BANCA D'ITALIA

EUROSISTEMA

Temi di discussione

(Working Papers)

Recent trends in economic activity and TFP in Italy with a focus on embodied technical progress

by Alessandro Mistretta and Francesco Zollino

December 2018

Number 1204

BANCA D'ITALIA
EUROSISTEMA

Temi di discussione

(Working Papers)

Recent trends in economic activity and TFP in Italy with a focus on embodied technical progress

by Alessandro Mistretta and Francesco Zollino

Number 1204 - December 2018

The papers published in the Temi di discussione *series describe preliminary results and are made available to the public to encourage discussion and elicit comments.*

The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.

ISSN 1594-7939 (print)
ISSN 2281-3950 (online)

Printed by the Printing and Publishing Division of the Bank of Italy

RECENT TRENDS IN ECONOMIC ACTIVITY AND TFP IN ITALY WITH A FOCUS ON EMBODIED TECHNICAL PROGRESS

by Alessandro Mistretta* and Francesco Zollino*

Abstract

In this paper we provide fresh evidence on TFP performance in the Italian economy since 1995, taking into account the changing composition of primary inputs across different capital goods and employment skills, as well as technical progress embodied in different vintages of the productive assets. We first estimate a technical depreciation rate by using individual data on Italian industrial firms. We then obtain an experimental measure of the capital stock adjusted for technical efficiency, by augmenting the standard depreciation rate by our own estimate of technical depreciation (about 5 per cent per year). Once we introduce our measure of capital stock in a standard growth accounting exercise, we find a less dismal performance of the Italian TFP than usually estimated. Focusing on the years between 2007 and 2016, the upward correction in TFP amounts to around 1.5 percentage points in the overall period for the total economy and to about 2.5 percentage points when only considering manufacturing. These findings shed a somewhat more positive light on future TFP developments in Italy, suggesting a more rapid increase of potential output than otherwise estimated. In addition, the efficiency of installed capital might soon return to growth, as the expected recovery of investment results in the replacement of old vintages with new and more technically advanced ones.

JEL Classification: O3, D24, L60.
Keywords: TFP, technical progress, embodied technology.

Contents

*Bank of Italy, Economic Outlook and Monetary Policy Directorate.

1. Introduction and main references in the literature[1]

In recent years the investigation of weak productivity growth at global level has gained increased attention in the academic and institutional debate, also in view of the persistent gap between saving and investment (IMF, 2017). In particular, proponents of the secular stagnation assumption warn against the possibility that the economy will remain in a situation of low growth and productivity for an extended period of time (Summers, 2014). In this respect, the Italian economy provides an interesting case study, considering that it displayed sluggish economic growth and weak productivity over the last two decades. This is especially true when the Italian performance is compared with the country's historical trends and with other countries (Giordano, Toniolo and Zollino, 2017).

In this paper we focus on the disappointing productivity performance of the Italian economy since the mid-1990s, by providing fresh evidence of growth–accounting exercise performed using the latest standards for national accounts established by the ESA 2010 accounting framework (previous results are in Bassanetti and Zollino, 2010; Broadberry, Giordano and Zollino, 2013) under different approaches in the computation of primary inputs.

We first estimate TFP dynamics in the years 1995-2016 for the total economy (net of housing) and for the main productive sectors, taking into account the changing quality of the productive services provided by primary inputs, namely the composition effects across different capital assets and employment skills (Jorgenson, 2001).

We then, as a novel contribution, experimentally measure the capital stock, taking into account the evolution over time of the technical efficiency of a single productive asset, in line with the recently resurgent debate on capital vintage models (Boucekkine et al., 2011). Indeed, by considering advances over time in the technical progress embodied in capital goods, we are able to get rid of a potential source of misvaluation of the net stock of capital implied by the current national accounts standards, which consider only the physical consumption of productive assets, leaving aside the impact of their technical obsolescence (OECD, 2009). In this respect, we join the large debate about the role of measurement errors in the analysis of productivity trends in times of steady technical progress, by considering more to the risks of biased estimates of the capital stock efficiency (Solow, 1960; Greenwood and Jovanovic, 2003) than to the difficult estimates of the total value of supply and/or expenditure (Byrne, Fernald and Reinsdorf, 2016; Syverson, 2017).

Our paper is closely linked to the vintage approach to capital measurement, which has a long tradition in the theoretical and empirical literature. First Johansen (1959) and then Solow (1960) stressed the difference between embodied and disembodied progress, and proposed to adopt an appropriate technical depreciation rate in addition to the standard measure used for physical consumption. Indeed, a major contribution of Solow's work is its focus not only on the quantity of

[1] We thank the participants to the Bank of Italy Internal Workshops "Secular Stagnation and Financial Cycles" (30-31 March 2017) and "Assessing the performance of the Italian economy: the role of demand and supply factors" (12-13 March 2018), as well as Rita Cappariello, Massimiliano Tancioni, Stefano Siviero, Roberta Zizza and two anonymous referees for their valuable comments on previous drafts. The opinions expressed and the conclusions drawn are those of the authors and do not necessarily reflect the views of the Bank of Italy; all errors remain our own.

capital but also on its quality. Starting from these seminal contributions, the related literature flourished during the 1990s. Greenwood et al. (1997) found that more than 60 per cent of output growth can be attributed to embodied technical progress, thus suggesting its prominent role in advanced countries. Several improvements to the standard model were later proposed, also within the endogenous growth literature (Krusell, 1998).

Interestingly, a strand of the literature investigated how vintage effects may also affect labour, thus driving productivity growth (Zeckhauser, 1968; Chari and Hopenhayn, 1991 and Parente, 1994). In this vein, Greenwood and Jovanovic (2003) proposed a model in which both physical capital and human capital vintage effects were considered.

As regards the empirical methodology, since the vintage effect may be considered an additional depreciation factor, the main problem is the sound estimation of this parameter. The basic idea is that the price of goods embodying more recent technology should include a premium. In particular Gordon (1990) argued that the positive gap between the price trends of durable (capital) and non-durable goods traces back to "quality" as an inherent characteristic of the former, and he proposed an index that captures changes in capital quality accordingly. However, the actual implementation of the idea is fraught with difficulties, and Gordon (1996) himself warned that the gap in the price trends of the two categories of goods is not completely linked with the quality change, since consumers' demand can also play a role.

Another part of the literature tries to estimate embodied technical progress using a production function approach (see Nelson, 1964). In this vein, Sakellaris and Wilson (2004) proposed an estimation method based on micro data and found that embodied technological change in the US was between 8 and 17 per cent per year.

In this paper we follow a similar micro approach to estimate the embodied technological change in Italy, using individual data at firm level obtained from the Bank of Italy's Survey of Industrial and Service Firms and *Centrale dei Bilanci* (*CeBi*). We then calculate a rate of technical obsolescence of the installed capital, which provides us with an experimental measure of the net capital stock. Finally, we apply this measure of capital to a standard growth-accounting model to detect the impact on recent TFP dynamics in Italy. In this respect we claim that, by taking into account the most advanced technology embodied in the most recent vintages of capital goods, we are in a position to more closely proxy the pure, disembodied technical progress as well as the mix of organizational factors that drive TFP, which would then enable to better track the overall efficiency of the productive system.

Importantly, in our growth accounting we follow the standard Cobb-Douglas specification of the production function, thus assuming constant returns to scale and perfect competition in both goods and factor markets, as well as negligible complementarities between the labour and capital inputs and no adjustment costs in the adoption of new vintages of capital. Testing the impact of the single assumptions on our findings is beyond the scope of this paper, and we leave this task to our future research.[2]

The paper is organized in five sections. The first consists of these introductory notes; the second describes the growth accounting framework we adopt as well as the analytical model by which we estimate the technical depreciation of fixed capital; the third section reviews the data set; in the fourth section we provide updated results of the growth accounting exercise by comparing those arising from a standard aggregation versus a quality-adjusted (à la Jorgenson) aggregation of the contributions of single components of the capital stock and of labour; in the fifth section we discuss our estimate of the technical depreciation rate and its impact on the measurement of the net stock of capital and, via this channel, on TFP dynamics; the final section draws some conclusions.

Among the main findings, our standard growth accounting exercise confirms that the dismal TFP performance has long been an important drag on the growth potential of the Italian economy, even prior to the start of the crisis. In the years 1995-2007 the decline in TFP was accompanied by a sizeable contribution to GDP growth provided by both capital and labour (especially if adjusted for the quality of their productive services). Since the start of the crisis, the contribution of capital first came to a halt, then turned negative in recent times. If we exclude the dramatic fluctuations in the years 2009-11, TFP performance has been more positive in industry than in services, where it has remained negative even after 2013, despite the start of the recovery in economic activity.

Based on firm-level data for the Italian industrial sector, our estimate of the technical depreciation rate of capital is around 5 per cent per year, significantly lower than the value found for the US. When we accept this value to augment the overall depreciation of the capital assets − in addition to the physical consumption considered in the national accounts standards − we find that during the crisis the resulting stock of capital registered a more severe drop than usually estimated. This points to a substantial efficiency loss in the installed capital due to a more limited turnover between old and new (more technically advanced) vintages of capital goods, as investment spending dramatically shrank. By the same token, the steady recovery in capital accumulation started in 2014 would also appear to be fostering a gradual improvement in the technical efficiency of the capital assets.

When our experimental estimates of capital stock (adjusted for technical obsolescence) are used in a growth accounting exercise, TFP performance looks less disappointing over the last two decades, especially in manufacturing. When looking at developments since the onset of the crisis, TFP in the total economy appears to have recorded an overall decrease of 0.7 per cent up until 2013, which is 1 percentage point less than implied by the national account measure of the capital

[2] Focusing on Italy, based on standard measures of capital stock, Bassanetti, Torrini and Zollino (2010) perform a growth accounting exercise assuming changing mark-ups in the goods markets and workers' bargaining power in the labour markets across industries in Italy and in other large European countries. Giordano and Zollino (2017) extend the analysis in a historical perspective, considering only the Italian economy and focusing on mark-ups. Rossi and Toniolo (1992) investigate the role of imperfect competition on the goods markets and variable returns to scale in the long-run performance of the Italian economy. More generally, a thorough discussion of the effects of departures from the standard growth accounting model on productivity measurement is provided by Greenwood and Jovanovic (2003).

stock; since the start of the recovery, it appears to have increased by 0.6 per cent, or around half a percentage point more than in the standard measure; in manufacturing we estimate an overall increase of 0.2 per cent between 2007 and 2013, as opposed to a decline of 2.1 per cent according to standard estimates; during the following recovery, the overall growth appears to have been equal to 3.3 per cent, largely in line with the trends calculated on the basis of national accounts data.

2. The model

2.1 Growth accounting

In order to investigate the sources of growth of the Italian economy, in this paper we adopt the standard approach based on the neoclassical production function:

$$(1) \qquad Y = AF(K, L)$$

where Y is output, K is capital, L is labour and A is the level of technology. Totally differentiating the production function, and assuming that factors of production are paid their marginal products, yields the usual growth accounting identity:

$$(2) \qquad \frac{\Delta Y}{Y} = \alpha \frac{\Delta K}{K} + (1-\alpha)\frac{\Delta L}{L} + \frac{\Delta A}{A}$$

where the weights α and (1- α) are the income shares of capital and labour, respectively. Total factor productivity (TFP) growth is then computed as the residual:

$$(3) \qquad \frac{\dot{A}}{A} = \frac{\dot{Y}}{Y} - \left(\alpha \frac{\dot{K}}{K} + (1-\alpha)\frac{\dot{L}}{L}\right)$$

The estimation of TFP growth is notoriously fraught with major difficulties: as a residual, it is affected by the statistical bias arising from measurement errors regarding output (especially in services) and the primary inputs (especially for the capital stock). The contributions of both labour and capital may be heterogeneous across employee skills and the productive services of different capital assets, respectively; to make things worse, the dispersion can change across sectors and over time. Importantly, the evolution of technical progress may imply an increasing obsolescence of the installed capital, a feature that is currently ignored in the national accounting practices (OECD, 2009). Misspecification in the theoretical model can also have a role, since the standard formulation of the production function rules out variable returns to scale and imperfect competition in both product and input markets.

In this paper we try to mitigate the bias in the estimation of TFP induced by the main sources of measurement errors, and we leave aside the possible effects coming from more fundamental issues regarding the specification of the production function, which may have a substantial impact on the estimates of input shares (Bassanetti, Torrini and Zollino, 2010).

