BANCA D'ITALIA

Temi di discussione

del Servizio Studi

Determinants of long-run regional productivity: The role of R&D, human capital and public infrastructure

by Raffaello Bronzini and Paolo Piselli

Number 597 - September 2006

DETERMINANTS OF LONG-RUN REGIONAL PRODUCTIVITY: THE ROLE OF R&D, HUMAN CAPITAL AND PUBLIC INFRASTRUCTURE

Raffaello Bronzini* and Paolo Piselli§

Abstract

In this paper we estimate the long-run relationship between regional total factor productivity, R&D, human capital and public infrastructure between 1980 and 2001. We take advantage of recent developments panel cointegration techniques that control for endogeneity of regressors to estimate cointegration vectors. Empirical evidence shows that there exists a long-run equilibrium between productivity level and the three kinds of capital; among them, human capital turns out to have the strongest impact on productivity. Regional productivity is found also to be positively affected by R&D activity and public infrastructure of neighbouring regions. Finally, results of the Granger-causality tests support the hypothesis that human capital and infrastructure Granger-cause productivity in the long-run while the opposite is not true; only for R&D stock is the bi-directional causality found.

JEL: O4, O18, R11, C23.

Keywords: Total factor productivity, research and development, public infrastructure, human capital, panel cointegration.

Contents

* Bank of Italy, Research Department, Via Nazionale 91, 00184 Rome, Italy. Email: raffaello.bronzini@bancaditalia.it.

§ Bank of Italy, International Relations Office, Via Milano 64, 00184 Rome, Italy. Email: paolo.piselli@bancaditalia.it.

1. Introduction[1]

It is widely known that the Italian economy is affected by strong territorial disparities. GDP per capita in the South is around 60 per cent of that in the Centre and North, labour productivity is about 80 per cent. Even though during the last decade the economic gap between the two areas has narrowed slightly, differences in standards of living among Italian regions remain profound. In the face of this evidence, it is understandable why regional growth is still at the centre of empirical research, and how reducing regional disparities remains a central question in Italian economic policy.

There is a broad consensus among economists, favoured by the flourishing endogenous growth theories, that research and development (R&D) and human capital are two of the most influential forces capable of boosting productivity (Romer, 1990 and Lucas, 1988). The link between productivity and R&D stock has been investigated in several empirical studies since Coe and Helpman's (1995) seminal paper (see for example: van Pottelsberghe de la Potterie and Lichtenberg, 2001 and Frantzen, 2002). This essential framework has been extended by including human capital in the empirical setting (Coe et al., 1997 and Engelbrecht, 1997, among others). On the other hand, a different strand of research has also pointed out that public infrastructure can play a central role in promoting economic growth, since it raises the availability of resources and enhances the productivity of existing resources (see for example: Aschauer, 1989; Fernald, 1999 and Everaert and Heylen, 2001).

Despite the fact that the literature on growth determinants encompasses a large body of studies there has been no empirical research that assesses the role of these three productivity sources together. If all these factors affect productivity and interact with each other, their contribution can be properly measured only within a unified framework. If one of the

[1] We thank Luigi Cannari, Valerio Crispolti, Guido de Blasio, Massimo Gallo, Daniela Marconi, Massimo Omiccioli, Alfonso Rosolia and two anonymous referees for helpful suggestions and comments. We also benefited from the comments of participants in the Bank of Italy "Seminario di analisi economica territoriale" (Rome 2004) and in the 45th Conference of the European Regional Science Association, (Amsterdam 2005). We are grateful to Pasqualino Montanaro for providing us with data on public capital. The views expressed in the paper are personal and do not represent those of the Bank of Italy.

relevant inputs is omitted, estimations of elasticity of the other factors are bound to be biased (Frantzen, 2000).

In this paper we try to fill this gap. We assess the role of the technological knowledge, as measured by the stock of R&D capital, the human capital, and the stock of public infrastructure, in enhancing the Total Factor Productivity (TFP) of Italian regions over the period 1980-2001. Unlike the majority of empirical models, we focus on the level of the variables instead of on growth rates. As Hall and Jones (1999) have argued, the investigation of the level may be a more natural research question since differences in the level of productivity or income reflect differences in welfare, and growth rates are studied only for their effect on the level of variables. By contrast, by estimating models in growth rates we lose information on the relationships between the levels of the variables.

The estimation of a model in which the variables are in level poses the well-known problem of spurious regression if the variables are I(1) and are not cointegrated. We handle this question by taking advantage of the recent panel cointegration techniques, that allow us to explore long-run relations controlling for omitted or unobservable factors through time and regional fixed effects. In addition, as Temple (1999) pointed out, endogeneity of the regressors and reverse causality can bias the results of the econometric estimates of growth models such as ours. In order to deal with these issues, we use the Pedroni's Fully Modified OLS estimator (see Pedroni, 1996, 2000) that controls for endogeneity of the regressors as well as for autocorrelation of the error term. Next, we carry out Granger-causality tests in the error correction models to verify both the long and the short-run causality.

With respect to the majority of similar works based on panels of countries, this paper takes advantage of the sub-national perspective that reduces the weakness of cross-country analyses, plagued by the scant cross-country comparability of data on education systems, R&D expenditures and infrastructure.

Results show that there exists a long-run equilibrium between the productivity level and the three kinds of capital; among them, human capital turns out to have the strongest impact on TFP. Regional productivity is found to be positively affected also by R&D activity and the public infrastructure of neighbouring regions. Finally, results of the Granger-causality tests support the hypothesis that human capital and public capital cause productivity in the long run while the opposite is not true; only for R&D capital stock is the bi-directional causality found.

The remainder of the paper is organised as follows. In the second section we discuss the theoretical background and the related empirical literature. In the third and fourth sections we present the empirical model and the data employed. In section five, we describe the econometric strategy. The results of the econometric exercise are reported in section six, while some extensions, together with the robustness checks and some summarizing remarks, are discussed in the final two paragraphs.

2. Theoretical framework and related literature

2.1 R&D, human capital and productivity

Recent developments in theoretical endogenous growth models have emphasized the key role of R&D efforts in driving technical progress and productivity (Romer 1990; Grossman and Helpman 1991). The rationale is that technological knowledge, created and accumulated through R&D activity, enhances the production and diffusion of innovations, and then promotes productivity growth. A vast literature spurred by the work of Coe and Helpman (1995), mostly focused on cross-country data, has empirically demonstrated the positive impact of R&D on productivity: see among others, Coe et al. (1997), Xu and Wang (1999), van Pottelsberghe de la Potterie and Lichtenberg (2001), Frantzen (2002).[2]

In this paper we transpose this theoretical approach to a regional context. It is worth noting that using a regional setting is not simply a change of geographical scale. By testing if regional R&D is important to explain regional growth we are implicitly assuming that technological knowledge has a localized scope. We consider this a plausible hypothesis.

