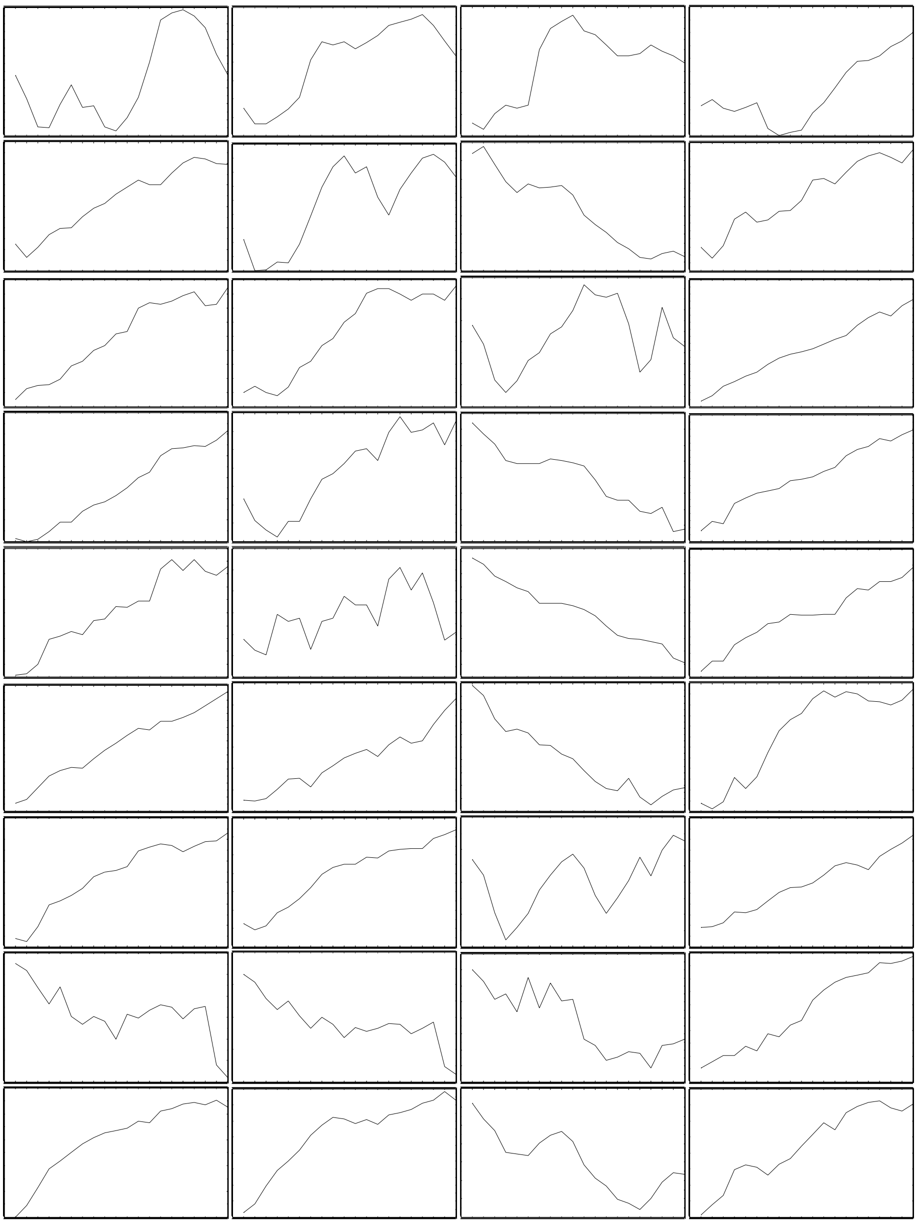

Fig. 2A. Columns, left to right: Value Added per Labour Unit, Value Added, Employment in Labour Units, Gross Capital per Labour Unit, 1981-2001 (logs; Value Added at 1995 prices; Capital at 1995 prices rescaled by the Bank of Italy Capacity Utilisation Index); rows, top to bottom: [1] Energy [2] Non-Energy [3] Food [4] Textiles [5] Leather [6] Wood [7] Paper [8] Coke [9] Chemicals (abbreviations: see table A1).