In line with the framework first put forward by Jorgenson (2001) and already adopted in previous studies on the Italian economy (Bassanetti et al., 2004; Bassanetti and Zollino, 2010), we first control for the composition effects on quality in the flows of productive services provided by the primary inputs. In this respect, we measure the aggregate input of capital by weighting the individual assets by the respective cost shares (rather than the implicit deflators as in national accounting practices), which we compute as the ratio of the cost of productive services of a given asset to the total costs of capital. For this purpose, we need to estimate the user costs for an individual asset, which we proxy by the sum $u_t^i = i_t - \delta_t^i + cg_t^i$ i.e. the value of the financial costs minus the depreciation rate plus the expected capital gains. Following Jorgenson (2001), we aggregate the net stock of any single capital goods, namely S_i, by computing the following Törnqvist index

$$(4) \qquad \frac{\dot{K}_t}{K_t} = \sum_{i=1}^{n} \frac{1}{2}(v_{t-1}^i + v_t^i) * \frac{\dot{S}_t^i}{S_{t\,t}^i}$$

where $v_t^i = \frac{u_t^i S_t^i}{\sum u_t^i S_t^i}$ is the share in total cost at time *t* of asset *i,* and u_i is the corresponding user cost.

Importantly, by comparing our estimates of capital input with the standard measure of the net stock of capital we can single out the contribution to the output growth coming from asset substitution, namely the changes in capital composition in terms of more valuable capital assets, i.e. assets with higher user costs needed to purchase their productive services.

Similarly, as in Brandolini and Cipollone (2001) we estimate the total labour input by aggregating the stock of hours worked by employees in the same skill class based on the respective wage shares in the total wage bill; the difference between our estimates of labour input and the stock of hours worked as reported in the national accounts proxies the contribution to output growth provided by changes in skill composition of the labour force.

In order to take account of the changing composition in the productive services provided by primary factors, the standard growth accounting identity (2) is adjusted as follows

$$(5) \quad \frac{\Delta Y}{Y} = \alpha\left(\frac{\Delta K}{K} + \frac{\Delta E_K}{E_K}\right) + (1-\alpha)\left(\frac{\Delta L}{L} + \frac{\Delta E_L}{E_L}\right) + \frac{\Delta A}{A}$$

where E_K, E_L are proxies of the quality of the productive services of capital and labour input, which we allow to change over time, as the composition of capital moves towards assets with higher user costs (i.e. more valuable services) and the composition of labour moves towards workers with higher wages (i.e. more advanced skills). As a result, our adjustment in the measures of both capital and labour inputs in principle eliminates the possibly sizeable bias in the estimates of TFP that is implicit in (2), where the residual improperly includes productivity gains or losses related to the primary factors of production. A remaining limit is that the factor shares adopted in our growth accounting are retrieved from national accounts; therefore, we maintain the standard assumption of constant returns to scale and perfect competition, which implies that the profit and wage shares sum up to unity.

By comparing equations (2) and (5) it is straightforward to notice that in ordinary conditions, in which the average quality of productive services delivered by primary factors is not declining, in equation (5) changes in the residual tracking the TFP prove no higher than in equation (2). In this respect, equation (5) allows to proxy more closely the pure externality factors affecting the productive environment, as it controls for the possible bias in equation (3) coming from the substitution across the different capital assets and skills of workers, whose productive services show heterogeneous quality.

In this paper we explore a further refinement in measuring TFP by controlling for the substitution across different vintages of a single capital asset, as the technical progress therein embodied evolves over time. In other words, in addition to the productive gains coming from the changing composition of the total capital stock in terms of assets, we analyse the effects of more advanced technical progress being introduced in the production process as the old vintages of a given asset are gradually replaced with new (and technically more advanced) vintages. This allows us to investigate the impact of technical obsolescence on the value of the installed capital in addition to the standard depreciation considered in national accounts, due to the wear and tear of assets as they age. For this purpose, we follow the capital vintage model presented in the following section.[3]

As a result, we obtain three different estimates of TFP: *i)* the national account measure, obtained by weighting by the respective market prices the stock of single capital goods and simply adding up the hours worked by a single skill class of workers; *ii)* the adjusted measure obtained by revising the weighting scheme according to user costs and wage shares respectively for each capital asset and worker class; *iii)* an experimental measure obtained by adopting a capital stock net of technical obsolescence in addition to the usual economic depreciation.

It is important to notice that each of three TFP measures may be affected by important statistical issues and limitations. For example, the estimated user costs are subject to the simplifying assumptions regarding the measurement of the opportunity costs of investing in fixed capital or the expected capital gains, and the following section will examine the difficult imputation of the overall depreciation of capital. Accordingly, it is difficult to argue which TFP measure proves the most reliable, and this is not our primary interest. Rather, our purpose is to single out the impact

[3] In the model, obsolescence in knowledge and competencies also affects the productive inputs of old versus new flows of workers belonging to a given skill category, with a possibly important impact on TFP dynamics. We have conducted a preliminary assessment of this additional refinement, but the data requirements are currently very demanding, so we leave this task to our future research.

of specific sources of measurement errors, with the final goal of shedding additional light on the root causes of the recently dismal performance of TFP in the Italian economy.

2.2 The vintage capital model

In this section we describe the approach we follow to control for the technical efficiency of the installed capital as old vintages are gradually replaced with new (and technically more advanced) vintages of the single capital goods. We consider a two-sector model, in which one sector produces investment goods (*i*) and the other sector produces consumption goods (*c*) using as inputs capital (*k*) and labour (*L*) according to the following production function;

$$(6) \qquad \tilde{\imath}_t = z_t q_t \tilde{k}_t^{\alpha} L_t^{1-\alpha}$$

$$(7) \qquad c_t = z_t \tilde{k}_t^{\alpha} L_t^{1-\alpha}$$

where *z* is the common technology and *q* is a specific technology for the investment sector. The inputs are assumed to be completely mobile across sectors.

We can consider the total output as the sum of consumption and capital goods adjusted for quality:[4]

$$(8) \quad \tilde{\imath}_t = z_t q_t \tilde{k}_t^{\alpha} L_t^{1-\alpha} \qquad\qquad i_t = \frac{\tilde{\imath}_t}{q_t} = z_t \tilde{k}_t^{\alpha} L_t^{1-\alpha}$$

$$(9) \quad \frac{i_t}{q_t} + c_t = y_t = z_t \tilde{k}_t^{\alpha} L_t^{1-\alpha}$$

where

$$(10) \quad \tilde{k}_t = (1-\delta)\tilde{k}_{t-1} + \tilde{\imath}_t$$

and

$$k_t = \frac{\tilde{k}_t}{q_t}$$

Therefore,

$$(11) \quad \tilde{k}_t = k_t q_t = (1-\delta) k_{t-1} q_{t-1} + i_t q_t \qquad k_t = (1-\delta) k_{t-1} \frac{q_{t-1}}{q_t} + i_t$$

[4] We use ~ when the variable is adjusted for the quality embodied in it.

The model thus collapses to a single equation in which technical progress is partially disembodied (z) and partially embodied in capital goods.

For computational reasons, we assume that technical change is constant over time,[5]

$$(12) \qquad \frac{q_{t-1}}{q_t} = \frac{1}{(1+\widetilde{\gamma})} = (1-\gamma)$$

we can thus rewrite the previous equation as

$$(13) \qquad k_t = (1-\delta)(1-\gamma)k_{t-1} + i_t$$

In this model γ can be estimated using firm level data once we find an investment deflator that does not take into account the quality improvement of the capital goods. As extensively stressed in Sakellaris and Wilson (2004) this strategy allows us to exclude general inflation but, at the same time, to control for price heterogeneity owing to the different quality of the capital, which the algorithm we adopted uses to extract information that is needed to estimate the technical progress.

For this purpose we proxy the free of the capital quality deflator with the deflator of non-durable consumption goods taken from the national accounts.

The capital stock may thus be written as the sum of different vintages of investment

$$(14) \qquad J_{it}(\gamma) = \sum_{s=1}^{T} \frac{i_{t-s}(1-\delta)^{s-t}}{(1+\widetilde{\gamma})^{t-s-t0}} = \sum_{s=1}^{T} i_{t-s}(1-\delta)^{s-t}(1-\gamma)^{t-s-t0}$$

where the technical depreciation rate γ, our parameter of interest, is measured with respect to a reference year. To simplify the computation process, we assume 2014 as the reference year as it is the latest year considered in our individual firm data set.

Using the previous definition of capital, we estimate the following production function

$$(15) \qquad ln(VA_{it}) = \alpha\, ln(L_{it}) + \beta\, ln(CU_{it} * J_{it}(\gamma)) + \mu_i + I_i * t + \varepsilon_{it}$$

where we consider firm-specific fixed effects (μ_i) and a sector-specific time dummy ($I_i * t$).

Differently from Sakellaris and Wilson (2004), who infer utilized capacity using a given firm's energy consumption, we estimate a capital utilization rate (Cu_{it}) based on information at firm level coming from the Bank of Italy's Survey of Industrial and Service Firms.

However, at this stage we cannot estimate the technical progress embodied in the construction assets since the necessary data are not available.

[5] We are aware that this restriction could be strong, especially for years in which disruptive innovation occurs; however, as our estimation involves a recursive procedure, we are not able to estimate a time-varying parameter.

3. The Data

Our growth accounting exercise is based on the Italian national accounts released by Istat in September 2017,[6] which among other things contain important upward revisions in non-construction investment compared with 2014. We benefit from the high disaggregation now available for service activities, on both the output and the input side, to better investigate different trends between *private* services (namely trade, hotels, transport and communication; business services) and *mixed* services (namely health, education, arts and entertainments; other activities). We are aware that the IT revolution and the increasing share of services currently exchanged on the web (especially travel and holiday packages) make it even more important to consider the usual measurement issues concerning the value added in services. Accordingly, our exercise should be accepted with caution; nevertheless, we still believe it is worth investigating the impact on the growth potential of a country stemming from an increasing share of labour employed in service activities.

As for the *private* services, we exclude the value added in housing rental and sale intermediation services on the output side, employment in the same sector and the stock of residential buildings on the input side. This is a common assumption as housing-related activities have a less direct impact on aggregate productivity and output (see Bassanetti et al., 2004).

Following a common practice, in this paper we exclude the activities purely operated by the Public Administration, which in NACE Rev. 2 are classified in the group “Public administration and defence; compulsory social security”, in view of the particularly serious issues relating to the measurement of their value added and productivity. However, we extend our analysis to a group of services that are likely supplied by both public and private entities, which are classified as: “Education”, “Human health and social work activities” and “Arts, entertainment and recreation”. In fact, the value added of these activities, which we identify as “mixed services”, accounts for a substantial share of the total value added in services, which in Italy currently stands at 25 per cent if we exclude the Public Administration and real estate.

As for capital inputs, we aggregate net capital stocks by asset and by sector according to the cost shares obtained from our estimates of user costs. We proxy the financial costs by the real interest rate on Italian public-sector bonds with ten year maturity (which mostly affects the opportunity costs of financing investment expenditure with internal funding), the depreciation rate by the average ratio of depreciation to gross capital stock, and the capital gains by the three year moving average of the implicit deflator (thus assuming adaptive expectations).

As for labour inputs, we use total hours worked, which covers both employees and self-employed workers, to eliminate the possible noise coming from labour hoarding over the business cycle. Very much in line with the capital inputs, we control for composition effects on the productive services provided by workers by assuming that higher wages correlate with higher skills, thus with

[6] The historical analysis performed in Giordano, Toniolo and Zollino (2017) is based on the national accounts released in September 2016; this explains some minor differences with results reported in this paper for the overlapping periods.

efficiency gains. Accordingly, the changes in hours worked as obtained from the national accounts are augmented by

$$(16) \qquad \frac{\Delta E_{L,t}}{E_{L,t}} = \sum_{i=1}^{n} \frac{1}{2} (s_{t-1}^{i} + s_{t}^{i}) * \left(\frac{\Delta E_{t}^{i}}{E_{t}^{i}} - \Delta L_{t} \right)$$

where $s_t^i = \frac{w_t^i E_t^i}{\sum w_t^i E_t^i}$ is the share in the total wage bill of workers with skill *i;* the data on wages by skill class were taken from the Bank of Italy's Survey on Household Income and Wealth, while the data on the number of workers sharing the same skill were taken from Istat's Labour Force Survey, with *L* measuring the total job positions.[7]

As for the estimate of the technical obsolescence rate, we use firm data from *Centrale dei Bilanci* (*CeBi*), which collects balance-sheet information and provides yearly observations regarding about 75,800 firms between 1979 and 2015. For each firm, 12 yearly observations are available on average. We exclude the observations before 1982 and after 2014 (because of the very low number of observations per year) and we consider only manufacturing firms (i.e. we assume that in services the technical obsolescence rate of a given asset is the same as in manufacturing). The final sample consists of about 500,000 observations covering about 41,900 firms representing the different manufacturing sub-sectors. In the following table, the main summary statistics are reported.