[2] In their seminal paper Coe and Helpman (1995) assume that total factor productivity depends on both the stock of R&D accumulated in the country and the stock of R&D accumulated in other countries, hypothesising that knowledge spills over from the other countries proportionally to aggregate imports flows. A similar approach is followed by Coe et al. (1997) and Xu and Wang (1999), although they assume that only imports of capital goods are effective in transferring technical knowledge across countries, and by van Pottelsberghe de la Potterie and Lichtenberg (2001) and Crispolti and Marconi (2005), who demonstrate that the transfer of technology across countries can also take place through FDI.

Proximity can encourage the circulation of ideas and the transmission of information and learning, thanks to face-to-face contacts and social interaction. Moreover, the role of proximity becomes crucial when the knowledge is tacit and so non-codifiable. A wide range of theoretical and empirical studies on localized learning have demonstrated that geographical proximity matters in transmitting knowledge (for a review see: Audretsch and Feldman, 2005). In this paper we share the same view. We assume knowledge has a regional dimension and, to take account of potential spatial (inter-regional) spillovers, we also assess whether regional productivity is affected by knowledge accumulated in proximate regions, assuming that the greater the distance between regions, the smaller the spillovers will be. From the policy view this has an important policy implication. If learning has a localized scope, the location of public or private research centres will impact on local development. Therefore, policy-makers should take this aspect into account in designing regional development policies.

Another primary source of economic growth emphasized by the literature is human capital (see, for example, Lucas, 1988 and Stokey, 1991). It is argued that the level of education drives growth because it increases the ability to adapt and implement existing technology or to create new technologies. Subsequent theoretical analyses have emphasized the strategic complementarities between human capital and R&D activities. Redding (1996), for instance, builds a model in which investment in human capital made by workers and R&D efforts made by firms are complementary and interdependent, so that they jointly determine the growth equilibrium. In this vein, several empirical papers have placed human capital next to R&D as an explanatory variable of productivity, to avoid omitted variables bias and to measure its impact on growth (see Coe et al., 1997; Engelbrecht, 1997 and 2002; Xu and Wang, 1999; Frantzen, 2000; Crispolti and Marconi, 2005, among others). We follow this stream of research and assume that human capital is an additional factor able to affect regional total factor productivity.[3]

[3] An alternative way to take human capital into account would be to consider it as an augmenting factor of labour productivity, as in Bils and Klenow (2000). We test for this specification in the robustness section.

2.2 Public infrastructure and productivity

Economists and policy-makers have pointed to public sector infrastructure as a fundamental element in the strategy of regional development policies. They claim that infrastructure provides valuable facilities to private sectors, increasing the availability of resources and contemporaneously improving the productivity of existing ones (Munnell, 1992). For example, the construction of a new highway can reduce transport costs by lowering shipping times and the use of vehicles; similar arguments apply also to water systems, electricity or other public capital goods. Public capital may also affect growth indirectly, since by raising the rate of return to private capital it can stimulate private investment expenditure.[4] Yet, from the empirical viewpoint the effectiveness of infrastructure in driving productivity is controversial. A first body of evidence, showing a substantial positive impact of public capital (see Aschauer, 1989 and 1990; Munnell, 1990a and 1990b, among others), has been questioned by Holtz-Eakin (1994) and Garcia et al. (1996), who argued that earlier analyses were plagued by reverse causation from productivity to public capital, spurious correlation due to non-stationarity of the data, and unobserved state-specific characteristics. Taking these aspects into account, they found an irrelevant effect of public capital on productivity or output. However, these results were later challenged by a group of studies that, even controlling for reverse causation and unobservable characteristics, demonstrated the positive influence of public capital on productivity (see, for example, Evereart and Heylen, 2001; Fernald, 1999; Canning, 1999; Bonaglia et al., 2000; Canning and Pedroni, 2004). Hence, the effect of public infrastructure on productivity remains an open question that leaves room for further empirical investigation.

To what extent does public capital in one region impact on productivity of proximate regions? For sub-national analyses this appears an important question and one that has been relatively little explored. It is reasonable to envisage that building, say, a new highway in a region can also have an impact on transport costs incurred by firms located in proximate regions that use the same highway. This issue has been explored by Holtz-Eakin and

---

[4] Theoretical models that describe the productivity-infrastructure link include Arrow and Kurtz (1970), Holtz-Eakin and Schwartz (1995a) and Holtz-Eakin and Lovely (1995).

Schwartz (1995b), who provide no evidence of infrastructure spatial spillovers however, and by Pereira and Roca-Sagalés (2003) and Cohen and Morrison Paul (2004) who, by contrast, find significant positive spatial spillovers. Yet, inter-regional spatial spillovers could also have a negative sign. According to Boarnet (1998), public capital provided in a particular region raises the comparative advantage of that region over the others, and could therefore attract factors of production from other locations where output or productivity might decrease. Using data for California, he found that the output of counties is negatively affected by neighbouring counties' infrastructure. We consider inter-regional public capital spillovers a question that would be worth exploring further in our empirical analysis.

We recalled above that infrastructure can have indirect effects on productivity because it can attract productive inputs in the same location: more public capital may lead to an increase in private investment or draw more qualified workers. This mechanism can be extended to other productivity sources analysed here. For example, an increase in human capital may encourage the location of R&D-intensive firms that look for highly qualified workers. Several similar links between human capital, infrastructure and R&D activity, with multiple causality directions, can be imagined. Even if we feel that this issue deserves attention, in our paper we focus only on the direct impact of these factors on productivity, leaving the analysis of the indirect effects for future research.

3. The model

In this paper we adopt a production function approach. We assume a standard Cobb-Douglas production function with Hicks-neutral technical change:

$$Y_{i,t} = TFP_{i,t} L_{i,t}^{\alpha} K_{i,t}^{\beta} \qquad (1)$$

where i = 1, …19 is a regional index; t = 1980,…2001 is a time index; *Y* is the output in region i; *L* is labour input; *K* is private physical capital stock; *TFP* is total factor productivity representing technical change. We assume total factor productivity is driven by human capital, public infrastructure and R&D activity:

$$TFP_{i,t} = A_{i,t} HC_{i,t}^{e1} G_{i,t}^{e2} RD_{i,t}^{e3} \qquad (2)$$

where *HC* is the stock of human capital, *G* is the public infrastructure capital stock, *RD* is the stock of research and development expenditure and *A* is the part of technical progress not caused by the factors mentioned.