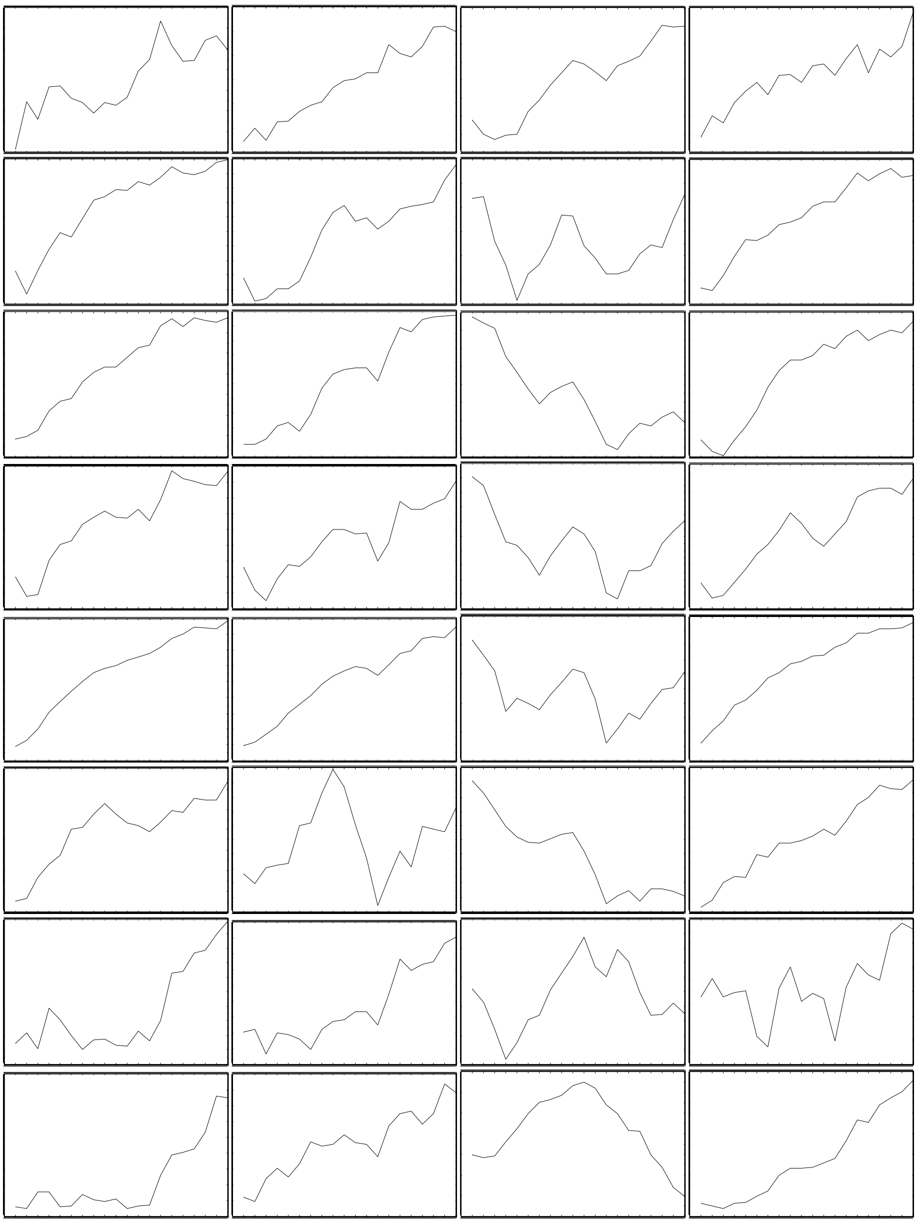

Fig. 2B. Columns, left to right: Value Added per Labour Unit, Value Added, Employment in Labour Units, Gross Capital per Labour Unit, 1981-2001. (logs; Value Added at 1995 prices; Capital at 1995 prices rescaled by the Bank of Italy Capacity Utilisation Index); rows, top to bottom: [1] Rubber [2] Non-metals [3] Metals [4] Machinery [5] Electricals [6] Transport [7] Other [8] Utilities (abbreviations: see table A1).

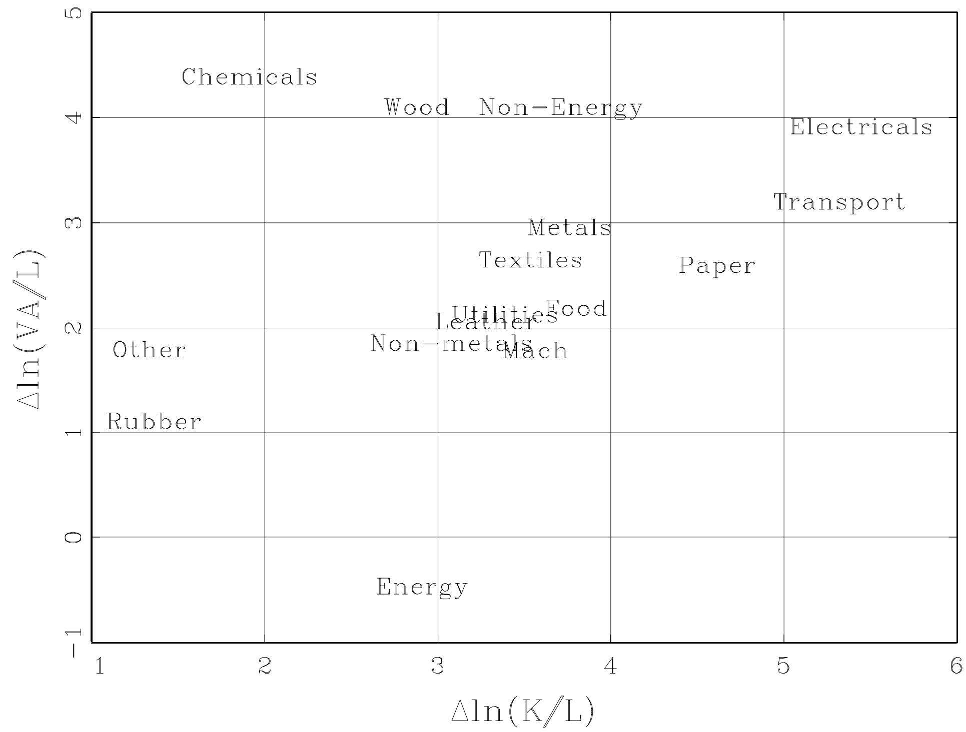

Fig. 3. Annual average rates of growth×100 of Capital per Labour Unit (K/L) and Value Added per Labour Unit (VA/L), 1982-2001 (Industries abbreviations: see table A1). Coke excluded to improve readibility.

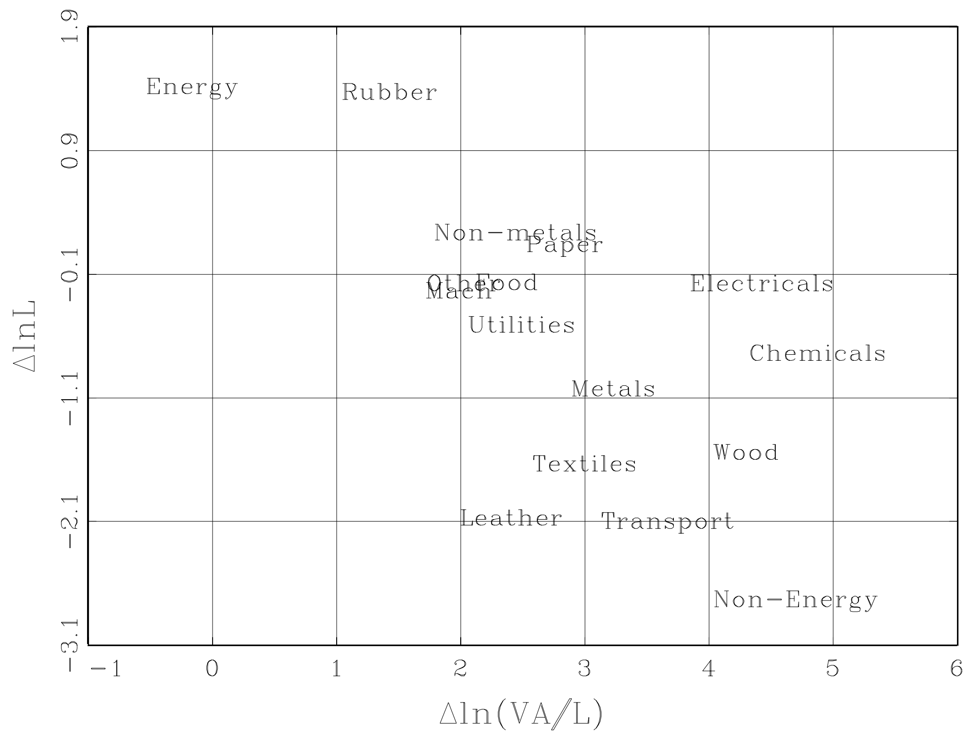

Fig. 4. Annual average rates of growth×100 of Value Added per Labour Unit (VA/L) and Labour Units (L), 1981-2001 (Industries abbreviations: see table A1).