Table 1

Summary statistics

Manufacture of	Value added	Labour cost	Investiment
Food products, beverages and tobacco	2,100	808	317
Textiles and textile products	1,835	767	111
Leather and leather products	1,384	645	87
Wood and wood products	1,896	782	195
Pulp, paper and paper products; publishing and printing	2,721	1,063	337
Coke, refined petroleum products and nuclear fuel	3,193	2,088	499
Chemicals, chemical products and man-made fibres	3,666	1,801	420
Rubber and plastic products	2,616	1,049	373
Other non-metallic mineral products	2,525	1,028	334
Basic metals and fabricated metal products	2,659	1,083	289
Machinery and equipment n.e.c.	2,815	1,245	178
Electrical and optical equipment	2,948	981	217
Transport equipment	3,278	1,335	338
Manufacturing n.e.c.	1,594	735	102

Median values are reported for different manufactoring sub-sectors industry According to NACE Rev. 1 classification. Data are in thousands of euros.

[7] We are indebted to Federico Giorgi for providing us with updated estimates in line with the approach followed in Brandolini and Cipollone (2001).

Since the balance sheets do not provide complete information on employees, we use the total labour cost as a proxy for the labour input. Capital input is computed according the perpetual inventory method (for a complete description of this approach, see Berlemann, 2016) using equation (14): starting from the oldest book value, for each year, we cumulate the flows of new investments[8] net of physical and technical depreciation. The physical depreciation is computed using the annual depreciation rate provided by ISTAT at industry level. The technical depreciation, our main parameter of interest, is endogenously estimated. In order to evaluate the "starting capital value" we would need data on the capital age structure and determine the time distance between it and the reference year. Since we do not have this information, we use different empirical strategies: *i)* we consider the initial stock as new capital; *ii)* as an indicator of the age of capital, we use the average length of use of capital provided by ISTAT (about 11 years). We then compare the results to test their robustness.

We are aware that *CeBI* is more representative of medium-large incorporated companies than of small firms. The former drive most of the national economy, but they typically show a higher propensity to invest in new technology. For this reason, our estimate of the technical depreciation rate could be upward biased; therefore we decide to be conservative and to fix the rate at 5 per cent in the remaining part of the paper.

Finally, in order to track the capacity utilization rate, which is not available in the *CeBi* data set, we follow an imputation procedure based on data from the Bank of Italy's Survey of Industrial and Service Firms. To our knowledge this survey is the only source that regularly collects individual data on capacity utilization for Italian manufacturing firms. However, for our purposes, it has the important limitation of only covering a relatively small portion of the *CeBi* sample (about 35,000 firms against 500,000).

Accordingly, we need to implement an imputation procedure by which we expand the information from the Bank of Italy sample to the *CeBi* sample. To achieve this, for the overlapping set of firms we estimate a linear regression between the utilized capacity declared in the Bank of Italy survey and a set of controls retrieved from *CeBI,* such as the region in which the firms are headquartered (regions), size, total labour costs, age and inventories. Moreover, to consider industry-specific dynamics we run a set of different regressions for each manufacturing sub-sector.[9] We then used the estimated coefficients to impute the capacity utilization for the remaining firms in the *CeBi* sample according to their specific values of the control variables.

In order to check the reliability of our imputation procedure, for firms in in the Bank of Italy sample we compare the *"*declared*"* information with the *"*imputed*"* one (in sample validation; Figure 1). A reassuring piece of evidence is that the two measures show a reasonably high correlation (above 0.5). We acknowledge that our imputed measure of capacity utilization is

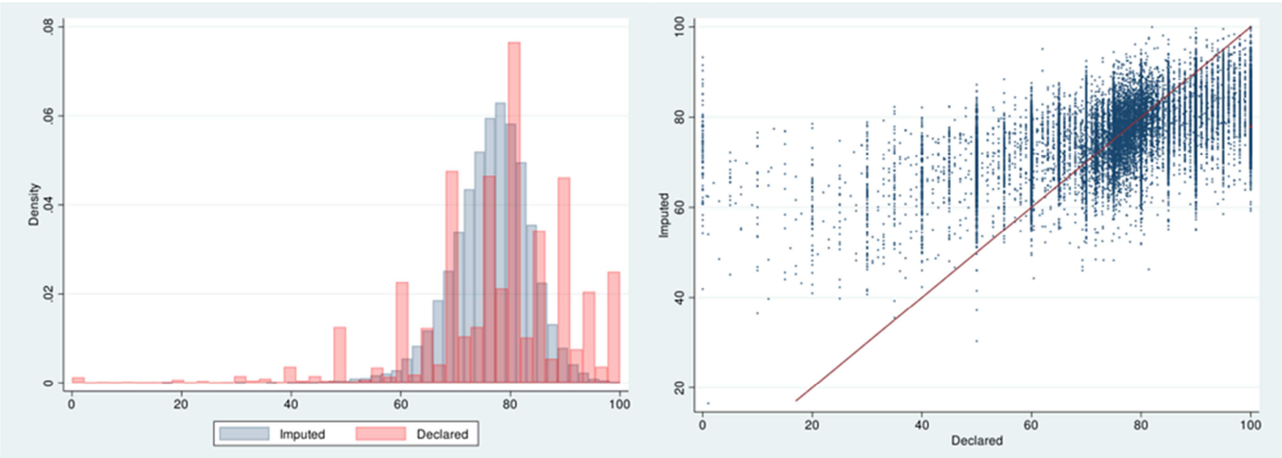
[8] Due to data constraints we are not able to estimate the technical depreciation rate for constructions.

[9] The sub-sectors considered in the analysis are those shown in Table 1; we decided to use the NACE Rev. 1 classification instead of NACE Rev. 2 since the former was the one used in the Bank of Italy survey.

fraught with some issues, mostly due to the fact that the distribution of the declared variable is left-skewed and characterized by several heaps.[10]

Figure 1

Capacity Utilization - Declared vs Imputed data



Note: “Declared” values come from the *Bank of Italy’s* Survey of Industrial and Service Firms; “Imputed” values are obtained in accordance with the described procedure using *CeBi* data.

We are aware that our estimated measure may be somewhat biased, although it is the best we can obtain so far. Given that controlling for capacity utilization is particularly important during crises, we estimate the rate of technical depreciation of capital with and without utilized capacity.

4. Empirical results

4.1 The sources of economic growth in Italy

In this section we perform a growth accounting exercise for the Italian economy as a whole and for main sectors of activity following equations (3) and (5) based on the ESA 2010 annual national accounts. Compared with previous standards, the latter provide a richer data disaggregation on both the output side, especially for services, and the input side, especially for capital assets, as R&D and other intangible activities are included in investment spending.

As for the total economy, our estimates confirm previous evidence (Broadberry, Giordano and Zollino, 2013) that since the mid-1990s the dismal TFP performance has been an important drag

[10] These issues are quite common for individual survey data. In particular, Giustinelli et al. (2018) find that a large number of surveys elicit responses on a 0-100 scale of percent chance, with the result that these data reveal substantial heaping at multiples of 10 and 5 percent, which suggests that respondents round their reports.

on the growth potential of the Italian economy, even more so in the period following the start of the global financial crisis (Table 2).

Table 2

The sources of growth in the economy as a whole[1]

(percentage changes; percentage points for the contributions; average values in any period)

Periods	Growth in value added	Contribution of capital services	*of which: asset substitution*	*ICT*	*Non-ICT*	*Intangibles*	Contribution of labour services	*of which: skill substitution*	TFP Adjusted	TFP Standard
1995-1999	1.57	0.67	0.20	0.22	0.35	0.09	1.03	0.39	-0.13	0.46
1999-2007	1.53	0.67	0.11	0.12	0.46	0.10	1.00	0.25	-0.14	0.22
2007-2013	-1.59	0.01	0.00	-0.01	-0.04	0.07	-0.72	0.60	-0.88	-0.28
2013-2016	0.56	-0.10	0.04	0.08	-0.23	0.05	1.06	0.43	-0.40	0.07
2006	1.95	0.50	0.05	0.05	0.39	0.06	1.59	0.01	-0.14	-0.08
2007	1.89	0.53	0.09	0.08	0.37	0.08	1.29	0.10	0.07	0.26
2008	-1.13	0.39	0.07	0.05	0.24	0.11	0.00	0.35	-1.53	-1.10
2009	-6.61	0.11	0.00	-0.05	0.05	0.11	-2.09	0.62	-4.63	-4.01
2010	2.24	-0.11	-0.06	-0.03	-0.15	0.07	0.08	0.65	2.27	2.85
2011	0.45	0.05	0.00	-0.03	0.03	0.05	0.47	0.42	-0.07	0.35
2012	-2.82	-0.14	-0.02	-0.02	-0.15	0.03	-1.26	0.85	-1.42	-0.59
2013	-1.63	-0.22	0.00	0.00	-0.24	0.02	-1.50	0.71	0.09	0.79
2014	0.17	-0.23	0.03	0.05	-0.29	0.00	0.55	0.67	-0.15	0.55
2015	0.77	-0.10	0.05	0.11	-0.28	0.07	1.17	0.59	-0.30	0.33
2016	0.76	0.04	0.05	0.08	-0.11	0.07	1.48	0.04	-0.75	-0.66

[1] Standard estimates of TFP are based on national accounts data for total capital stock and hours worked (equation 3); they regularly identify an upper bound as they include the impact of the changing quality in the productive services provided by capital and labour, which should be properly attached to the same inputs (equation 5).

On the one hand, the developments that have taken place since the crisis largely trace back to the usually high sensitivity of TFP to the business cycle since, as a residual in the growth accounting excercise, it absorbs the effects of unobservable adjustments in the intensity of the primary factor utilization. On the other hand, TFP was slightly negative also in the period 1995-2007, though economic activity increased by 1.5 per cent per year on average. This was accompanied by the sizeable contribution to output growth provided by both capital and labour inputs, especially when they are adjusted for the quality of their productive services (equation 5) rather than measured according to the national account standards (equation 3). As shown in the last column of Table 2, ignoring the quality adjustment that augments the contribution of the two primary factors – especially labour – would imply a positive, although decelerating, trend for *standard* TFP in the first decade since 1995. Following the decline during the double dip recession, standard TFP appears to have virtually stagnated in the years 2014-16.

Adjusted TFP, which incorporates changes in the quality of productive services provided by the primary inputs, shows a decline over the last 20 years, although with variable intensity. Focusing on developments since the global crisis, adjusted TFP fell by 0.9 per cent per year between 2008 and 2013 as the contribution of the capital input vanished and the upgrading in the quality of the productive services of labour almost offset the effect of job destruction. Despite the recovery in the business cycle, in the years 2014-16 the combined effects of skill upgrading and, especially more recently, employment creation implied negative adjusted TFP on average (against the stagnation signalled by the standard measure). As for the contribution of capital services, it turned slightly negative with the start of the sovereign debt crisis: the fall registered for the aggregate of machinery, equipment and transport equipment was partially offset by the increase in intangible spending and in ICT-related assets. The contribution of the capital input gradually improved since the start of the economic recovery, turning slightly positive in 2016.