Substituting equation (2) into equation (1) we get:

$$Y_{i,t} = A_{i,t} HC_{i,t}^{e1} G_{i,t}^{e2} R\&D_{i,t}^{e3} L_{i,t}^{\alpha} K_{i,t}^{\beta} \qquad (3)$$

We consider three different empirical specifications of model (3). First, we assume constant returns to private inputs (*L* and *K*) and perfect competition. This is the standard assumption that allows us to compute α as the labour income share and β=1-α as the capital income share calculated as residual. By knowing income shares, we can compute total factor productivity as $TFP_{i,t} = Y_{i,t}/L_{i,t}^{\alpha}K_{i,t}^{\beta}$. In addition, we assume that the "unexplained" technical progress depends on regional and time fixed-effects in the form: log $A_{i,t}= \theta_i + \theta_t$. Thus, taking the log of equation (2) we estimate the following baseline equation:

$$tfp_{i,t}= \theta_i + \theta_t + e_1\, hc_{i,t} + e_2\, g_{i,t} + e_3\, rd_{i,t} + \varepsilon_{i,t} \qquad (4)$$

where lower-case variables denote logarithms; θ_i and θ_t represent regional and time-specific intercepts, respectively, that allow us to take account of regional unobservable or omitted factors affecting productivity and control for common cyclical dynamics or common productivity shocks; $\varepsilon_{i,t}$ is a stochastic error term.

Equation (4) is extended by including the effect of spatial spillovers. As discussed in the previous section we assume that R&D and public capital accumulated in the neighbouring regions also affect regional productivity, so that the model becomes: $TFP_{i,t}=A_{i,t}HC_{i,t}^{e1}G_{i,t}^{e2}RD_{i,t}^{e3}Gneigh_{i,t}^{e4}RDneigh_{i,t}^{e5}$, where $Gneigh_i=\Sigma_{i*}W_{ii*}G_{i*}$ and $RDneigh_i=\Sigma_{i*}W_{ii*}RD_{i*}$ are, respectively, public capital and R&D stock of all regions but i (i*≠i), weighted by the geographical distance between regions i and i*. The standardized weight W_{ii*} reflects the geographical distance between each pair of regions. We make use of different types of spatial weights. First, we assume that weights are inversely related to the distance between areas: $\omega_{1ii*}=(1/d_{ii*})$, where d_{ii*} is the distance in kilometres between region i and i*. Second, we assume that spillovers occur only among border regions, then $\omega_{2ii*}=1$ if regions i and i* share a common border and $\omega_{2ii*}=0$ otherwise. The two structures of weights can be regarded as two extreme bounds: in the former, all the regions contribute to the geographical spillovers proportionally to the distance, so that weights penalize more the most distant regions; in the latter the penalization is stronger, since it is assumed that spillovers occur only among the closest, bordering regions. As a robustness exercise two additional weight matrices, used in the spatial econometrics literature, have been included. In the first, weights are inversely related to the square distance: $\omega_{3ii^*}=(1/d_{ii^*})^2$, in the second they decrease exponentially with distance: $\omega_{4ii^*}=exp(-d_{ii^*})$. With these weights the degree of penalization of distant regions falls within the interval set by the previous couple of weight structures: it is higher than that associated with ω_1, but smaller than that related to ω_2.

Spatial weights are all standardized, so that for each region the sum of weights is equal to one. The standardized version of spatial weights will be: $W_{hii^*}=(\omega_{hii^*}/\Sigma_{i^*}\ \omega_{hii^*})$; where h indicates the type of weights used.

The extended form of equation (4) with inter-regional spillovers is:

$$tfp_{i,t}= \theta_i +\theta_t + e_1\, hc_{i,t} + e_2\, g_{i,t} + e_3\, rd_{i,t} + e_4\, g\_neigh_{i,t} + e_5\, rd\_neigh_{i,t} + \varepsilon_{i,t} \qquad (4)'$$

where g_neigh_i=log($Gneigh_i$) and $rd\_neigh_i=log(RDneigh_i)$. In the models (4) and (4)' the parameters denote elasticities, i.e. the percentage change in productivity for a given percentage change in the corresponding explanatory variable.

The second empirical specification of the model is obtained by dividing equation (3) by labour input and using labour productivity as dependent variable. Thus, taking logs we obtain:

$$y_{i,t} - l_{i,t} = \theta_i +\theta_t + e_1\, hc_{i,t} + e_2\, g_{i,t} + e_3\, rd_{i,t} + \beta\, (k_{i,t} - l_{i,t}) + \eta_{i,t} \qquad (5)$$

The advantage of this specification is that it allows us to estimate private inputs elasticities, which in equation (4) are computed as income share. However, we are still assuming constant returns to labour and private capital: $\alpha+\beta=1$.

In the third specification, we make no assumption on the returns to scale and market structure and we leave all the parameters free to vary. Hence, the model to be estimated is equation (3), which rewritten in logs takes the form:

$$y_{i,t} = \theta_i + \theta_t + e_1\, hc_{i,t} + e_2\, g_{i,t} + e_3\, rd_{i,t} + \alpha\, l_{i,t} + \beta\, k_{i,t} + \varphi_{i,t} \qquad (6)$$

The equations (4)-(6) represent our empirical setting on which the econometric analysis will be based. It is worth noting that in all the models proposed we impose no constant returns to scale to all inputs. This is because factors affecting output or productivity may generate positive externalities, which make their social marginal benefits exceed their private benefits as measured by the rewards they earn. This is particularly true for R&D efforts and public capital, but it also holds for human capital (see, among others, Acemoglu and Angrist, 2001).

4. Data

In the specification of the baseline model, total factor productivity of the business sector[5] is estimated as the Solow residual $TFP_{i,t} = Y_{i,t}/L_{i,t}^{\alpha}K_{i,t}^{\beta}$. The output is measured by the value added at constant price; labour input by the standard units of labour; the private physical capital stock of each region by breaking down the national series, using regional investment to calculate the regional shares. Finally, α is measured by the national labour income share and β=1-α by the residual national capital income share.

In order to compute regional R&D capital stock, we use the methodology designed by Coe et al. (1995), who apply the perpetual inventory method to R&D investment data.[6] Istat (National Institute for Statistics) provides separate data on regional R&D expenditure by firms, public research institutes and universities. Data are available from 1980 except for universities' expenditure, which is available only since 1993. In order to carry out the analysis over a longer time span, we construct R&D capital stocks using only expenditure of firms and public research institutes.[7]

---

[5] The business sector does not include public administration, education, health and social services, other public, social and personal services.

[6] This method is standard in the literature. See, among others, Coe and Helpman (1995), Coe, Helpman and Hoffmaister (1997), van Pottelsberghe de la Potterie and Lichtenberg (2001), Xu and Wang (1999), Frantzen (2002), Crispolti and Marconi (2005).