Table 1
Labour Productivity, Value Added, Labour and Capital
in the Italian Mining, Manufacturing and Utilities Industries, *1982-2001*
Average annual rates of growth×100

	VA per Labour Unit		Value Added		Labour Units		Capital per Labour Unit	
	81-95	96-01	81-95	96-01	81-95	96-01	81-95	96-01
Energy	1.1	-5.3	3.3	-6.3	2.2	-1.0	2.4	5.0
Non-Energy	5.3	0.6	1.3	0.7	-3.7	0.1	3.9	0.7
Food	2.5	1.0	2.2	0.9	-0.3	0.0	4.0	3.9
Textiles	2.8	1.8	1.0	0.4	-1.8	-1.3	4.1	2.7
Leather	2.7	-0.3	0.6	-2.5	-2.1	-2.3	3.4	3.5
Wood	4.2	3.6	1.8	4.1	-2.3	0.5	3.3	1.0
Paper	2.7	1.9	2.8	2.2	0.0	0.3	3.7	7.7
Coke	−3.4	-6.3	-4.7	-6.0	-1.4	0.3	5.1	3.0
Chemicals	6.0	-0.5	4.4	0.9	-1.5	1.4	2.4	-0.1
Rubber	1.1	0.8	2.3	2.4	1.2	1.6	0.9	2.6
Non-metals	2.3	0.3	1.7	2.9	-0.6	2.6	3.5	0.2
Metals	3.7	0.5	2.1	0.9	-1.6	0.4	3.7	2.2
Machinery	2.1	0.6	1.2	2.0	-0.9	1.4	3.5	2.1
Electricals	4.8	0.9	4.1	2.2	-0.7	0.2	7.3	1.8
Transport	3.0	3.7	0.1	3.2	-2.7	-0.4	6.3	2.9
Other	1.3	2.9	1.3	2.0	0.0	-0.8	0.6	4.4
Utilities	1.2	4.8	1.5	1.5	0.3	-3.1	2.6	4.8
Aggregate	2.9	1.1	1.7	1.4	-1.2	0.3	3.8	2.7

VA: Value Added at 1995 prices; 1 Labour Unit = 1 full time employee;
Capital: Gross Capital at 1995 prices rescaled by the Bank of Italy utilisation index.
Source: Istat, *Conti economici nazionali 1970-2004*.

Table 2
Labour Productivity, Labour and Capital/Labour ratio
Panel Unit Root Tests 1981-2001

	VA per Labour Unit	Labour Units	Capital per Labour Unit
$CIPS^C$	-1.43	-0.64	-1.81
$CIPS^T$	-1.70	-1.52	-1.65

CIPS: truncated mean of the individual ADF statistics augmented with cross-section means; panel: all industries of the Mining, Manufacturing and Utilities Sections except Energy Mining and Coke ($N = 15$).
$CIPS^C$: CIPS statistic with constant;
$CIPS^T$: CIPS statistic with constant and trend.
Critical values ($T = 20$, $N = 15$):
constant : $5\% - 2.26; 10\% - 2.14$;
trend: $5\% - 2.78; 10\% - 2.67$.

3 Modelling Labour Productivity

Although the economic analysis of productivity is well-known (to say the least) we shall briefly review some basic concepts in order to establish notation.

We are interested in Labour Productivity trends in a panel of N industries over T time periods. Since data on intermediate inputs are not available we measure production by Value Added (Y), rather than the theoretically preferable Gross Output. Denoting by F_i a generic production function for industry i, by L and K, as usual, respectively labour inputs and capital, by P a time-dependent factor capturing Hicks-neutral technical progress in industry i, we are thus interested in estimating the function $Y_{it} = P_{it}F_i(L_{it}, K_{it})$. Since capital-labour substitution is the main issue of interest a Cobb-Douglas specification, which assumes elasticity of substitution equal to 1, is out of question. Some experimentation with the Translog, the most general production function, delivered unsatisfactory results, with erratic and unprecise coefficient estimates likely to be due to multicollinearity problems. The only viable option thus seems to be the well-known Kmenta (1967) linearisation of the CES around the point implying capital-labour elasticity of substitution equal to 1:

$$y_{it} = \alpha_i + p_{it} + \beta_0 l_{it} + \beta_1 k_{it} + \beta_2 (k_{it} - l_{it})^2 + \varepsilon_{it} \qquad (1)$$

where lower-case letters indicate logs and α_i is a scale parameter. Subtracting log labour inputs from both sides of (1) and rearranging we finally obtain an equation for log labour productivity (π) under CES technology with unconstrained returns to scale:

$$\pi_{it} = \alpha_i + p_{it} + (\beta_0 + \beta_1 - 1) l_{it} + \beta_1 (k_{it} - l_{it}) + \beta_2 (k_{it} - l_{it})^2 + \varepsilon_{it}. \qquad (2)$$

The CES with constant returns to scale and the Cobb-Douglas may be readily obtained from (2) excluding respectively the labour and squared capital-labour ratio terms.

Before examining in detail the issue of technical progress two points must be discussed. First, although (2) allows for an elasticity of substitution different from 1, the linearisation is valid only for small deviations from this value. Thus, although estimates of the elasticity of substitution very distant from 1 have been reported in the literature (for instance, Duffy and Papageorgiu, 2000, report estimates implying an elasticity of substitution close to 2.5) the results obtained must be interpreted with great care. Estimated elasticities close to 1 should be regarded as inconclusive, rather than supporting the Cobb-Douglas hypothesis.

Second, since, as we will see below, capital per labour unit is nonstationary the presence of its square brings us into the domain of asymptotics for non-linear transformations of integrated series. Fortunately, things turn out to be very simple, as Park and Phillips (1999) showed that with functions such as the square power of interest here we may expect the OLS estimator to be consistent and mixed normal as in the usual linear cointegrating regression.