Table 3

The sources of growth in industry[1]

(percentage changes; percentage points for the contributions; average values in any period)

Periods	Growth in value added	Contribution of capital services	*of which: asset substitution*	*ICT*	*Non-ICT*	*Intangibles*	Contribution of labour services	*of which: skill substitution*	TFP Adjusted	TFP Standard
1995-1999	0.51	0.80	0.11	0.12	0.32	0.10	0.17	0.12	-0.46	*-0.23*
1999-2007	1.12	0.82	-0.03	0.04	0.46	0.08	0.20	0.33	0.09	*0.39*
2007-2013	-2.81	0.12	0.10	-0.01	-0.02	0.11	-1.78	0.70	-1.16	*-0.36*
2013-2016	0.97	-0.09	0.16	0.08	-0.23	0.10	0.30	0.14	0.76	*1.06*
2006	3.89	0.70	-0.06	-0.01	0.45	0.03	1.08	0.12	2.10	*2.16*
2007	2.32	0.87	0.02	0.03	0.44	0.09	0.63	-0.25	0.82	*0.60*
2008	-2.48	0.84	0.10	0.02	0.38	0.15	-0.06	1.08	-3.26	*-2.09*
2009	-17.15	0.06	0.04	-0.03	-0.08	0.15	-3.89	3.58	-13.32	*-9.70*
2010	6.37	0.15	0.16	-0.03	0.00	0.12	-1.40	0.08	7.62	*7.87*
2011	1.14	0.16	0.10	-0.04	0.00	0.14	-0.13	-0.14	1.11	*1.08*
2012	-2.51	-0.14	0.12	-0.02	-0.16	0.08	-2.61	0.23	0.25	*0.59*
2013	-2.25	-0.32	0.11	0.02	-0.26	0.03	-2.55	-0.63	0.63	*0.11*
2014	-0.05	-0.26	0.20	0.06	-0.29	0.06	-0.53	0.25	0.74	*1.19*
2015	1.23	-0.05	0.15	0.10	-0.26	0.12	0.92	0.95	0.36	*1.46*
2016	1.74	0.03	0.12	0.06	-0.15	0.11	0.51	-0.78	1.19	*0.53*

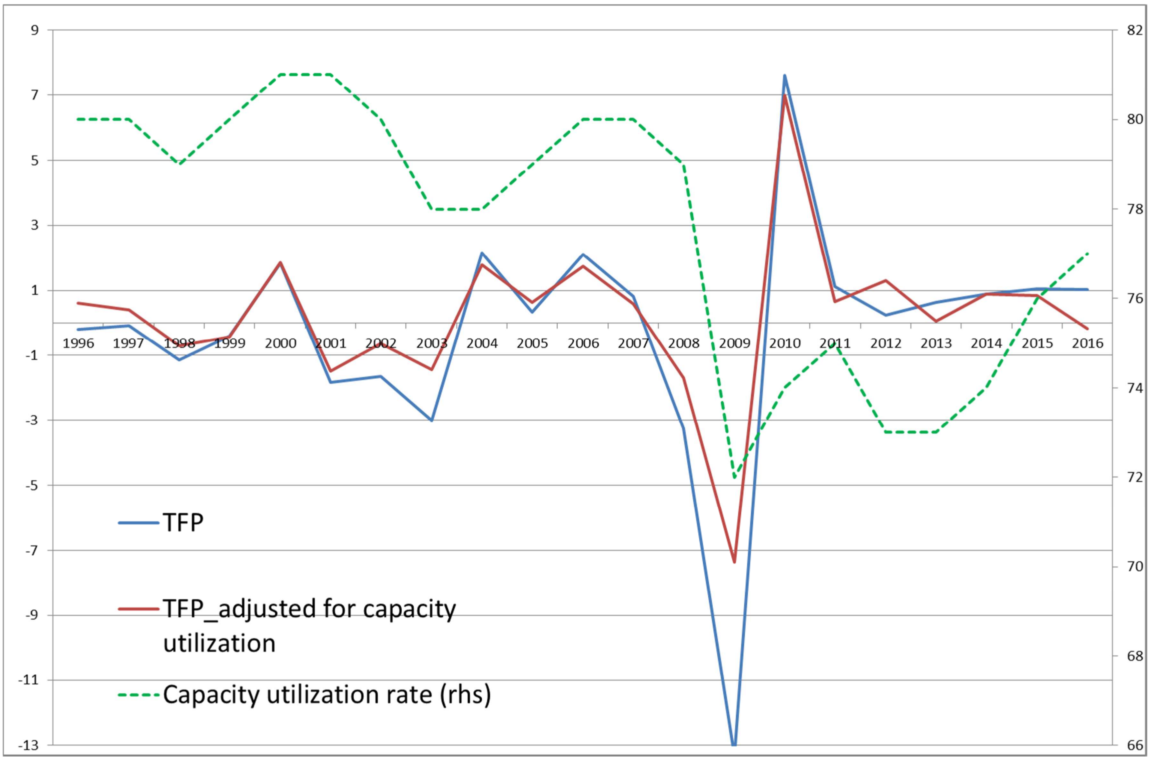
[1] Standard estimates of TFP are based on national accounts data for total capital stock and hours worked (equation 3); they regularly identify an upper bound as they include the impact of the changing quality in the productive services provided by capital and labour, which should be properly attached to the same inputs (equation 5).

In industry, TFP dynamics have proved more satisfactory since the late 1990s, and even more so in recent years (Table 3). Focusing on the *adjusted* measure, following the collapse recorded in 2008-2009 (-16.5 per cent as a whole compared to -19.6 per cent in value added), TFP has turned positive since then. Excluding the jump in 2010, it increased by 4 per cent over the last six years as a whole despite the small reduction in value added. However, in view of the fact that most of the improvement in TFP occurred in the most recent years as the recovery in value added consolidated, for industry we netted out the effects of the changing utilization rate of primary factors over the business cycles.

Cyclical changes in labour input are reasonably tracked by total hours worked, which we adopted as our preferred measure of employment. As for capital, we adopt the estimates of the capacity utilization rate for the Italian industry provided in Mistretta, Monteforte and Zevi (2016) in order to proxy the actual contribution of the productive assets (net of intangibles) along the business cycle. As expected, the pattern of the resulting TFP is less dramatic, especially during the double deep recession of the Italian industry that started in 2008 (Figure 2). The average fall in TFP halves at -0.2 per cent; more reassuringly, the recovery in 2014-16 was confirmed (0.5 per cent per year), although less pronounced than shown in Table 3 (*Adjusted TFP* column).

Figure 2

Industry TFP over the business cycle



Regarding the contribution of the capital input in industry, in line with the evidence for the total economy it was largely positive between 1995 and 2007, mostly thanks to non-ICT tangible components, and kept supporting activity up to the sovereign debt crisis. The lagged effects of the fall in investment started in 2008, combined with the more severe contraction that began three years later, imply that capital input has remained negative since 2014, to a larger extent in industry than in the total economy, despite investment spending having returned to growth (up by 11 per cent in the whole period for machinery, equipment and transport equipment). The contribution to output growth coming from the labour input, markedly negative at the peak of the global crisis in 2009 and of the sovereign debt crisis in 2012-13, turned on average positive in the following three years, supported initially by skill adjustment in the labour force and later by employment creation.

In private services, activity has been more buoyant than in the total economy since 1995, and fell less during the crisis mostly owing to the larger contribution coming from capital input in the first period and the lower drag on TFP in the second (Table 4). Differently from industry, however, TFP kept declining in the latest years, despite the cyclical recovery in output, which was driven by labour and, to a lower extent, by capital inputs.

For mixed services, which include some activities run by the public sector, TFP trends became significantly negative as early as in the period 1999-2007, i.e. before this occurred for the other services. However, during the crisis the fall in value added was much more limited, mostly due to a lower drag from the labour input, and TFP suffered a milder deterioration. Remarkably, the latter performed the worst in the last three years (-1.6 per cent on average), despite the moderate recovery in economic activity: the high contribution of the labour input (1.8 percentage points per year) and, to a much lesser extent, that of the capital input, implied dismal dynamics in the residual of the growth equation. These readings are subject to the usual caveat concerning the difficulty of measuring value added in the service sector.

Table 4

The sources of growth in services

(percentage changes; percentage points for the contributions; average values in any period)

Periods	Growth in value added		Contribution of capital		Contribution of labour		TFP	
	Private	Mixed	Private	Mixed	Private	Mixed	Private	Mixed
1995-1999	2.48	1.66	1.24	0.11	1.33	1.25	-0.09	0.30
1999-2007	2.22	0.53	1.02	0.12	1.15	0.96	0.06	-0.54
2007-2013	-1.16	-0.18	-0.12	0.01	-0.63	0.00	-0.41	-0.19
2013-2016	1.01	0.34	0.47	0.12	0.89	1.83	-0.36	-1.61
2006	1.90	0.06	0.71	0.05	1.64	3.04	-0.45	-3.04
2007	3.02	0.08	0.80	0.04	1.58	0.44	0.64	-0.40
2008	-0.82	0.35	0.40	0.02	0.22	0.81	-1.44	-0.48
2009	-5.12	0.49	-0.18	0.04	-1.99	0.97	-2.95	-0.52
2010	2.40	0.13	-0.07	0.00	0.18	-0.54	2.28	0.66
2011	0.93	0.90	-0.10	-0.01	0.64	0.60	0.39	0.31
2012	-2.85	-2.25	-0.36	0.00	-0.92	-0.75	-1.57	-1.50
2013	-1.51	-0.68	-0.45	-0.01	-1.88	-1.09	0.81	0.42
2014	0.99	1.45	-0.32	-0.03	-0.03	1.54	1.33	-0.06
2015	1.17	-0.36	0.90	0.22	0.74	1.00	-0.47	-1.58
2016	0.87	-0.08	0.84	0.17	1.98	2.94	-1.95	-3.19

4.2 Estimates of technical depreciation

Using the data previously described we are able to estimate the technical depreciation rate, with 2014 as the reference year. We estimate the model sketched in Section 2.2 by using a Nonlinear Least Square procedure (NLLS) and under different assumptions regarding: *a)* capital being or not being corrected for the utilization rate; *b)* the initial stock being modelled as "new capital" (i.e. as the first vintage for firms entering our data set for the first time) or estimated under the same average life officially adopted by Istat (about 11 years, considering the average life of machinery, equipment and transport equipment).

Our evidence suggests that the technical depreciation rate for Italian firms is around 5 per cent per year if we correct for the capacity utilization rate (Table 4), with a negligible impact from the different assumptions on the initial value of the capital stock. By contrast, when remove the control for utilized capacity, we find a substantial impact, as the ensuing depreciation rate is almost double than in the case in which capacity utilization in considered. These results appear to be reasonable, as the changes in capital stock prove sensibly more pronounced when we ignore the fact that only part of the installed capital is actually used in production.

Table 5

Empirical estimates of capital obsolescence due to technical progress[11]

Parameters	Initial stock with imputed vintage		Initial stock considered as new	
	adjusted for CU	*Not adjusted for CU*	*adjusted for CU*	*Not adjusted for CU*
α	0.8203***	0.8316***	0.8199***	0.8306***
β	0.0563***	0.0361***	0.0513***	0.0327***
γ	**0.0505*****	**0.0942*****	**0.0496*****	**0.0874*****
N	503.102	503.102	503.102	503.102
R^2	0.5522	0.5507	0.5526	0.5512

Note: *** significant at 1 per cent

Due to the computational complexity of the NLLS estimation, we assume that the technical depreciation rate is constant over time. We are aware that this assumption could be very restrictive: technical innovation is mostly likely not characterized by a linear increase over time, especially when major innovations occur (i.e. the diffusion of IT determined an acceleration in technical improvements).

5. The effects of embodied technical progress

5.1 Adjusting the measure of capital stock

As argued in the previous sections, in our analysis estimates of the technical depreciation rate deliver information about an additional source of depreciation of the capital stock compared with the national account standards, in which only the decay of productive services due to the consumption of the installed capital is considered.

In this section we adjust the measure of capital input (net of residential constructions) taking into account the evolution of technical efficiency along the sequence of vintages installed (and still operating) for a given asset.

First, for computational simplicity we take that the technical depreciation rate is constant over time, and it stands around 5 per cent per year. We decide to use this relatively low value for the

[11] As argued by Sakellaris and Wilson (2004), since the deflators used for the different variables are not the standard ones, the parameters related to labour and capital cannot been considered as the "standard" parameters of a Cobb-Douglas function.

depreciation rate, which is consistent with changes in capacity utilization (Table 5), because it entails a more conservative adjustment in the standard data of capital stock than under the alternatively higher rates (see Figure A1 in the Appendix). Moreover, we apply the technical depreciation rate only to the machinery, equipment and transport equipment as it is reasonable to assume that they are influenced the most by changes in the embodied technology.[12]

Second, we produce new estimates of the net capital stock following the same methodology as Istat (Lupi and Mantegazza, 1994) and using the updated parameters adopted in the latest releases of the annual national accounts. Accordingly, for every capital assets we first compute the gross capital stock by applying a retirement function (a truncated normal density over minimum and maximum values centred around the length of the service's life) to any vintage of investment and we then sum the value of the surviving vintages at each point in time (see Giordano and Zollino, 2017). The net capital stock is then obtained by subtracting the standard linear depreciation (due to economic consumption) over the service life of any vintage (conditional on survival as implied in the computation of the gross capital); the resulting amount is then reduced according to our estimates for technical depreciation; finally, we sum the "efficient" vintages still surviving at each point in time to compute our adjusted net capital stock.