[7] This choice does not seem too restrictive. According to Istat, from 1997 to 2000 R&D expenditure by firms and public research institutes covered most of the total expenditure on R&D, i.e. about 70 per cent (respectively, about 50 per cent firms and 20 per cent public research institutes, while only the remaining 30

In the empirical literature several measures of human capital stock are used. In this work we stick to one of the most commonly used, education, which is approximated by the average years of schooling of employees (see Benhabib and Spiegel, 1994; Engelbrecht, 1997; Xu and Wang, 1999; Frantzen, 2000).

The stock of public capital infrastructure can be quantified either by some physical measures such as the kilometres of road (Canning and Pedroni, 2004), or by using perpetual inventory method on public investment (Everaert et al., 2001; Fernald, 1999). Following this second route, we make use of regional public capital stock estimates provided by Montanaro (2003). The author calculates the regional public capital by applying the perpetual inventory method to the flows of regional public investment. Amongst the five stocks constructed by the author we make use only of economic infrastructures, which include roads and motorways, railways, water and electricity. Of course, the estimation of public capital is a complex task that leaves room for measurement errors. Thus, in the robustness exercises we check the results by using also an alternative measure of public capital in physical terms such as kilometres of roads and motorways by region.

Our empirical analysis is performed over the period 1980-2001. One region, Valle d'Aosta, has been excluded due to lack of data on human capital. Variables are all constructed as indices with 1990=1. Data used to calculate all the variables are provided by Istat. More details on the construction of the variables can be found in the Appendix.

In Table 1, we tabulate TFP and the other variables divided by a scale factor by region. We set the national average equal to 100. Data on TFP confirm the well-known productivity gap between the Centre and North and the South; in 2001 TFP of southern regions was on average about 85 per cent of the national average, while in the central and northern regions it was 115 per cent of the Italian mean. However, over the two decades the gap has narrowed slightly: in 1980 TFP was 80 per cent of the mean in the South, against about 111 per cent in the Centre and North. The R&D capital stocks show that research efforts are concentrated in

per cent is made by universities). Since R&D outlay is relatively larger in the South, in order to rule out the possibility of potential bias, we successfully checked that in the years for which data are available R&D expenditure of universities grows at basically the same rate in the Centre and North as in the South.

a few regions, namely Piedmont, Lombardy and Lazio. This is because the largest firms and public research institutes are concentrated in these areas. Furthermore, a sizeable and expected gap between central and northern and southern regions is revealed: in the Centre and North R&D capital stock in 2001 was about 120 per cent the national average, against about 38 per cent in the South.[8] As for productivity, in 2001 human capital and infrastructure were lower in the southern regions, even though the differences were relatively smaller than in productivity.

5. The econometric strategy

In order to estimate equation (4)-(6) where variables are in levels, we need first to establish whether the series are non-stationary and, in this case, if they are cointegrated. If variables are non-stationary and not cointegrated, ordinary panel techniques of estimation by least squares are inconsistent and standard inference on significance of the coefficients is impossible.[9]

We start by applying four unit root tests for panel data to our series to assess stationarity. Tests are introduced by Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003) and Maddala and Wu (1999), which are henceforth indicated as LLC, IPS and MW, respectively. All are based on an ADF specification and include individual constants and individual trends.[10] For all the series except the R&D spatially lagged, at least two out of

---

[8] In interpreting these results we should take into account that the total R&D stock of the South is under-estimated relative to the Centre and North, since the share of R&D expenditure of universities (excluded from the computation) is relatively higher in the South.

[9] Some authors tend to overcome the problem of estimating non-stationary data by differencing out the series and using conventional panel techniques (Coe, Helpman and Hoffmaister, 1997; Engelbrecht, 1997; 2002). However, only in the absence of cointegration can one differentiate the data and estimate the model in growth rates; otherwise, if variables are cointegrated, a model in differences is misspecified as it ignores the long-run information. Additionally, in doing so higher frequency relationships are actually estimated and long-term relationships are relegated to fixed effects (Bottazzi and Peri, 2004).

[10] LLC assume a common unit root, while IPS allow for individual unit root process so that the autoregressive coefficient can vary across units. Finally, MW derive a statistic that combines the p-value from individual unit root tests (ADF-Fisher). We also use a unit root test *à la* Fisher Perron and Phillips (PP-Fisher), provided by the econometric package Eviews 5 (see Eviews 5, 2004. *User's Guide, Quantitative Micro Software)*. Under the null hypothesis of non-stationarity (presence of unit root) the first two tests are normally distributed, while the others are χ^2 with 2N degrees of freedom. Presenting more than one unit root test is common practice, owing to the different hypothesis underlying each test and their diverse power in small samples. See for a discussion Maddala and Wu (1999), Karlsson and Lothgren (2000).

four tests accept the hypothesis of non-stationarity at the standard conventional significance (Table 2). These findings suggest that results of standard panel estimation procedures may be affected by spurious correlation. We also verify the stationarity of our variables in differences. As expected, there is large evidence that the series are difference-stationary.[11]

The next step is to test for cointegration. We verify the cointegration hypothesis by carrying out Pedroni's (1999, 2004) cointegration tests, which allow coefficients (cointegration vectors) to vary across units and can take into account individual fixed effects and time trends. Pedroni introduces seven statistics asymptotically normally distributed.[12]

If tests reject the null of no cointegration, it is well known that OLS estimates of the panel cointegration relationship are “superconsistent” and also possess a normal limit distribution (Kao and Chiang, 2000). Accordingly, in the case of cointegrated variables many authors perform standard OLS estimates[13]. However, in finite samples, OLS estimates generally have non-standard distribution and suffer from strong finite sample bias caused by endogeneity of regressors and serial correlation of residuals (Phillips and Moon, 1999; Kao and Chiang, 2000). It is worth remarking that in our production function model the risk of bias due to endogeneity is particularly high. It is likely that input and output variables are jointly determined in a system in which all are endogenous, therefore the explanatory variables could be correlated with the error term and the results of OLS estimates might be biased by endogeneity due to simultaneity (Temple, 1999). This risk is amplified by the possibility of reverse causality from productivity to the explanatory variables. For example, in the period of productivity or output expansion, investment in R&D, human capital or infrastructure could increase as well, owing to the greater availability of economic resources, and therefore the direction of causality might also go from productivity to the regressors, biasing OLS estimates.

---

[11] At least according to two out of four tests, only $\Delta(K/L)$ and Δ(g_neigh_distance) turn out to be still non-stationary after differencing. However, ΔK and ΔL present some evidence of stationarity, so that we assume their difference is still stationary and we proceed supposing that all series are difference-stationary. Should this assumption be incorrect, we expect that the cointegration tests and the estimated ECM do not support the hypothesis of a long-run stable relationship between the variables of interest (Kremers et al., 1992).