Let us now move to technical progress, represented in (2) by the term p_{it} which can be described as a "technology shift parameter" (Mahony and Vecchi, 2003) or a "total factor productivity [TFP] index" (Harrigan, 1999). While in pure time series modelling a functional form for p_{it} must be specified *a priori,* exploiting the panel structure of the data we can obtain unconstrained estimates. First of all, over rather short time spans, as it is the case here, we can assume p_{it} to be the sum of a common factor (θ_t), general technical progress, and a time-constant industry shift factor (ι_i). Then (2) becames

$$\pi_{it} = \alpha_i' + \theta_t + (\beta_0 + \beta_1 - 1) l_{it} + \beta_1 (k_{it} - l_{it}) + \beta_2 (k_{it})^2 + \varepsilon_{it} \qquad (3)$$

where $\alpha_i' = \alpha_i + \iota_i$. Define a set of time dummies $D_\tau = 1$ if $t = \tau, 0$ else, $t = 2, \ldots, T$ (one of the time periods must be excluded to avoid singularity); an heterogenous panel long-run model of labour productivity based on (3) and including common time dummies is given by:

$$\pi_{it} = \delta_i + \gamma_0 l_{it} + \gamma_1 (k_{it} - l_{it}) + \gamma_2 (k_{it} - l_{it})^2 + \varphi_t D_t + \varepsilon_{it} \tag{4}$$

where $t = 1, 2, \ldots, T$ and $i = 1, 2, \ldots, N$. The coefficients of the common time dummies $\boldsymbol{\varphi} = [\varphi_2 \varphi_3 \ldots \varphi_T]$ measure the mean shifts in labour productivity which in every period cannot be explained by changes in Capital/Labour ratio and, when $\gamma_0 \neq 0$ so that returns to scale are different from one, changes in scale of production. They thus do capture the trend in Hicks-neutral general technical progress θ_t we are seeking to estimate, but also the effects of any other random shock. We thus need a further step: assume the random shocks are (log) additive and generated by a symmetric probability distribution we have $\theta_s = E(\varphi_s | t = s)$, so that an estimate of $\boldsymbol{\theta} = [\theta_2 \theta_3 \ldots \theta_T]$ can be recovered from a non parametric regression of $\boldsymbol{\varphi}$ on a linear time trend.

Since all variables included in (4) should generally be expected, and indeed in our case are, non-stationary, it should be estimated by some suitable estimation method, such as *e.g.*, FM-OLS, and the existence of cointegration tested. However, the estimation of the long-run covariance matrix is pratically unfeasible (Pedroni, 1997) unless the time dimension is significantly larger than the cross-section dimension. This is definitely not the case for our 1981-2001 panel of the Manufacturing Industries: $T = 22$, $N = 17$. We then propose to follow the mixed approach applied by Fachin (2007), which involves OLS-based panel cointegration testing coupled with single industry FM-OLS model estimation, with technical progress extracted from the OLS panel estimates. More precisely, the approach proposed involves five steps:

1. estimate equation (4) by OLS; let $\widehat{\boldsymbol{\varphi}}$ be the OLS estimate of the vector of the coefficients of the time dummies.

2. compute the Nadaraya-Watson estimator of the regression curve of $\widehat{\boldsymbol{\varphi}}$ on a time trend and obtain the smoothed coefficients $\widetilde{\boldsymbol{\varphi}}$;

3. compute the deviations of labour productivity ($\widetilde{\pi}_{it}$) from the smoothed coefficients $\widetilde{\boldsymbol{\varphi}}$: $\widetilde{\pi}_{it} = \pi_{it} - \widetilde{\varphi}_t$; hereafter we will refer to $\widetilde{\pi}_{it}$ as "detrend labour productivity";

4. compute OLS-based panel cointegration tests for model (4); details of the test are given in the Appendix;

5. estimate the equations $\widetilde{\pi}_{it} = \delta_i + \gamma_0 l_{it} + \gamma_1(k_{it} - l_{it}) + \gamma_2(k_{it} - l_{it})^2 + \varepsilon_{it}$ separately for each industry by FM-OLS.

The estimated and smoothed general[5] TFP trend (obviously non-stationary: for the smoothed series, $ADF = -2.12$, largely in the non-rejection region) and its log difference are plotted respectively in the top and bottom panels of Fig. 5; smoothing has been carried out using a Gaussian kernel and Silverman (1986) bandwidth. From these estimates TFP growth appears substantial (on the average, about 2.8% a year), but declining: from a peak of 3.8% a year in the second half of the 1980's to 1.8% a decade later. It should be remarked that these are estimates of long-run TFP growth, which may well be higher than actual productivity growth. Hence, cannot be directly compared with those obtained through the growth-accounting approach, by construction smaller than the latter. To allow such a comparison we centred both our estimates and those by Bassanetti *et al.* (2005) on their respective averages. The results, plotted in Fig. 7, are striking. Following an entirely different method which does not require the restrictive assumptions of the growth accounting approach (constant returns to scale and perfect competition in the products and factors markets), we end up drawing an essentially similar picture of TFP growth patterns in the 1980's and 1990's: close to, or just slightly below, the average of the period in the early 1980's, then above the average for about a decade (1985-1995), finally (late 1990's) strongly below the average. The evidence suggesting that TFP growth has bee declining since the mid-90's thus appears to robust to the estimation method adopted.

The detrended Value Added per Labour Unit, plotted in Fig. 7, follow a variety of patterns. In about half of the cases (Food, Leather, Paper, Rubber, Non Metals, Machinery) there is a clear negative trend, while the opposite holds only for the Non Energy and Wood industries. Breaks are evident in the Textiles, Transport, Metals, Other Manufacturing and Utilities, while a fast growth in the early 1980's followed by stagnation is found for the Chemical and Electrical Industries. Overall non-stationarity prevails: the null hypothesis is never rejeced by the CIPS panel unit root test, either with and without a linear trend, with statistics always very distant from the rejection region (respectively, -1.86 and -1.56, with 5% critical values -2.78 and -2.26).

[5] Except Energy Mining and Coke, which have been excluded from the panel.