As Figure 3 shows, when we take into account the technical depreciation rate for the different vintages of instrumental assets (namely non-construction capital goods), even under our prudent assumption that it is constant at a relatively low level compared with international evidence, the value of the net capital stock installed in the Italian economy turns out to be significantly lower than that measured in the national accounts (which consider only the physical consumption in line with the current international standards).[13] In times of rapid technical progress, this finding signals the risk of a substantial overvaluation of the capital input when we disregard the upgraded technical efficiency of later versus earlier vintages of a given capital good.

More interestingly, we find a widening gap between the efficiency-adjusted measure and the standard measure of the Italian capital stock during the protracted crisis. Indeed, the ratio between the two measures was steadily but moderately declining even before the crisis, as it was reasonable to expect on the basis of technical progress (see the green histogram in Figure 3). Importantly, as the crisis deepened the gap became wider and wider: at the end of 2016 the efficiency-adjusted capital stock in the whole Italian economy (net of housing) stood at less than 90 per cent of the standard value (compared with around 95 per cent prior to the crisis). Indeed, between 2007 and 2016 the total net capital stock (net of housing) declined by about 6 per cent when we take account of the changing efficiency along the different vintages, or five times more than in the standard measures.

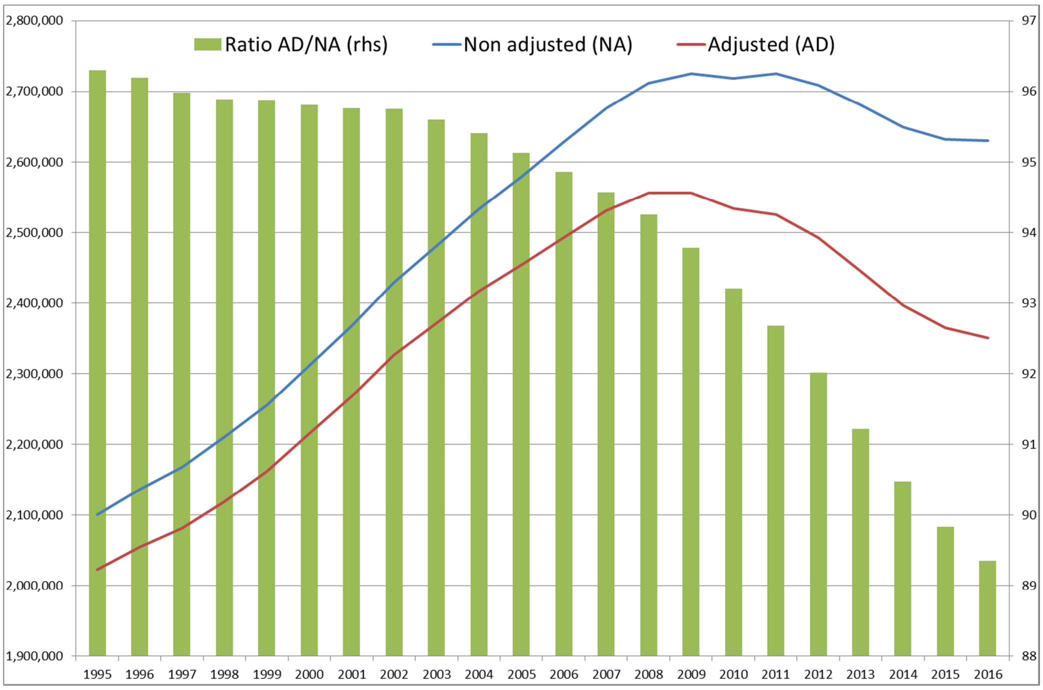
[12] According to footnote 8, in our measure we are not able to distinguish investment in construction. For this reason, in this exercise we use the traditional measure for this kind of capital.

[13] Although we estimate the depreciation rate using only data on manufacturing firms, we apply this correction to all the economy. We implicitly assume that the technological depreciation rate in the service and construction sectors is similar to that in manufacturing for any given capital good we consider. However, this assumption should have a negligible effect on our final results since machinery, equipment and transport equipment represent around 10 per cent of the total stock of capital (compared with 60% in manufacturing).

Figure 3

Capital stock in the total economy

(Total assets net of dwellings, chained values in millions of euros; for the ratio, percentage values, right-hand scale)



Focusing on non-construction assets − the sole components for which we have expanded depreciation to include technical obsolescence − the cumulative fall in the efficiency-adjusted capital stock was 19 per cent, or 11 points more pronounced than in the standard measure of capital. Accordingly, the fall in the total adjusted capital stock was even more pronounced in manufacturing than in the rest of the economy, as in industry the share of capital assets more influenced by technical progress (equipment and machinery) is higher.

Our findings are strictly related to the severe drop in investment registered during the double-dip recession that hit the Italian economy starting in 2007, and unveil an additional unpleasant effect on potential output: the drop in investment (-29.5 per cent between 2007 and 2013; -22,4 per cent excluding construction) dramatically limited the room for manoeuvre for the turnover between new and old capital vintages, with the result that the installed equipment not only shrank in volume but also became older and older, entailing an important loss in the overall capital efficiency.

In other words, when we consider the role of embodied technical progress, the drag on the Italian economy's growth, which during the crisis came from the lower accumulation, would prove even more pronounced than shown in previous sections of this paper based on the standard measure of capital stock. On a positive tone, we find that following a three-year recovery in instrumental good investments (11.1 per cent according to the latest national accounts), which would continue in 2017 according to the latest projections (Banca d'Italia, 2017), the gap between the efficiency–adjusted measure and the standard measure of capital is broadly stabilising. This may comfortably signal that the replacement of old vintages of capital with new ones is gradually picking up in the

Italian economy, though it needs to strengthen further to fully offset the lagged effects of the previous drop in investment.

5.2 The impact on TFP

In view of the efficiency-adjusted capital stock calculated based on our estimate of technical obsolescence, in this section we perform the growth accounting exercise as per equation (3) by replacing the national account capital stock with our experimental measure.[14] An important caveat is that, under the maintained assumptions of perfect competition and constant returns to scale, we did not impute any revision for value added or factor shares. Accordingly, in the last 20 years on average, the lower contribution of the capital input that we found following the downward correction in capital stock due to technical obsolescence translates almost automatically into significantly higher values of the residual by which we proxy TFP (Figure 4).

Interestingly, the positive gap between the TFP adjusted for capital efficiency ("embodied" in the figure) and the standard one, which prior to the crisis was modest though widening, became increasingly larger until the recovery in capital formation started in 2014. This reinforces the positive signal, already mentioned, that the loss in efficiency of installed capital has gradually mitigated as the flow of new vintages has gained momentum following the exit from the most severe recession in Italian history.

Focusing on the trends recorded since the inception of the crisis, when we control for technical obsolescence of the capital stock we find that TFP in the total economy decreased by 0.7 per cent overall in the period 2007-13, or 1 percentage points less than implied by the standard measure; since the start of the recovery, it increased by 0.6 per cent, or around half a percentage point more than implied by the standard measure.[15]

The improvement appears to be even more pronounced in industry, where again instrumental goods claim the highest share of total capital. In this case we find that the "embodied" TFP appears to have recorded a slight increase of 0.2 per cent between 2007 and 2013, rather than a 2.1 per cent decline; during the subsequent recovery, overall growth appears to have been equal to 3.3 per cent, largely in line with the standard measure.

---

[14] At this stage we believe that it is more reliable to test the impact of capital efficiency on TFP within the standard growth accounting model as per equation (1), rather than as per equation (4), and this for two reasons: i) controlling for the composition effects in the productive services of capital requires capital stocks to be available for a reasonably detailed list of assets (in national accounts we can retrieve data for nine different capital goods useful for our analysis), whereas we are able to estimate technical obsolescence only for three assets taken together; ii) the imputation of user costs is not neutral under the assumption we maintained regarding the magnitude of the capital depreciation as well as the dynamics of deflators, and both statistics need to be revised to incorporate our estimates of technical obsolescence; the task is easy for the depreciation rate while it is challenging for the deflators, for which the national accounts data should be adjusted to control for the uncertain impact on the market price of a given capital good arising from changes in its relative technical content.

[15] As a direct result of TFP being a residual in the growth accounting, the overall impact on TFP would have been significantly stronger, all other things being equal, if we had maintained a higher rate of technical obsolescence (Figure A2 in the Appendix)

Figure 4

TFP developments under different assumptions on embodied technical progress

(percentage changes; percentage points for differences, right-hand scale)

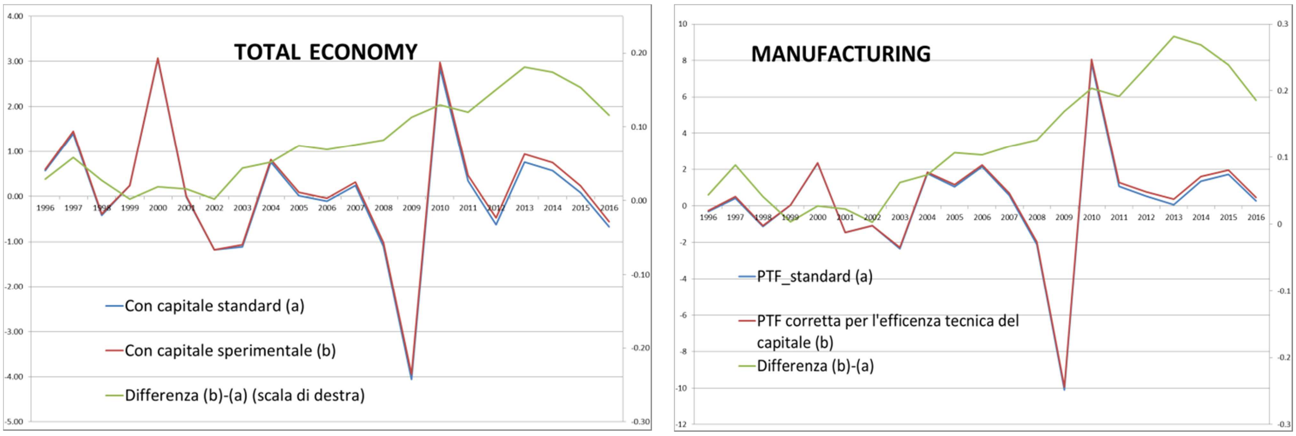


Table 6

TFP developments under different assumptions on embodied technical progress

(cumulated percentage changes in the given periods)

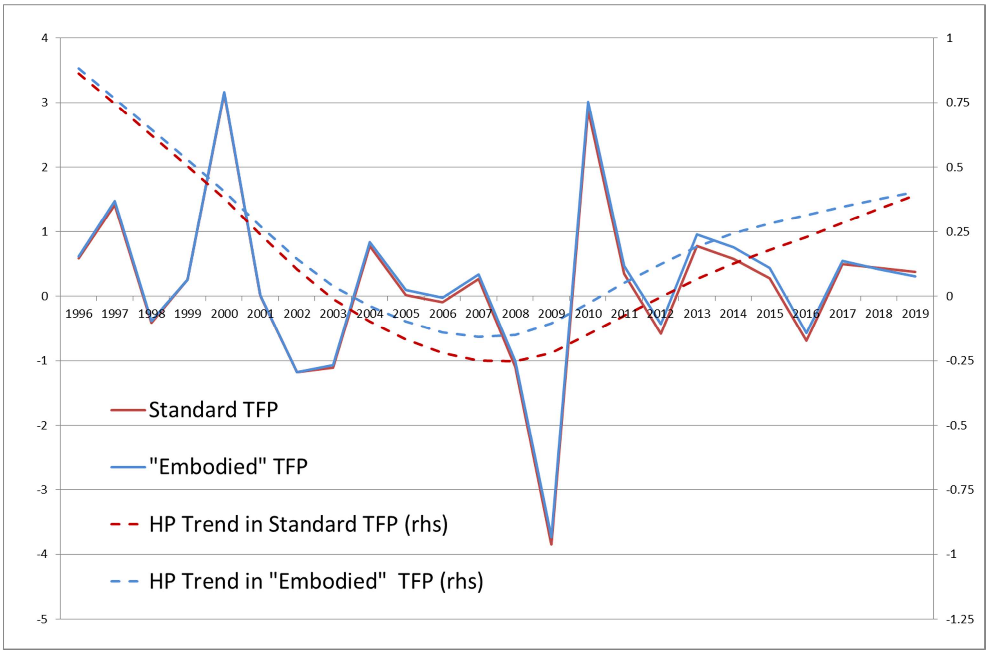
Periods	TFP IN TOTAL ECONOMY			TFP IN MANUFACTURING		
	"Standard" (A)	"Embodied" (B)	(B)-(A)	"Standard" (A)	"Embodied" (B)	(B)-(A)
1995-1999	1.83	1.97	0.13	-0.92	-0.78	0.14
1999-2007	1.76	2.18	0.42	3.08	3.68	0.59
2007-2013	-1.71	-0.74	0.96	-2.15	0.22	2.37
2013-2016	0.21	0.62	0.41	3.18	3.30	0.12

Looking ahead, based on the macroeconomic scenario presented in Banca d'Italia (2017) we simulate developments in TFP for the years 2017-19 under the standard approach and using our experimental measure of net capital. The strong acceleration projected in gross fixed capital formation, especially in machinery, equipment and transport equipment, entails that the gap between the two measures of capital is expected to narrow rapidly in the next few years; accordingly, developments in TFP would also be similar regardless of whether we control for technical obsolescence of capital (Figure 5). It is worth mentioning that, by using standard statistical tools to filter out the cyclical components, we find that under the standard measure of capital input the underlying trend of TFP has only returned to very moderate positive values since 2013, with a gradual improvement in the following years.