[12] We refer the reader to Pedroni (1999) for further details concerning these tests.

[13] Coe and Helpman (1995), Frantzen, (2000), Xu and Wang (1999), de La Potterie and Licthenberg (2001).

To appropriately estimate long-run elasticities we require an estimator that handles endogeneity of regressors. We make use of the Fully-Modified OLS estimator (FMOLS) developed by Pedroni (1996, 2000), which controls for endogeneity of explanatory variables and serial correlation of the errors[14]. In particular, we use the between-dimension (group-mean) FMOLS, which has a relatively lower distortion in small samples than the other FMOLS estimators and allows cointegration vectors to be heterogeneous across units.

6. Empirical results

In column (1) of Table 3 we report the results of econometric estimates and cointegration tests of our baseline model (4).[15] All the estimates include regional and time fixed effects. Cointegration tests are run without heterogeneous trends.[16]

Results strongly support the hypothesis of a cointegration relationship between our variables. The null of no cointegration is rejected by five out of seven tests at 10 per cent probability level: this evidence shows that there exists a long-run relationship between productivity and the regressors. All the elasticities estimated by FMOLS have the expected sign and are statistically significant. As regards their size, we find larger coefficients for human and public capital, while research and development stock has a rather small coefficient. According to our findings, a 1 per cent increase in the human capital stock would raise total factor productivity by 0.38 per cent. The same percentage increase in the public capital stock, or in R&D stock, would boost regional TFP by 0.11 and 0.03 per cent respectively.

---

[14] This estimator is the panel version of the Phillips and Hansen's (1990) estimator, suggested to correct for possible simultaneity equation bias in a time series regression. Everaert and Heylen (2001) use this estimator to tackle simultaneity of public capital in estimating a production function.

[15] Since the estimation of the initial level of R&D stock might not be precise, we run the regression starting from 1985 because the impact of errors in the estimate of the initial stock should have a relatively small impact on 1985. The empirical literature is aware of the possibility of imprecise estimates of initial technological knowledge stock and it is common practice to post-pone the initial year to overcome this problem (see, for example, Bottazzi and Peri, 2004).

[16] We should bear in mind that the probability of rejecting the null of no cointegration will be greater in models with trends than in those without, since heterogeneous trends may have a high explanatory power for productivity dynamics. For that reason, we prefer running the cointegration tests in models without trends, where only regressors explain productivity.

Compared with previous studies, human capital elasticity appears slightly larger. For example, in panel data models based on a large sample of countries, Frantzen (2000), Xu and Wang (1999) and Engelbrecht (1997) found human capital elasticities that varied from 0.10 to 0.16. This discrepancy can be due to several factors, such as data characteristics, model specification or estimation method. However, it is worth noting that the studies cited are based on cross-country data in which heterogeneity of the education system or quality of schooling across countries could be substantial. Thus, in such studies, human capital variables might be affected by measurement error, which biases downwards the relative coefficient, more than our human capital variable, which is computed across regions within the same country.

The estimated elasticities of TFP with respect to R&D capital stock and public capital infrastructure are quite consistent with the elasticities previously found by the empirical literature. Griliches (1988), for example, reports elasticities found in the studies for industrial countries in the range of 0.06 to 0.1.[17] Reviewing several papers, Munnell (1992) reports an average elasticity of public capital to output of about 0.15. Our smaller R&D elasticity may be due to the occurrence of inter-regional technological spillovers that lower the correlation between local R&D efforts and regional productivity.

It is also of interest to split public capital into different categories in order to explore the contribution of different types of infrastructure to productivity growth. We consider three main categories: roads and motorways, railways, and water and electricity, and we run three regressions, one for each type of public capital as regressor. The results confirm our expectations: the infrastructure most closely connected to economic activity has the greatest impact on productivity (columns 2-4 of Table 3). We see that roads and motorways have the strongest positive relationship with productivity, while the correlation slightly decreases for railways and substantially drops for water and electricity. In all the models where cointegration is accepted the elasticities of the variables are all positive and significant, moreover there are no substantial changes in the magnitude of the coefficients of human capital and R&D.

[17] In the cross-country model of Frantzen (2000), R&D elasticity is about 0.1; in the estimates of Xu and Wang (1999) it varies from 0.035 to 0.15, while in Engelbrecht (1997) is from 0.055 to 0.079.

We proceed by estimating the extended baseline model that allows for spatial spillovers from knowledge and public capital in geographically proximate regions. We present results for four structures of spatial weights (Table 4). In the first, weights are inversely related to the distance between regions (column 1); with this structure we take account of spillovers across all the regions, even if we penalize distant areas. In the second, weights capture the effect of the bordering regions only, through a contiguity matrix (column 2); in this case we assume that spatial spillovers occur only across bordering regions, so that penalization for more distant areas is stronger. In the third and fourth weight structures (columns 3 and 4) the intensity of penalizations is in the middle of those associated with the previous couple of weights.

Overall, our results show positive and significant geographical spillovers. It would seem that the diffusion of knowledge follows a spatial pattern and the availability of infrastructure in the adjacent regions generates improvement in local productivity as well.[18] However, different patterns of spatial spillovers arise. While knowledge spillovers seem to occur also among distant regions, public infrastructure spillovers turn out to be more geographically concentrated. According to our econometric results, R&D spillovers are strongest when the distance matrix is used, as if flows of knowledge could go across distant areas, and taking all the regions into account, as the distance matrix does, may help to fully capture these types of benefits. On the other hand, for public capital the findings show that geographical spillovers are greatest, and statistically significant, when public capital of the bordering regions is used. This could display a rather rapid decay of public capital spillovers with distance, as if such geographical effects mainly occur between the closest areas. When we introduce spatial spillovers, we note that cointegration is still found and the coefficients of local variables of our baseline model previously estimated do not change substantially. The changes in the coefficients' size seem to suggest a positive correlation between the local explanatory variables and the corresponding spatially lagged variables.[19]

---

[18] Results confirm the outcome of Costa and Iezzi (2004) who estimate a spatial spillover-augmented convergence model, where the contribution of R&D technological spillovers from the other regions to the convergence of Italian regions is substantial.