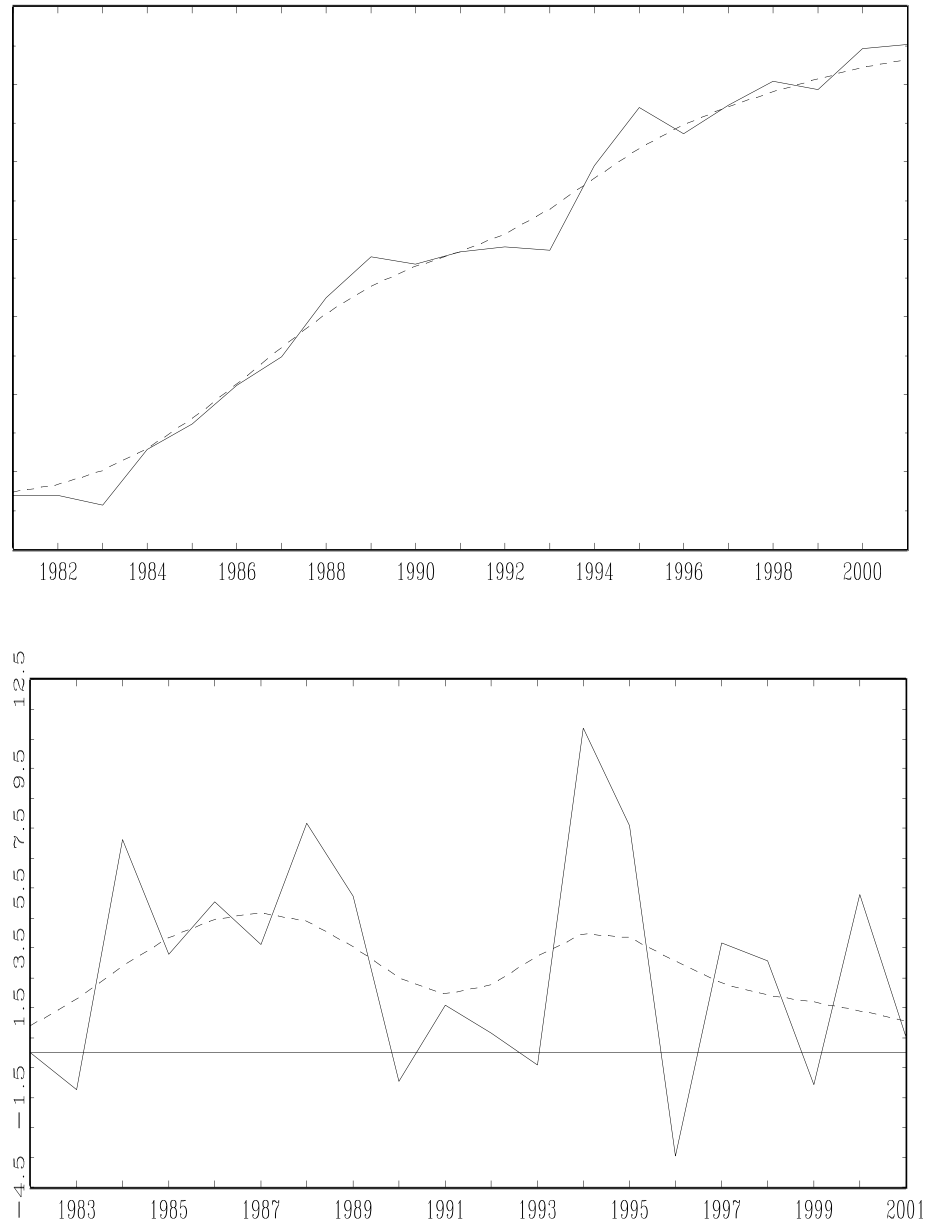

Fig. 5. Estimated (time dummies from OLS panel regression) and smoothed general trend in technical progress. Top panel: level; bottom panel: rates of growth×100.

Fig. 6 - Estimated TFP growth rates centred on their 1982-2001 average. Growth accounting: estimates by Bassanetti, Iommi, Jona-Lasinio and Zollino (2004); panel regression: smoothed coefficients of time dummies in model (4). The growth accounting estimate for 1982-85 is equal to 1982-2001 average.