Figure 5

Underlying components of TFP under different assumptions on capital stock

(total and de-trended percentage changes or points for difference)



However, in our efficiency-adjusted capital stock the same components of TFP started to turn positive again as early as in 2011 and since 2016 have returned to the same pace as in the early 2000s. Since the start of the cyclical recovery in 2014, the overall gain in trend TFP appears to have been close to 2 per cent, or half a percentage point higher than under the standard measure of capital. Accordingly, when we introduce our experimental results in the production function we adopted to measure potential growth (Bassanetti et al., 2010), we obtain a persistently more positive contribution of TFP than usually assumed, even more so if the cyclical recovery continues in the following years as currently projected by most forecasters.

Should the business cycle recovery, together with capital formation, firm up in line with expectations, potential output would benefit not only from a higher trend in TFP but also form larger gains in the technical efficiency of the installed capital, as the replacement of older vintages with new (and technically more advanced) ones would steadily resume following the halt we suspect occurred during the crisis.

6. Conclusions

In this paper we present evidence on TFP trends in Italy for the years 1995-2016 that confirms previous results suggesting the existence of a significant drag on potential growth stemming from dismal TFP performance. This appears to have happened to an even greater extent during the deep recession that began in 2007. If we exclude the dramatic fluctuations observed in 2009-11, TFP performance has been more positive in industry than in services, where it has been declining in recent years despite the recovery in the business cycle.

As a novel contribution, in this paper we control for the technical progress embodied in instrumental capital, using a vintage model for single assets estimated with firm level data on the Italian industrial sector. By adding our estimate of the technical depreciation rate to the more standard economic consumption rate of productive assets, we find that during the crisis our adjusted stock of capital fell more severely than that estimated in the national accounts. The result is coherent with a more limited turnover of old and new (more technically advanced) vintages of capital goods as the investment expenditure dropped during the crisis. Based on our experimental measure of the capital stock, we find that TFP performance was less disappointing then otherwise estimated. Focusing on the years since 2007, we find that the cumulative fall of TFP in the total economy during the crisis was almost completely offset by its steady increase during the subsequent recovery; this compares with the overall figure of 1.5 per cent obtained from national account measures of capital. Focusing on manufacturing, since 2007 TFP has increased by about 3 per cent, almost 2.5 points more than in standard estimates. Finally, the estimated underlying components of TFP gradually improved as well and, according to our simulations, the trend will continue to be positive in the years 2017-19. This sheds a somewhat more positive light as regards future TFP developments in Italy, entailing a more rapid increase in potential output than usually estimated. In addition, the efficiency of installed capital might soon begin to grow again, as the expected recovery of investment results in the replacement of old vintages with new and more technically advanced ones.

APPENDIX

In this appendix we estimate the stock of capital and the related TFP considering three different values of the proposed technical depreciation parameter. In particular, $\gamma = 0.05$ when we don't consider capacity utilization in production function estimation ($\gamma = 0.09$ otherwise). The standard measure of capital doesn't take into account technical depreciation ($\gamma = 0.00$). As we expected, the effect on capital and, obviously, on TFP is greater when a higher depreciation rate is used.

Figure A1

Capital stock in the total economy using different rates of technical obsolescence

(total assets net of dwellings; chained values in millions of euros)

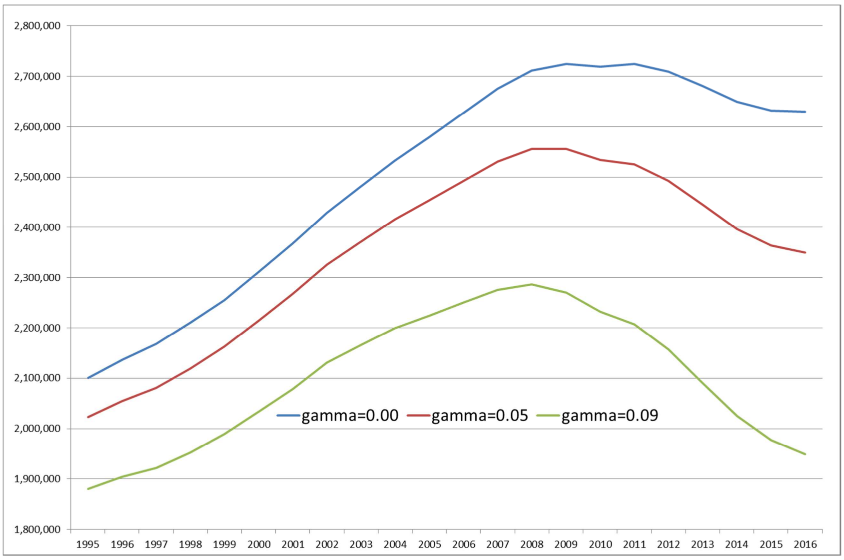
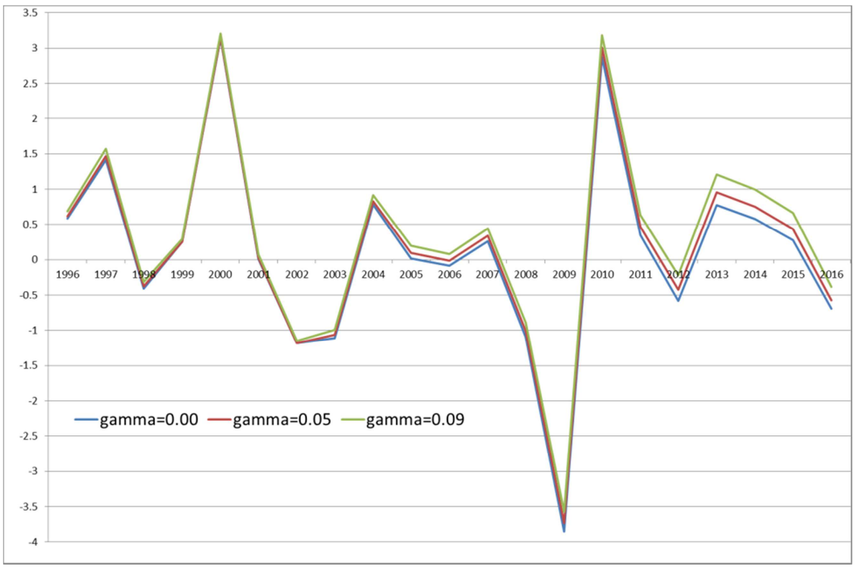


Figure A2

TFP in the total economy using different rates of technical obsolescence

(percentage changes)



References

Banca d'Italia (2017) *Economic Bulletin, 1 2017.*

Bassanetti A., Iommi M., Jona-Lasinio C. and Zollino F. (2004). 'La crescita dell'economia italiana negli anni novanta tra ritardo tecnologico e rallentamento della produttività', Banca d'Italia, Temi di Discussione (Working Papers), 539, 2010.

Bassanetti A., Torrini R. and Zollino F. (2010). 'Changing institutions in the European market: the impact on mark-ups and rents allocation', Banca d'Italia, Temi di Discussione (Working Papers), 781, 2010.

Bassanetti A. and Zollino F. (2010). 'L'andamento della Produttività totale dei fattori in Italia nell'ultimo ventennio'. Banca d'Italia, mimeo.

Bassanetti A., Caivano M. and Locarno A. (2010). 'Modelling Italian potential output and the output gap', Banca d'Italia, Temi di Discussione (Working Papers), 565, 2010.

Boucekkine R., de la Croix D. and Licandro O. (2011). 'Vintage Capital Growth Theory: Three Breakthroughs'. Barcelona GSE, Working Paper n. 565.

Brandolini A. and Cipollone P. (2001). 'Multifactor Productivity and Labour Quality in Italy, 1981-2000', Banca d'Italia, Temi di Discussione (Working Papers), 422, 2001.

Broadberry S., Giordano C. and Zollino F. (2013). 'Productivity'. In Toniolo, G. (ed.) *The Oxford Handbook of the Italian Economy since Unification,* New York, Oxford University Press.

Byrne D. M., Fernald J. G. and Reinsdorf B. (2016). 'Does the United States Have a Productivity Slowdown or a Measurement Problem? '. *Brookings Papers on Economic Activity.*

Chari V. and Hopenhayn H. (1991). 'Vintage Human Capital, Growth, and the Diffusion of New Technology'. *Journal of Political Economy* vol. 99(6).

Giordano C., Toniolo G. and Zollino F. (2017). 'Long run trends in Italian Productivity', Banca d'Italia, Questioni di economia e finanza (Occasional Papers), 406, 2017.

Giordano C. and Zollino F. (2017). 'Macroeconomic estimates of Italy's mark-ups in the long-run, 1861-2012', Banca d'Italia, Quaderni di storia economica (Economic History Working Papers), 39, 2017.

Giustinelli P., Manski C. F. and Molinari F. (2018). 'Tail and Center Rounding of probabilistic Expectations in the Health and Retirement Study', National Bureau of Economic Research, NBER Working Papers 24559.

Gordon R. (1990). '*The Measurement of Durable Goods Prices*'. University of Chicago Press.

Gordon R. (1996). *'Can technology improvements cause productivity slowdowns? Comment'. In J. J. Rotemberg, B. S. Bernanke (Eds.), NBER Macroeconomics Annual 1996,* MIT Press, Cambridge.

Greenwood J., Hercowitz Z. and Krusell P. (1997). ‘Long-Run Implications of Investment-Specific Technological Change’. *American Economic Review,* vol. 87(3).

Greenwood J. and Jovanovic B. (2003). ‘Accounting for growth’. In E. Dean, M. Harper and C. Hulten (eds.), *New directions in productivity analysis.* National Bureau of Economic Research.

Johansen L. (1959). ‘Substitution versus Fixed Production Coefficients in the Theory of Economic Growth: A Synthesis’. *Econometrica,* vol. 27.

Jorgenson W. D. (2001). ‘Information Technology and the U.S. Economy’. *American Economic Review,* 91(1).

Krusell P. (1998). ‘Investment-specific R&D and the decline in the relative price of capital’. *Journal of Economic Growth,* vol. 3.

Lupi C. and Mantegazza S. (1994). ‘Ricostruzione delle serie degli investimenti per branca utilizzatrice, per branca proprietaria e calcolo dello stock di capitale’. Istat Quaderni di Ricerca Economia e ambiente, 14, 1994.

Mistretta A., Monteforte L. and Zevi G. (2016). ‘Manufacturing capacity in Italy and demography of firms’. Bank of Italy, mimeo.

Nelson R. (1964), ‘Aggregate Production Functions and Medium-Range Growth Projections’. *American Economic Review, 54*.

OECD (2009). ‘*Measuring Capital*’. OECD Manual - Second edition.

Parente S. (1994). ‘Technology adoption, learning-by-doing, and economic growth’. *Journal of Economic Theory,* vol. 63.

Rossi N. and Toniolo G. (1992). ‘Catching up or falling behind? Italy's economic growth, 1895-1947’. *Economic History Review, 45(3).*

Summers L. (2014). ‘U.S. economic prospects: secular stagnation, hysteresis and the zero lower bound’, *Business Economics 49(2)*.

Sakellaris P. and Wilson D. J. (2004). ‘Quantifying Embodied Technological Change’, *Review of Economic Dynamics*, vol. 7(1).