[19] In interpreting these results a note of caution is needed. Taken at their face value, the coefficients of the spatial lagged variables are quite large and, for public capital, elasticity sometimes turns out to be greater than one. It is no straightforward matter justifying such elevated elasticities. A possible explanation is that the

We proceed with the econometric exercise by relaxing some assumptions of the baseline model. In the first column of Table 5 we present the estimate of equation (5) where labour productivity is our dependent variable and the coefficient of private capital/labour ratio, used as regressor, denotes the elasticity of output to private capital. The results again indicate a long-run relationship between the variables. The coefficients of R&D, human capital and public capital remain similar in magnitude to the previous estimates. The coefficient of private capital/labour ratio, corresponding to the parameter β of our model, is equal to 0.4, very close to the value used to calculate TFP.[20] The second column of Table 5 reports the estimates of equation (6), where regional output is the dependent variable and there are no restrictions on the coefficients of the explanatory variables. In the unrestricted model the cointegration tests confirm the long-run relationships previously detected. As regards the coefficients, we note a slight increase in R&D and human capital elasticities, while the coefficient of private capital is relatively low, showing a size consistent with previous empirical findings (Picci, 1999).

On the whole, when we assume constant returns to scale of private inputs (labour and capital) as in equation (1)-(5), in accordance with other empirical works on Italian data (Lodde, 2000; Maroccu, Paci e Pala, 2001) we find increasing returns to all factors, due to the positive externalities on output produced by R&D, human and public capital. This result holds in specification (6) as well, when we do not impose constant returns to scale on labour and capital.

At this stage we are able to compute the rates of return on investment in R&D and in public infrastructures.[21] Based on our data for the year 2001 and the elasticities of our baseline model, we obtain an overall rate of return to R&D equal to 0.43, which means that

---

spatially lagged variables might capture also other spatially lagged omitted factors affecting productivity. However, this hypothesis is not supported by our data. If there were spatially lagged omitted factors, the error term should be spatially correlated; yet the results of the spatial correlation tests, carried out on the errors of the baseline model (model 1 of table 3), indicate no correlation (tests are carried out through the Stata package which computes tests by Moran *I*, Geary and Getis and Ord). On the whole, we believe that such results could be due to the positive correlation between R&D and public capital with the corresponding spatially lagged variables: calculated in pooling, the coefficients of correlation are about 0.8 for both.

[20] According to our data the labour income share used to calculate TFP was equal to 0.65 and the capital income share was 0.35.

[21] Assuming the simple Cobb-Douglas production function of equation (3), the returns on R&D investment will be $\partial Y/\partial R\&D = e_3 Y/R\&D$.

in Italy € 1 million increase in the R&D capital stock increases output by € 0.43 million. This is a reasonable rate of return, which falls in the range reported by Wang and Tsai (2003).[22] The rate of return of public capital turns out to be smaller than that of R&D, about an average of 0.23.

7. Extensions and robustness

Having estimated the long-run relationships between the variables and having found cointegration, we can re-parameterize the model in the error correction form and analyze the short-run dynamic and the speed of adjustment to equilibrium. The Error Correction Model (ECM) also allows us to carry out Granger-causality tests among the variables in both the long and short-run (Granger, 1988).

Let us define the disequilibrium term of long-run estimates of the baseline model (4) as $\hat{u}_{i,t} = tfp_{i,t} - \theta_i - \theta_t - \hat{e}_1\, hc_{i,t} - \hat{e}_2\, g_{i,t} - \hat{e}_3\, rd_{i,t}$, where coefficients are the long-run elasticities previously estimated. $\hat{u}_{it,}$ represents how far our variables are from equilibrium. Hence, we can write the following error correction models:

$$\Delta tfp_{i,t} = \theta_{1i} + \theta_{1t} + \lambda_1\, \hat{u}_{i,t-1} + \gamma_{10}\, \Delta tfp_{i,t-1} + \gamma_{11}\, \Delta rd_{i,t-1} + \gamma_{12}\, \Delta hc_{i,t-1} + \gamma_{13}\, \Delta g_{i,t-1} + \chi_{1i\,t} \quad (7)$$

$$\Delta rd_{i,t} = \theta_{2i} + \theta_{2t} + \lambda_2\, \hat{u}_{i,t-1} + \gamma_{20}\, \Delta tfp_{i,t-1} + \gamma_{21}\, \Delta rd_{i,t-1} + \gamma_{22}\, \Delta hc_{i,t-1} + \gamma_{23}\, \Delta g_{i,t-1} + \chi_{2i,t} \quad (8)$$

$$\Delta hc_{i,t} = \theta_{3i} + \theta_{3t} + \lambda_3\, \hat{u}_{i,t-1} + \gamma_{30}\, \Delta tfp_{i,t-1} + \gamma_{31}\, \Delta rd_{i,t-1} + \gamma_{32}\, \Delta hc_{i,t-1} + \gamma_{33}\, \Delta g_{i,t-1} + \chi_{3i,t} \quad (9)$$

$$\Delta g_{i,t} = \theta_{4i} + \theta_{4t} + \lambda_4\, \hat{u}_{i,t-1} + \gamma_{40}\, \Delta tfp_{i,t-1} + \gamma_{41}\, \Delta rd_{i,t-1} + \gamma_{42}\, \Delta hc_{i,t-1} + \gamma_{43}\, \Delta g_{i,t-1} + \chi_{4i,t} \quad (10)$$

where Δ is the first difference operator and the coefficient λ measures the speed of adjustment of the model to the equilibrium. The equations (7)-(10) are error correction representations of the model (4) (see Canning and Pedroni, 2004; Strauss and Wohart, 2004). Long-run Granger-causality is tested by the significance of the error correction term λ. For

[22] They report values of returns on R&D capital estimated by the literature from 0.1 to 0.5. We find that the unequal territorial distribution of R&D stock across areas produces strong territorial heterogeneity of returns: in the North and in the Centre the rate of return is 0.37 and 0.33, respectively, in the South it rises to about 1. Of

example, if λ_2 turns out to be different from zero, the explanatory variables of the model (8), including productivity, Granger-cause *rd* in the long-run, that is in the long-run the prediction of R&D stock is enhanced by the current values of our regressors. Short-run Granger-causality is tested by the joint significance of the lagged differentiated variables, i.e when the parameters γ are jointly different from zero. If the long-run test alone is accepted the dependent variable of the corresponding equation will be weakly exogenous. If both the tests are accepted the dependent variable will be strongly exogenous (Hendry, 1995). Since cointegration relationships are found, the right-hand side variables of equations (7)-(10) are all stationary, and therefore the system can be estimated by the OLS method. Moreover, no assumptions on the exogeneity of the variables with respect to the system are made and thus we inserted only the lagged variables and estimated the system equation by equation.

Table 6 shows that in the equation for TFP the error correction term is strongly significant with the correct sign: hence the evidence supports the hypothesis of long-run Granger-causality from the explanatory variables to productivity and confirms the results obtained through the cointegration analysis. The rather large coefficient in absolute value, about 0.2, means that we do not move far away from the long-run equilibrium and that in approximately five years we return to equilibrium after a deviation.[23] On the other hand, there is no evidence of a short-run impact of the regressors on productivity dynamics.