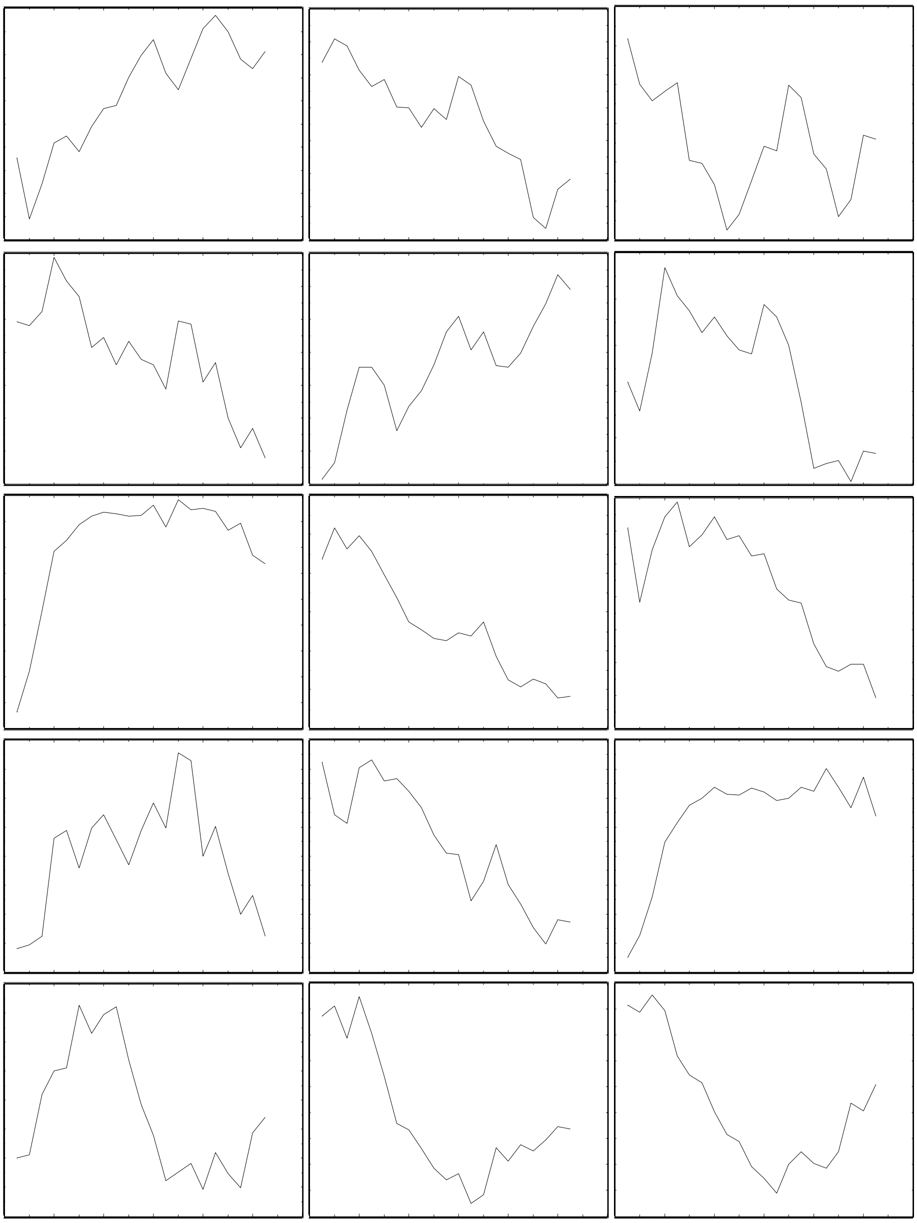

Fig. 7. Deviations of Value Added per Labour Unit from estimated general technical progress (logs). From left to right and top to bottom (rows in brackets): [1] Non-Energy, Food, Textiles; [2] Leather, Wood, Paper; [3] Chemicals, Rubber, Non-Metals; [4] Metals, Machinery, Electricals; [5] Transport, Other, Utilities (abbreviations: see table A1).

Initial estimates are reported in Table 4A and final estimates in Table 4B, with plots in Fig. 8. A critical step of the procedure is the choice of the block size to be used in the bootstrap. In this case the results turned out to be quite robust (details available on request); given the very small sample size we decided to fix the block size at 4 observations. Since the p-values of the panel cointegration statistics are rather small in mean even with the full specification we chose to delete only the labour variable when appropriate (thus moving to a specification implying constant returns to scale), while the capital variables have always been retained. Taking into account that with the available sample size the power of the test must to be expected to be rather low (Fachin, 2005) the hypothesis of no panel cointegration for the restricted specification, with p-values definetely smaller than 5%, appears to be strongly rejected both in mean and median. The coefficient of labour units is most cases significant, suggesting returns to scale different from 1. Although the quadratic term is generally significant the estimates of the elasticity of substitution between labour and capital are always very close to 1, with the only exception of the Rubber industry (1.20). To evalutate the uncertainty in the estimates of these highly non-linear functions of the coefficients of the production function we computed bootstrap confidence intervals; the details of the algorithm are documented in the Appendix. The 95% confidence intervals (reported in brackets below the point estimates) always include the point estimates (and 1, except in the Electricals industry) but are often very wide: for instance, in the Machinery Industry the interval is [0.59, 1.63]. Thus, although the point estimates suggest a Cobb-Douglas pattern of substitution between labour and capital, the confidence intervals are compatible with very different scenarios implying both less and more than proportional substitution between the factors of production.

Table 4A

Modelling Labour Productivity, 1981-2001

Mining, Manufacturing and Utilities

Deviations from estimated TFP trend

Panel Cointegration Tests		Bootstrap $p - values \times 100$		
		simple	FDB_1	FDB_2
Mean t	−4.26	11.40	7.94	7.28
Median t	−3.31	26.20	24.64	24.74

FM-OLS estimates

Industries	γ_0	γ_1	γ_2	ES	Z_α
Non-Energy	0.30 (0.79)	9.31 (2.97)	−0.84 (2.61)	0.99 [0.98,1.00]	−13.88
Food	0.30 (0.94)	2.59 (1.25)	−0.30 (1.38)	0.95 [0.79,1.04]	−15.04
Textiles	−0.47 (3.35)	−0.38 (0.56)	0.01 (0.17)	1.04 [0.78,1.65]	−8.25
Leather	0.30 (1.00)	4.30 (3.21)	−0.57 (3.12)	0.97 [0.76,1.20]	−14.57
Wood	−0.06 (0.15)	7.38 (1.36)	0.83 (1.38)	1.01 [0.97,1.10]	−10.91
Paper	−1.08 (4.99)	3.39 (4.45)	−0.39 (4.48)	1.10 [0.71,1.44]	−9.96
Chemicals	−0.51 (3.02)	83.29 (15.40)	−7.60 (15.34)	1.00 [0.99,1.01]	−7.92
Rubber	−1.26 (16.50)	0.10 (0.01)	−0.01 (0.02)	1.20 [0.74,1.31]	−21.82
Non-metals	−0.29 (4.63)	13.04 (12.22)	1.39 (12.48)	0.99 [0.98,0.99]	−11.88
Metals	−0.37 (3.21)	5.58 (6.75)	−0.61 (6.87)	0.96 [0.66,1.18]	−19.80
Machinery	0.11 (0.36)	3.26 (1.38)	−0.41 (1.52)	0.95 [0.70,1.54]	−12.22
Electricals	−0.18 (1.67)	2.84 (9.68)	−0.32 (9.26)	0.92 [0.55,0.96]	−19.58
Transport	1.21 (3.98)	7.14 (4.07)	−0.74 (3.98)	0.99 [0.98,1.00]	−6.42
Other	−3.13 (12.45)	17.14 (4.92)	−2.09 (4.97)	1.00 [1.00,1.01]	−10.21
Utilities	−0.77 (3.52)	−19.33 (3.87)	1.34 (3.75)	1.01 [0.87,1.13]	−12.78

Model: $\widetilde{\pi}_{it} = \delta_i + \gamma_0 l_{it} + \gamma_1 (k_{it} - l_{it}) + \gamma_2 (k_{it} - l_{it})^2 + \varepsilon_{it}$

ES: Labour-Capital Elasticity of substitution;

Z_α *10% critical point*: -23.54

Bootstrap: 5000 redrawings, block size 4.