Solow R. (1960). ‘Investment and technological progress’. *In K. Arrow, S. Karlin and P. Suppes (eds.), Mathematical Methods in Social Sciences* 1959, 89-104. Stanford University Press.

Syverson C. (2017). ‘Challenges to Mismeasurement Explanations for the US Productivity Slowdown’. *Journal of Economic Perspectives, 31(2).*

Zeckhauser R. (1968). ‘Optimality in a world of progress and learning’. *Review of Economic Studies*, vol. 35.

RECENTLY PUBLISHED "TEMI" (*)

N. 1179 – *Labor market and financial shocks: a time varying analysis*, by Francesco Corsello and Valerio Nispi Landi (June 2018).

N. 1180 – *On the unintended effects of public transfers: evidence from EU funding to Southern Italy*, by Ilaria De Angelis, Guido de Blasio and Lucia Rizzica (June 2018).

N. 1181 – *Always look on the bright side? Central counterparties and interbank markets during the financial crisis*, by Massimiliano Affinito and Matteo Piazza (July 2018).

N. 1182 – *Knocking on parents' doors: regulation and intergenerational mobility*, by Sauro Mocetti, Giacomo Roma and Enrico Rubolino (July 2018).

N. 1183 – *Why do banks securitise their assets? Bank-level evidence from over one hundred countries in the pre-crisis period,* by Fabio Panetta and Alberto Franco Pozzolo.

N. 1184 – *Capital controls spillovers*, by Valerio Nispi Landi (July 2018).

N.1185 – *The macroeconomic effects of an open-ended asset purchase programme*, by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani (July 2018).

N.1186 – *Fiscal buffers, private debt and recession: the good, the bad and the ugly*, by Nicoletta Batini, Giovanni Melina and Stefania Villa (July 2018).

N. 1187 – *Competition and the pass-through of unconventional monetary policy: evidence from TLTROs*, by Matteo Benetton and Davide Fantino (September 2018).

N. 1188 – *Raising aspirations and higher education: evidence from the UK's Widening Participation Policy*, by Lucia Rizzica (September 2018).

N. 1189 – *Nearly exact Bayesian estimation of non-linear no-arbitrage term structure models*, by Marcello Pericoli and Marco Taboga (September 2018).

N. 1190 – *Granular Sources of the Italian business cycle*, by Nicolò Gnocato and Concetta Rondinelli (September 2018).

N. 1191 – *Debt restructuring with multiple bank relationships*, by Angelo Baglioni, Luca Colombo and Paola Rossi (September 2018).

N. 1192 – *Exchange rate pass-through into euro area inflation. An estimated structural model*, by Lorenzo Burlon, Alessandro Notarpietro and Massimiliano Pisani (September 2018).

N. 1193 – *The effect of grants on university drop-out rates: evidence on the Italian case*, by Francesca Modena, Enrico Rettore and Giulia Martina Tanzi (September 2018).

N. 1194 – *Potential output and microeconomic heterogeneity*, by Davide Fantino (November 2018).

N. 1195 – *Immigrants, labor market dynamics and adjustment to shocks in the Euro Area*, by Gaetano Basso, Francesco D'Amuri and Giovanni Peri (November 2018).

N. 1196 – *Sovereign debt maturity structure and its costs*, by Flavia Corneli (November 2018).

N. 1197 – *Fiscal policy in the US: a new measure of uncertainty and its recent development*, by Alessio Anzuini and Luca Rossi (November 2018).

N. 1198 – *Macroeconomics determinants of the correlation between stocks and bonds*, by Marcello Pericoli (November 2018).

N. 1199 – *Bank capital constraints, lending supply and economic activity*, by Antonio M. Conti, Andrea Nobili and Federico M. Signoretti (November 2018).

N. 1200 – *The effectiveness of capital controls*, by Valerio Nispi Landi and Alessandro Schiavone (November 2018).

N. 1201 – *Contagion in the CoCos market? A case study of two stress events*, by Pierluigi Bologna, Arianna Miglietta and Anatoli Segura (November 2018).

(*) Requests for copies should be sent to:
Banca d'Italia – Servizio Studi di struttura economica e finanziaria – Divisione Biblioteca e Archivio storico – Via Nazionale, 91 – 00184 Rome – (fax 0039 06 47922059). They are available on the Internet www.bancaditalia.it.

2016

ALBANESE G., G. DE BLASIO and P. SESTITO, *My parents taught me. evidence on the family transmission of values,* Journal of Population Economics, v. 29, 2, pp. 571-592, **WP 955 (March 2014).**

ANDINI M. and G. DE BLASIO, *Local development that money cannot buy: Italy's Contratti di Programma,* Journal of Economic Geography, v. 16, 2, pp. 365-393, **WP 915 (June 2013).**

BARONE G. and S. MOCETTI, *Inequality and trust: new evidence from panel data,* Economic Inquiry, v. 54, pp. 794-809, **WP 973 (October 2014).**

BELTRATTI A., B. BORTOLOTTI and M. CACCAVAIO, *Stock market efficiency in China: evidence from the split-share reform,* Quarterly Review of Economics and Finance, v. 60, pp. 125-137, **WP 969 (October 2014).**

BOLATTO S. and M. SBRACIA, *Deconstructing the gains from trade: selection of industries vs reallocation of workers,* Review of International Economics, v. 24, 2, pp. 344-363, **WP 1037 (November 2015).**

BOLTON P., X. FREIXAS, L. GAMBACORTA and P. E. MISTRULLI, *Relationship and transaction lending in a crisis*, Review of Financial Studies, v. 29, 10, pp. 2643-2676, **WP 917 (July 2013).**

BONACCORSI DI PATTI E. and E. SETTE, *Did the securitization market freeze affect bank lending during the financial crisis? Evidence from a credit register,* Journal of Financial Intermediation, v. 25, 1, pp. 54-76, **WP 848 (February 2012).**

BORIN A. and M. MANCINI, *Foreign direct investment and firm performance: an empirical analysis of Italian firms,* Review of World Economics, v. 152, 4, pp. 705-732, **WP 1011 (June 2015).**

BRAGOLI D., M. RIGON and F. ZANETTI, *Optimal inflation weights in the euro area,* International Journal of Central Banking, v. 12, 2, pp. 357-383, **WP 1045 (January 2016).**

BRANDOLINI A. and E. VIVIANO, *Behind and beyond the (headcount) employment rate,* Journal of the Royal Statistical Society: Series A, v. 179, 3, pp. 657-681, **WP 965 (July 2015).**

BRIPI F., *The role of regulation on entry: evidence from the Italian provinces,* World Bank Economic Review, v. 30, 2, pp. 383-411, **WP 932 (September 2013).**

BRONZINI R. and P. PISELLI, *The impact of R&D subsidies on firm innovation,* Research Policy, v. 45, 2, pp. 442-457, **WP 960 (April 2014).**

BURLON L. and M. VILALTA-BUFI, *A new look at technical progress and early retirement,* IZA Journal of Labor Policy, v. 5, **WP 963 (June 2014).**

BUSETTI F. and M. CAIVANO, *The trend–cycle decomposition of output and the Phillips Curve: bayesian estimates for Italy and the Euro Area,* Empirical Economics, v. 50, 4, pp. 1565-1587, **WP 941 (November 2013).**

CAIVANO M. and A. HARVEY, *Time-series models with an EGB2 conditional distribution,* Journal of Time Series Analysis, v. 35, 6, pp. 558-571, **WP 947 (January 2014).**

CALZA A. and A. ZAGHINI, *Shoe-leather costs in the euro area and the foreign demand for euro banknotes,* International Journal of Central Banking, v. 12, 1, pp. 231-246, **WP 1039 (December 2015).**

CESARONI T. and R. DE SANTIS, *Current account "core-periphery dualism" in the EMU,* The World Economy, v. 39, 10, pp. 1514-1538, **WP 996 (December 2014).**

CIANI E., *Retirement, Pension eligibility and home production,* Labour Economics, v. 38, pp. 106-120, **WP 1056 (March 2016).**

CIARLONE A. and V. MICELI, *Escaping financial crises? Macro evidence from sovereign wealth funds' investment behaviour,* Emerging Markets Review, v. 27, 2, pp. 169-196, **WP 972 (October 2014).**

CORNELI F. and E. TARANTINO, *Sovereign debt and reserves with liquidity and productivity crises,* Journal of International Money and Finance, v. 65, pp. 166-194, **WP 1012 (June 2015).**

D'AURIZIO L. and D. DEPALO, *An evaluation of the policies on repayment of government's trade debt in Italy,* Italian Economic Journal, v. 2, 2, pp. 167-196, **WP 1061 (April 2016).**

DE BLASIO G., G. MAGIO and C. MENON, *Down and out in Italian towns: measuring the impact of economic downturns on crime,* Economics Letters, 146, pp. 99-102, **WP 925 (July 2013).**

DOTTORI D. and M. MANNA, *Strategy and tactics in public debt management,* Journal of Policy Modeling, v. 38, 1, pp. 1-25, **WP 1005 (March 2015).**

GERALI A., A. NOTARPIETRO and M. PISANI, *Macroeconomic effects of simultaneous implementation of reforms,* International Finance, Wiley Blackwell, v. 19, 1, pp. 42-65, **WP 997 (December 2014).**

LIBERATI D., M. MARINUCCI and G. M. TANZI, *Science and technology parks in Italy: main features and analysis of their effects on hosted firms*, Journal of Technology Transfer, v. 41, 4, pp. 694-729, **WP 983 (November 2014).**

MARCELLINO M., M. PORQUEDDU and F. VENDITTI, *Short-Term GDP forecasting with a mixed frequency dynamic factor model with stochastic volatility,* Journal of Business & Economic Statistics, v. 34, 1, pp. 118-127, **WP 896 (January 2013).**

RODANO G., N. SERRANO-VELARDE and E. TARANTINO, *Bankruptcy law and bank financing,* Journal of Financial Economics, v. 120, 2, pp. 363-382, **WP 1013 (June 2015).**

ZINNA G., *Price pressures on UK real rates: an empirical investigation,* Review of Finance, v. 20, 4, pp. 1587-1630, **WP 968 (July 2014).**

2017

AABERGE, R., F. BOURGUIGNON, A. BRANDOLINI, F. FERREIRA, J. GORNICK, J. HILLS, M. JÄNTTI, S. JENKINS, J. MICKLEWRIGHT, E. MARLIER, B. NOLAN, T. PIKETTY, W. RADERMACHER, T. SMEEDING, N. STERN, J. STIGLITZ, H. SUTHERLAND, *Tony Atkinson and his legacy,* Review of Income and Wealth, v. 63, 3, pp. 411-444, **WP 1138 (September 2017).**

ACCETTURO A., M. BUGAMELLI and A. LAMORGESE, *Law enforcement and political participation: Italy 1861-65,* Journal of Economic Behavior & Organization, v. 140, pp. 224-245, **WP 1124 (July 2017).**

ADAMOPOULOU A. and G.M. TANZI, *Academic dropout and the great recession,* Journal of Human Capital, v. 11, 1, pp. 35–71, **WP 970 (October 2014).**

ALBERTAZZI U., M. BOTTERO and G. SENE, *Information externalities in the credit market and the spell of credit rationing,* Journal of Financial Intermediation, v. 30, pp. 61–70, **WP 980 (November 2014).**

ALESSANDRI P. and H. MUMTAZ, *Financial indicators and density forecasts for US output and inflation,* Review of Economic Dynamics, v. 24, pp. 66-78, **WP 977 (November 2014).**

BARBIERI G., C. ROSSETTI and P. SESTITO, *Teacher motivation and student learning,* Politica economica/Journal of Economic Policy, v. 33, 1, pp. 59-72, **WP 761 (June 2010).**

BENTIVOGLI C. and M. LITTERIO, *Foreign ownership and performance: evidence from a panel of Italian firms,* International Journal of the Economics of Business, v. 24, 3, pp. 251-273, **WP 1085 (October 2016).**

BRONZINI R. and A. D'IGNAZIO, *Bank internationalisation and firm exports: evidence from matched firm-bank data,* Review of International Economics, v. 25, 3, pp. 476-499 **WP 1055 (March 2016).**

BRUCHE M. and A. SEGURA, *Debt maturity and the liquidity of secondary debt markets,* Journal of Financial Economics, v. 124, 3, pp. 599-613, **WP 1049 (January 2016).**

BURLON L., *Public expenditure distribution, voting, and growth,* Journal of Public Economic Theory,, v. 19, 4, pp. 789–810, **WP 961 (April 2014).**