The results for R&D show that the error term is significant together with the short-run dynamics of some of the explanatory variables. Overall, R&D turns out to be endogenous in the long and short-run, and the significance of regional effects would suggest the model might not be appropriate for describing R&D dynamics. On the other hand, results for the human capital equation denote a strong exogeneity of education with respect to the model: both long and short-run Granger-causality is rejected. Finally, for public capital we obtain a mixed result. Public capital turns out to be only weakly exogenous, since the test rejects

---

course, this calculation by area can be largely sensitive to the method of calculation of R&D capital stock and measurement errors, therefore we do not pay too much attention to this evaluation.

[23] Note that only the model with time fixed effects is reported, since the likelihood-ratio test accepts the hypothesis of no heterogeneous regional intercepts, which suggests homogeneity of TFP trends among regions when the error correction term is taken into account. This is consistent with the cointegration tests carried out without heterogeneous trends. However, results are qualitatively similar even including regional effects.

long-run causality, but short-run causality is not rejected: education apart, the other variables seem to cause short-run dynamics of public capital.

7.1 Robustness

We check for the robustness of our results in several ways. A first group of controls are concerned with how we have calculated our baseline TFP. In particular, in the baseline model (4) we measured the productivity of the entire private sector. However, it is likely that in the real estate sector productivity can only be imperfectly calculated, since a rise in housing prices and in rents can increase output without an actual improvement in productivity. Hence, we have excluded this industry from our baseline model. In a second check we assume regional heterogeneity of the labour share and we compute TFP using α for each region, while in the baseline model we used a (national) parameter equal across regions. The first and the second columns of Table 7 show that these changes do not alter the outcomes.

A second group of checks deals with the choice of some regressors. First, we have changed the public capital variable using a physical measure of infrastructure: the kilometres of motorways and roads by region provided by the National Institute for Statistics (see Canning, 1999; Canning and Pedroni, 2004). Second, we have recalculated the R&D stock using a depreciation rate of 10%, instead of 15%. Columns (3) and (4) of Table 7 contain the results of these checks: our basic results are not affected by these changes and it is worth highlighting that the physical measure of infrastructure has a coefficient close in magnitude to that obtained in the model with the corresponding public capital stock in value.

Up to now we have analyzed the productivity of all private sectors, including services. Since the measure of productivity can be more reliable for industry than for services, we have estimated the baseline model only for industry as an additional check for robustness. In this case a note of caution is warranted. Because of the availability of data we have been able to use only the human capital of the entire private economy as regressor, instead of industrial sectors only; therefore, the estimation of the human capital coefficient might be imprecise. Results of the baseline model estimated for only industrial sectors, excluding construction, are reported in the fifth column of Table 7. They confirm our expectations: the coefficients of R&D and public capital are not significantly different from those previously obtained, while the human capital coefficient turns out to be positive, but not statistically significant, probably for the aforementioned problem of measure. Nevertheless, overall the results would tend to rule out that previous findings were strongly affected by productivity miscalculation.

Our primary purpose was to evaluate the impact of different factors on productivity, and therefore we assumed that human capital directly affects TFP. However, a different strand of literature assumes that human capital affects only labour productivity: $TFP_{i,t}=Y_{i,t}/(HC \cdot L_{i,t})^{\alpha}K_{i,t}^{\beta}$ (see Bils and Klenow, 2000; Brandolini and Cipollone, 2001).[24] We have re-estimated the baseline model after re-calculating TFP with this method. Results reported in the last column of Table 7 substantially confirm our earlier findings.

A final group of checks concerns Granger-causality tests. First, we have estimated the error correction model for equations (5) and (6) as well and we have obtained qualitatively similar results. Next, we have checked the results of the error correction model and Granger-causality tests including also regional fixed effects, even if they were found to be insignificant, and modifying the set of explanatory variables. Again, these changes do not alter our previous outcomes (results are not reported but are available upon request).

8. Conclusions

In this paper we assessed the impact of R&D, human capital and public infrastructure on the level of TFP of Italian regions between 1980-2001. Our results summarize the evidence consistently in favour of the positive long-run effect of these factors on productivity. A long-run relationship has been detected and the coefficients, estimated using Pedroni's method, which is robust to endogeneity and serial correlation, are all statistically significant. Moreover, we have run Granger-causality tests, showing that human capital and public capital are exogenous in the long run, while R&D comes out endogenous.

A larger stock of R&D is associated with productivity expansion. However, the contribution to productivity is rather small and less than that of the other variables. This

[24] In each region labor units are weighted by an index of labour force education, given by the years of schooling of employees in region i compared with the Italian average.

might be due to inter-regional knowledge spillovers, which attenuate the effect of local R&D activity on local TFP. This belief is confirmed by our data. When we estimate a model with geographical spillovers we find that R&D activity of proximate regions has a positive impact on local productivity and that knowledge spillovers occur not only among the closest regions but also across distant areas. In addition, according to Granger-causality tests, R&D efforts turns out to be endogenous in the long and short run, that is R&D stock is Granger-caused by productivity and the other variables of the model. Even though empirical research has found that R&D efforts are important in boosting countries' economic growth, on the whole our results suggest that encouraging R&D activity can be considered only a weak instrument for reducing regional disparities.

On the other hand, human capital and infrastructure seem to play an important role in explaining regional productivity dynamics. Both have a positive and quite remarkable effect on productivity. In the baseline model an increase of 1 per cent in human capital or public infrastructure raises productivity by approximately 0.38 and 0.11 per cent, respectively. Our results indicate that inter-regional spillovers from public capital occur - infrastructure of proximate regions positively affects local productivity - and that such spillovers turn out to be rather spatially concentrated. Both human and public capital are found to be exogenous in the long run by our causality tests: this means that in the Granger sense a causality direction from human and public capital to productivity is verified, but not vice versa. Overall, the findings suggest that these factors are suitable and effective instruments to design a regional policy aimed at narrowing regional gaps.

In this paper we focused on the long-run impact of R&D, human and public capital on regional productivity. It would be worthwhile to extend the present analysis at least in two directions. First, by investigating the potential interplay between these productivity sources, and between them and labour or private capital; second, by exploring in more detail to what extent, and through which channels, inter-regional spillovers occur. Empirical analyses on these topics would be useful to shed additional light on the forces behind regional economic development.