Table 4B
Modelling Labour Productivity, 1981-2001
Mining, Manufacturing and Utilities
Deviations from estimated TFP trend

Panel Cointegration Tests		Bootstrap $p-values \times 100$		
		simple	FDB_1	FDB_2
Mean t	−0.78	1.50	0.96	0.74
Median t	−3.51	4.80	3.40	3.44

FM-OLS estimates

Industries	γ_0	γ_1	γ_2	ES	Z_α
Non-Energy	–	9.83 (3.01)	−0.92 (2.85)	0.99 [0.98,0.99]	−12.97
Food	–	5.69 (2.90)	−0.63 (3.04)	0.97 [0.82,1.04]	−15.20
Textiles	−0.47 (3.35)	−0.38 (0.56)	0.02 (0.18)	1.04 [0.78,1.65]	−8.25
Leather	–	5.26 (4.20)	−0.72 (4.38)	0.97 [0.81,1.04]	−15.27
Wood	–	4.31 (0.64)	0.50 (0.67)	1.02 [0.91,1.12]	−10.93
Paper	−1.08 (4.99)	3.39 (4.45)	−0.39 (4.48)	1.10 [0.71,1.44]	−9.96
Chemicals	−0.51 (3.02)	83.29 (15.40)	−7.60 (15.34)	1.00 [0.99,1.01]	−7.92
Rubber	−1.31 (28.32)	−0.10 (0.01)	−0.02 (0.02)	1.20 [0.74,1.31]	−21.82
Non-metals	−0.29 (4.63)	13.04 (12.22)	1.39 (12.48)	0.99 [0.98,1.99]	−11.88
Metals	−0.37 (3.21)	5.58 (6.75)	−0.61 (6.87)	0.96 [0.66,1.18]	−19.80
Machinery	–	2.23 (1.07)	−0.30 (1.22)	0.90 [0.59,1.63]	−11.90
Electricals	−0.18 (1.67)	2.84 (9.68)	−0.32 (9.26)	0.92 [0.55,0.96]	−19.58
Transport	1.21 (3.98)	7.14 (4.07)	−0.74 (3.98)	0.99 [0.98,1.00]	−6.42
Other	−3.13 (12.45)	17.14 (4.92)	−2.09 (4.97)	1.00 [1.00,1.01]	−10.21
Utilities	−0.77 (3.52)	−19.33 (3.87)	1.34 (3.75)	1.01 [0.87,1.13]	−12.78

Model: $\widetilde{\pi}_{it} = \delta_i + \gamma_0 l_{it} + \gamma_1(k_{it} - l_{it}) + \gamma_2(k_{it} - l_{it})^2 + \varepsilon_{it}$
ES: Labour-Capital Elasticity of substitution;
95% bootstrap confidence interval in brackets.
Z_α *10% critical point:* −23.54
Bootstrap: 5000 redrawings, block size 4.

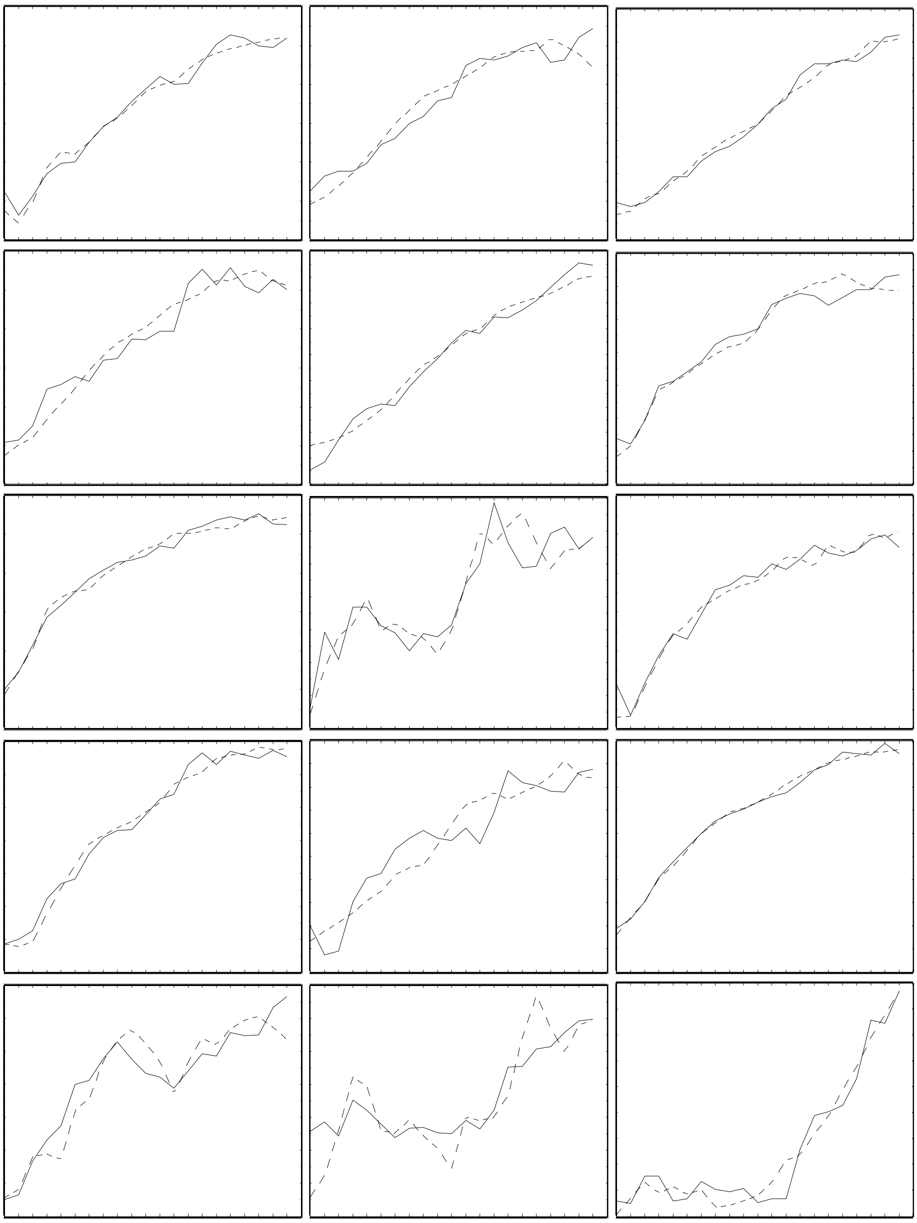

Fig. 8. Value Added per Labour Unit and FM-OLS estimates plus smoothed OLS estimates of general trend in technical progress, 1981-2001. From left to right and top to bottom (rows in brackets): [1] Non-Energy, Food, Textiles; [2] Leather, Wood, Paper; [3] Chemicals, Rubber, Non-Metals; [4] Metals, Machinery, Electricals; [5] Transport, Other, Utilities (abbreviations: see table A1).