BURLON L., A. GERALI, A. NOTARPIETRO and M. PISANI, *Macroeconomic effectiveness of non-standard monetary policy and early exit. A model-based evaluation,* International Finance, v. 20, 2, pp. 155-173, **WP 1074 (July 2016).**

BUSETTI F., *Quantile aggregation of density forecasts,* Oxford Bulletin of Economics and Statistics, v. 79, 4, pp. 495-512, **WP 979 (November 2014).**

CESARONI T. and S. IEZZI, *The predictive content of business survey indicators: evidence from SIGE,* Journal of Business Cycle Research, v.13, 1, pp 75–104, **WP 1031 (October 2015).**

CONTI P., D. MARELLA and A. NERI, *Statistical matching and uncertainty analysis in combining household income and expenditure data,* Statistical Methods & Applications, v. 26, 3, pp 485–505, **WP 1018 (July 2015).**

D'AMURI F., *Monitoring and disincentives in containing paid sick leave,* Labour Economics, v. 49, pp. 74-83, **WP 787 (January 2011).**

D'AMURI F. and J. MARCUCCI, *The predictive power of google searches in forecasting unemployment,* International Journal of Forecasting, v. 33, 4, pp. 801-816, **WP 891 (November 2012).**

DE BLASIO G. and S. POY, *The impact of local minimum wages on employment: evidence from Italy in the 1950s,* Journal of Regional Science, v. 57, 1, pp. 48-74, **WP 953 (March 2014).**

DEL GIOVANE P., A. NOBILI and F. M. SIGNORETTI, *Assessing the sources of credit supply tightening: was the sovereign debt crisis different from Lehman?,* International Journal of Central Banking, v. 13, 2, pp. 197-234, **WP 942 (November 2013).**

DEL PRETE S., M. PAGNINI, P. ROSSI and V. VACCA, *Lending organization and credit supply during the 2008–2009 crisis,* Economic Notes, v. 46, 2, pp. 207–236, **WP 1108 (April 2017).**

DELLE MONACHE D. and I. PETRELLA, *Adaptive models and heavy tails with an application to inflation forecasting,* International Journal of Forecasting, v. 33, 2, pp. 482-501, **WP 1052 (March 2016).**

FEDERICO S. and E. TOSTI, *Exporters and importers of services: firm-level evidence on Italy,* The World Economy, v. 40, 10, pp. 2078-2096, **WP 877 (September 2012).**

GIACOMELLI S. and C. MENON, *Does weak contract enforcement affect firm size? Evidence from the neighbour's court,* Journal of Economic Geography, v. 17, 6, pp. 1251-1282, **WP 898 (January 2013).**

LOBERTO M. and C. PERRICONE, *Does trend inflation make a difference?,* Economic Modelling, v. 61, pp. 351–375, **WP 1033 (October 2015).**

MANCINI A.L., C. MONFARDINI and S. PASQUA, *Is a good example the best sermon? Children's imitation of parental reading,* Review of Economics of the Household, v. 15, 3, pp 965–993, **D No. 958 (April 2014).**

MEEKS R., B. NELSON and P. ALESSANDRI, *Shadow banks and macroeconomic instability,* Journal of Money, Credit and Banking, v. 49, 7, pp. 1483–1516, **WP 939 (November 2013).**

MICUCCI G. and P. ROSSI, *Debt restructuring and the role of banks' organizational structure and lending technologies,* Journal of Financial Services Research, v. 51, 3, pp 339–361, **WP 763 (June 2010).**

MOCETTI S., M. PAGNINI and E. SETTE, *Information technology and banking organization,* Journal of Journal of Financial Services Research, v. 51, pp. 313-338, **WP 752 (March 2010).**

MOCETTI S. and E. VIVIANO, *Looking behind mortgage delinquencies,* Journal of Banking & Finance, v. 75, pp. 53-63, **WP 999 (January 2015).**

NOBILI A. and F. ZOLLINO, *A structural model for the housing and credit market in Italy,* Journal of Housing Economics, v. 36, pp. 73-87, **WP 887 (October 2012).**

PALAZZO F., *Search costs and the severity of adverse selection,* Research in Economics, v. 71, 1, pp. 171-197, **WP 1073 (July 2016).**

PATACCHINI E. and E. RAINONE, *Social ties and the demand for financial services,* Journal of Financial Services Research, v. 52, 1–2, pp 35–88, **WP 1115 (June 2017).**

PATACCHINI E., E. RAINONE and Y. ZENOU, *Heterogeneous peer effects in education,* Journal of Economic Behavior & Organization, v. 134, pp. 190–227, **WP 1048 (January 2016).**

SBRANA G., A. SILVESTRINI and F. VENDITTI, *Short-term inflation forecasting: the M.E.T.A. approach,* International Journal of Forecasting, v. 33, 4, pp. 1065-1081, **WP 1016 (June 2015).**

SEGURA A. and J. SUAREZ, *How excessive is banks' maturity transformation?,* Review of Financial Studies, v. 30, 10, pp. 3538–3580, **WP 1065 (April 2016).**

VACCA V., *An unexpected crisis? Looking at pricing effectiveness of heterogeneous banks,* Economic Notes, v. 46, 2, pp. 171–206, **WP 814 (July 2011).**

VERGARA CAFFARELI F., *One-way flow networks with decreasing returns to linking,* Dynamic Games and Applications, v. 7, 2, pp. 323-345, **WP 734 (November 2009).**

ZAGHINI A., *A Tale of fragmentation: corporate funding in the euro-area bond market,* International Review of Financial Analysis, v. 49, pp. 59-68, **WP 1104 (February 2017).**

2018

ADAMOPOULOU A. and E. KAYA, *Young Adults living with their parents and the influence of peers,* Oxford Bulletin of Economics and Statistics, v. 80, pp. 689-713, **WP 1038 (November 2015).**

BARONE G., G. DE BLASIO and S. MOCETTI, *The real effects of credit crunch in the great recession: evidence from Italian provinces,* Regional Science and Urban Economics, v. 70, pp. 352-59, **WP 1057 (March 2016).**

BELOTTI F. and G. ILARDI *Consistent inference in fixed-effects stochastic frontier models,* Journal of Econometrics, v. 202, 2, pp. 161-177, **WP 1147 (October 2017).**

BERTON F., S. MOCETTI, A. PRESBITERO and M. RICHIARDI, *Banks, firms and jobs,* Review of Financial Studies, v. 31, 6, pp. 2113-2156, **WP 1097 (February 2017).**

BOFONDI M., L. CARPINELLI and E. SETTE, *Credit supply during a sovereign debt crisis,* Journal of the European Economic Association, v.16, 3, pp. 696-729, **WP 909 (April 2013).**

BOKAN N., A. GERALI, S. GOMES, P. JACQUINOT and M. PISANI, *EAGLE-FLI: a macroeconomic model of banking and financial interdependence in the euro area,* Economic Modelling, v. 69, C, pp. 249-280, **WP 1064 (April 2016).**

BRILLI Y. and M. TONELLO, *Does increasing compulsory education reduce or displace adolescent crime? New evidence from administrative and victimization data,* CESifo Economic Studies, v. 64, 1, pp. 15–4, **WP 1008 (April 2015).**

BUONO I. and S. FORMAI *The heterogeneous response of domestic sales and exports to bank credit shocks,* Journal of International Economics, v. 113, pp. 55-73, **WP 1066 (March 2018).**

BURLON L., A. GERALI, A. NOTARPIETRO and M. PISANI, *Non-standard monetary policy, asset prices and macroprudential policy in a monetary union,* Journal of International Money and Finance, v. 88, pp. 25-53, **WP 1089 (October 2016).**

CARTA F. and M. DE PHLIPPIS, *You've Come a long way, baby. Husbands' commuting time and family labour supply,* Regional Science and Urban Economics, v. 69, pp. 25-37, **WP 1003 (March 2015).**

CARTA F. and L. RIZZICA, *Early kindergarten, maternal labor supply and children's outcomes: evidence from Italy,* Journal of Public Economics, v. 158, pp. 79-102, **WP 1030 (October 2015).**

CASIRAGHI M., E. GAIOTTI, L. RODANO and A. SECCHI, *A "Reverse Robin Hood"? The distributional implications of non-standard monetary policy for Italian households,* Journal of International Money and Finance, v. 85, pp. 215-235, **WP 1077 (July 2016).**

CECCHETTI S., F. NATOLI and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, v. 14, 1, pp. 35-71, **WP 1025 (July 2015).**

CIANI E. and C. DEIANA, *No Free lunch, buddy: housing transfers and informal care later in life,* Review of Economics of the Household, v.16, 4, pp. 971-1001, **WP 1117 (June 2017).**

CIPRIANI M., A. GUARINO, G. GUAZZAROTTI, F. TAGLIATI and S. FISHER, *Informational contagion in the laboratory,* Review of Finance, v. 22, 3, pp. 877-904, **WP 1063 (April 2016).**

DE BLASIO G, S. DE MITRI, S. D'IGNAZIO, P. FINALDI RUSSO and L. STOPPANI, *Public guarantees to SME borrowing. A RDD evaluation,* Journal of Banking & Finance, v. 96, pp. 73-86, **WP 1111 (April 2017).**

GERALI A., A. LOCARNO, A. NOTARPIETRO and M. PISANI, *The sovereign crisis and Italy's potential output,* Journal of Policy Modeling, v. 40, 2, pp. 418-433, **WP 1010 (June 2015).**

LINARELLO A., *Direct and indirect effects of trade liberalization: evidence from Chile,* Journal of Development Economics, v. 134, pp. 160-175, **WP 994 (December 2014).**

NUCCI F. and M. RIGGI, *Labor force participation, wage rigidities, and inflation,* Journal of Macroeconomics, v. 55, 3 pp. 274-292, **WP 1054 (March 2016).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, v. 22, 2, pp. 661-697, **WP 1100 (February 2017).**

FORTHCOMING

ACCETTURO A., W. DI GIACINTO, G. MICUCCI and M. PAGNINI, *Geography, productivity and trade: does selection explain why some locations are more productive than others?,* Journal of Regional Science, **WP 910 (April 2013).**

ALBANESE G., G. DE BLASIO and P. SESTITO, *Trust, risk and time preferences: evidence from survey data,* International Review of Economics, **WP 911 (April 2013).**

APRIGLIANO V., G. ARDIZZI and L. MONTEFORTE, *Using the payment system data to forecast the economic activity,* International Journal of Central Banking, **WP 1098 (February 2017).**

BELOTTI F. and G. ILARDI, *Consistent inference in fixed-effects stochastic frontier models,* Journal of Econometrics, **WP 1147 (October 2017).**

CIANI E. and P. FISHER, *Dif-in-dif estimators of multiplicative treatment effects,* Journal of Econometric Methods, **WP 985 (November 2014).**

COVA P., P. PAGANO and M. PISANI, *Domestic and international macroeconomic effects of the Eurosystem Expanded Asset Purchase Programme,* IMF Economic Review, **WP 1036 (October 2015).**

D'AMURI F., *Monitoring and disincentives in containing paid sick leave,* Labour Economics, **WP 787 (January 2011).**

D'IGNAZIO and C. MENON, *The causal effect of credit guarantees for SMEs: evidence from Italy,* Scandinavian Journal of Economics, **WP 900 (February 2013).**

ERCOLANI V. and J. VALLE E AZEVEDO, *How can the government spending multiplier be small at the zero lower bound?,* Macroeconomic Dynamics, **WP 1174 (April 2018).**

FEDERICO S. and E. TOSTI, *Exporters and importers of services: firm-level evidence on Italy,* The World Economy, **WP 877 (September 2012).**

GERALI A. and S. NERI, *Natural rates across the Atlantic,* Journal of Macroeconomics, **WP 1140 (September 2017).**

GIACOMELLI S. and C. MENON, *Does weak contract enforcement affect firm size? Evidence from the neighbour's court,* Journal of Economic Geography, **WP 898 (January 2013).**

GIORDANO C., M. MARINUCCI and A. SILVESTRINI, *The macro determinants of firms' and households' investment: evidence from Italy,* Economic Modelling, **WP 1167 (March 2018).**

NATOLI F. and L. SIGALOTTI, *Tail co-movement in inflation expectations as an indicator of anchoring,* International Journal of Central Banking, **WP 1025 (July 2015).**

RIGGI M., *Capital destruction, jobless recoveries, and the discipline device role of unemployment,* Macroeconomic Dynamics, **WP 871 (July 2012).**

SEGURA A., *Why did sponsor banks rescue their SIVs?,* Review of Finance, **WP 1100 (February 2017).**