4 Conclusions

Our preliminary results confirm that the decline in labour productivity in the past decade is largely due to a fall in TFP across the Italian economy. Our next step is to investigate what did bring this fall about. We will concentrate on two main hypotheses. The first is the lack of sufficient dynamism in the economy, especially of a process of reallocation among industries, skills and capital vintages. We hope to obtain some hints by regressing our estimated TFP onto variables which capture the extent of reallocation along these lines: for instance, a variance indicator of industry value added, the human capital quality index by Brandolini and Cipollone (2001), a measure of the average life of the capital stock.

Another important aspect that deserves further investigation is the link between TFP and export-oriented industries. The direction of causality can be ambiguous but preliminary evidence on data from Capitalia point to a positive correlation (Barba Navaretti, Faini and Tucci, 2005)

The second hypothesis is the inadequacy of the investment in R&D, education and innovation. To this purpose we plan to use the usual indicators of such phenomena, mainly provided by OECD.

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6 Appendix

6.1 A. A Bootstrap Panel Cointegration Test

A panel cointegration test suitable for our dataset needs to be robust to both short-run and long-run dependence across units, so that the asymptotic tests usually applied in the literature are not suitable. Fachin (2005) put forth a bootstrap test satisfying both requirements. The test is based on the Continuous-Path Block Bootstrap (CBB), which is applied independently to the cross-sections of time-series of the X's, $\{X_1 X_2 \ldots X_N\}_{t=1}^T$ and the Y's $\{Y_1 Y_2 \ldots Y_N\}_{t=1}^T$. Developed by Paparoditis and Politis (2001), the CBB is a block resampling method designed to construct non-stationary pseudodata. The pseudo-series is obtained in two steps: first, a block bootstrap series is constructed integrating within each block the resampled first differences of a series known to be non-stationary; second, the end points of the blocks are chained so to eliminate jumps between blocks (this implies that the pseudo-series are shorter than the original series, as one observation must be deleted when chaining two blocks). As the resampling is applied to the entire cross-section the pseudo-series will clearly preserve the cross-correlation structure of the non-stationary individual time series. On the other hand, the blocks are chosen independently for the $X's$ and the $Y's$, so that the two pseudo-series are independent by design. Denoting by G a group mean statistic the proposed bootstrap procedure includes five simple steps:

1. compute the Group statistic $\widehat{G}$ for the data set under study, $\{X_1 X_2 \ldots X_N, Y_1 Y_2 \ldots Y_N\}_{t=1}^T$;
2. construct separately by CBB two sets of N pseudo-series, $\{X_1^* X_2^* \ldots X_N^*\}_{t=1}^{T^*}$ and $\{Y_1^* Y_2^* \ldots Y_N^*\}_{t=1}^{T^*}$;

3. compute the Group statistics G^* for the pseudo-data set, $\{X_1^* X_2^* \ldots X_N^*, Y_1^* Y_2^* \ldots Y_N^*\}_{t=1}^{T^*}$;

4. repeat steps (2) and (3) a large number (say, B) of times;

5. compute the boostrap significance level; assuming that the rejection region is the left tail of the distribution, $p^* = prop(G^* < \widehat{G})$.

6.2 B. Bootstrap Confidence Intervals for the Elasticity of Substitution

The elasticity of substitution (ES) implied by the linearised CES production function (2) is a highly non-linear function of the function coefficients: $ES = \frac{1}{1+\rho}$, where $\rho = \frac{\gamma_2}{\gamma_1[1-\gamma_1(1+\gamma_0)]}$. To evaluate the uncertainty in the estimates we therefore compute bootstrap confidence intervals according to the following algorithm:

1. estimate the coefficients of the production function ($\delta_i, \gamma_0, \gamma_1, \gamma_2$, some of which may be constrained to zero) and compute the elasticity of substitution $\widehat{ES}$ and the residuals $\widehat{\varepsilon}$;

2. resample the weakly dependent estimated residuals $\widehat{\varepsilon}$ applying a suitable scheme, such as the stationary bootstrap (Politis and Romano, 1994) and obtain a series of pseudo-residuals ε^*;

3. construct the pseudodata: $\pi_t^* = \widehat{\delta} + \widehat{\gamma}_0 l_t + \widehat{\gamma}_1 (k_t - l_t) + \widehat{\gamma}_2 (k_t)^2 + \varepsilon_t^*$;

4. estimate a CES production function with the same restrictions imposed in step [1] using the dataset (π_t^*, l_t, k_t) and compute the elasticity of substitution ES_b^*;

5. repeat steps (2)-(4) a large number (say, B) of times;

6. compute the extremes of the 2α-level confidence interval for $\widehat{ES}$ as the αB^{th} and $(1-\alpha)B^{th}$ elements of the vector $\mathbf{ES}^* = \left[ES_{1'}^*, \ldots, ES_{B'}^*\right]$, where $ES_{1'}^* \leq \ldots \leq ES_{B'}^*$.

6.3 C. Industry Classification

The NACE Rev. 1.1 Classification:
Sections C, D and E and their Subsections

	Abbreviation	*Y Share*	*K/L*
Section C Mining and Quarrying	*Mining*		
Mining and quarrying of energy producing materials	Energy	0.3	468
Mining and quarrying, except of energy producing materials	Non-Energy	0.2	88
Section D Manufacturing	*Manufacturing*		
Food products, beverages and tobacco	Food	2.3	60
Textiles and textile products	Textiles	2.8	32
Leather and leather products	Leather	0.7	24
Wood and wood products	Wood	0.6	54
Pulp, paper and paper products; publishing and printing	Paper	1.4	46
Coke, refined petroleum products and nuclear fuel	Coke	0.4	261
Chemicals, chemical products and man-made fibres	Chemicals	1.9	125
Rubber and plastic products	Rubber	0.9	70
Other non-metallic mineral products	Non-metals	1.5	68
Basic metals and fabricated metal products	Metals	3.5	60
Machinery and equipment n.e.c.	Mach	2.7	45
Electrical and optical equipment	Electricals	2.3	44
Transport equipment	Transport	1.7	62
Manufacturing n.e.c.	Other	1.2	40
Section E Electricity, Gas and Water Supply	*Utilities*	1.8	600

Y Share: average GDP share×100, 1981-2001.
K/L: average Capital/Labour Unit ratio, 1981-2001; Capital at 1995 prices, Euros×1000.
Source: Istat, *Conti economici nazionali 1970-2004*.