Appendix

Private capital stock. In order to calculate regional private capital stock we have used the method introduced by Piselli (2001), whose methodology breaks down national capital stock by region, sector and type of capital good. Piselli's procedures can be divided into four steps: 1) regional gross investment is disaggregated by sector and type of capital good; 2) the national capital stocks, by sector and type of capital good, are split by region in a benchmark year; 3) regional stocks are calculated over the entire period with the capital stock in the benchmark year, the annual investment and the depreciation of capital; 4) total regional capital stocks are calculated by adding sectoral and by-type regional stocks.[25]

Human capital stock. The years of schooling in each region are obtained by the number of years required to reach a certain level of qualification (see below), weighted by the share of workers with that qualification to total employees:

$$\textit{Average years of schooling}_R = \frac{1}{N_R} \sum_q \mathrm{w(R,Q)} \cdot \mathrm{Y}S\mathrm{(R,Q)}; \mathrm{w(R,Q)} = \frac{\mathrm{N(R,Q)}}{\mathrm{n(R,Q)}}$$

where n(R,Q) is the number of individuals of the sample in region R with qualification Q, and N(R,Q) is the total number of employees in the region with qualification Q; YS is the years of schooling per employee with qualification Q in region R; the weights w are provided in the survey. Data are from Istat (*Indagine sulle forze lavoro*). Before 1993, data are not homogeneous with the present survey and we use data on age and qualification of employees reconstructed by Baffigi (1996). From 1993 to 2001, we attribute 0 to a person with no qualification, 5 for completing primary school, 8 for lower secondary school, 10.5 for a professional diploma, 12.5 for people completing secondary education, 15.5 for a "short" degree (*laurea breve*), 17.5 for a standard degree and finally 21.5 years of schooling

[25] For more details see Piselli (2001).

to those with a doctoral qualification or specialization. Before 1993, we have only three kinds of qualification: up to primary school, lower secondary school, secondary school diploma or more. We assign 5 and 8 years of schooling to the first two qualifications. In the third class, in order to estimate the share of graduates in the third class in each region i (G*i*), we use the average shares from the 1981 and 1991 Census regarding the regional population. Hence, we calculate the average years of schooling in region *i* as 13*(1-G*i*)+17*G*i*. Finally, to detect possible breaks in the series over the entire range 1980-2001, we compare the estimates obtained in the two samples in the overlapping year 1993. Differences turn out to be very small, about 1 per cent or less in all regions, regardless of the variable you taken into account. We calculate a correction coefficient based on the ratio of the data in 1993. This coefficient, which differs by region and variable, is applied to the series before 1993.

R&D capital stock. In order to calculate R&D capital stock, first of all we have deflated R&D nominal expenditure to obtain the real R&D expenditure series. The price index (*prd*) used to deflate R&D is set equal to: $prd = 0.5*p + 0.5*w$; where p is a price index obtained as implicit deflator of the value added and w is a wage index. Next, R&D capital stock is calculated from the real R&D expenditure (R) following the perpetual inventory method: $SR\&D_t=(1-\delta)SR\&D_{t-1} + R_t$; where δ is the depreciation rate (set equal to 15 per cent). Finally, as commonly found in the literature, the benchmark capital stock for the beginning year is given by: $SR\&D_0=R_0/(g+\delta)$; where R_0 is the average of the initial five years for which data on R&D are available and g is the average growth rate of R&D expenditure over the whole period. It should be noted that in the literature R_0 is usually set equal to the first year R&D expenditure for which data are available. We preferred averaging over the first five years in order to obtain a more robust estimate.

Table 1

SUMMARY STATISTICS: ITALIAN MEAN=100

Region	TFP of business sector (1)		Human capital		R&D stock in percentage of GDP		Public capital stock divided by region size (squared kilometres)	
	1980	2001	1980	2001	1980	2001	1980	2001
Piedmont	113.9	108.5	99.4	99.5	215.6	218.0	56.7	70.6
Lombardy	121.3	119.9	102.6	102.1	128.8	134.8	122.0	139.7
Trentino Alto-Adige	110.1	104.5	97.0	98.3	8.3	38.5	55.5	71.6
Veneto	103.3	106.7	97.4	99.0	26.9	41.6	100.7	104.2
Friuli Venezia-Giulia	105.4	107.9	104.2	102.7	103.5	93.6	103.5	115.2
Liguria	142.8	125.7	108.0	103.5	175.8	111.8	221.5	203.3
Emilia-Romagna	116.8	111.6	99.8	100.9	120.1	82.1	101.1	99.1
Tuscany	117.7	112.0	100.2	99.2	50.6	64.8	89.1	83.1
Umbria	103.3	101.7	99.1	104.4	22.3	28.4	68.3	59.2
Marche	96.3	100.9	94.6	99.0	29.3	23.6	91.5	81.6
Lazio	130.6	124.8	114.4	107.5	137.0	215.2	157.1	158.7
Abruzzo	88.9	91.9	99.4	99.8	15.2	67.1	108.0	92.8
Molise	74.7	85.2	94.8	98.7	0.7	8.9	41.6	46.2
Campania	79.1	86.5	98.7	99.5	65.5	59.3	170.3	170.6
Puglia	84.3	84.6	95.8	96.0	76.2	29.5	75.3	73.4
Basilicata	66.1	78.7	93.1	93.9	85.2	48.3	94.9	86.8
Calabria	64.6	77.9	101.0	99.3	17.8	8.0	131.0	114.6
Sicily	86.8	84.9	100.0	99.6	31.7	28.3	119.2	109.9
Sardinia	94.1	86.1	100.5	97.2	177.5	30.1	58.5	57.4
Centre and North	114.7	111.3	101.5	101.5	113.6	120.2	98.8	103.1
South	79.8	84.5	97.9	98.0	60.7	38.3	101.7	95.5
Italy (2)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: based on Istat data. (1) The business sector is computed excluding from the total public administration, education, health and social services, other public, social and personal services. (2) For TFP and human capital, Italy refers to the average across regions.

Table 2

UNIT ROOTS TESTS

(p-values in brackets)

Variable	PP-Fisher	Levin, Lin & Chu	Im, Pesaran and Shin	ADF-Fisher	Variable	PP-Fisher	Levin, Lin & Chu	Im, Pesaran and Shin	ADF-Fisher
Tfp	62.6*** (0.01)	1.49 (0.93)	-1.39* (0.08)	48.54 (0.11)	Δtfp	297.6*** (0.00)	3.21*** (0.00)	6.41*** (0.00)	110.82*** (0.00)
Rd	23.3 (0.97)	-4.22*** (0.00)	-0.53 (0.29)	49.93 (0.26)	Δrd	62.8*** (0.01)	3.56*** (0.00)	-2.11** (0.02)	51.81* (0.07)
hc	45.1 (0.20)	1.85 (0.97)	0.12 (0.55)	31.15 (0.77)	Δhc	313.2*** (0.00)	3.22*** (0.00)	6.83*** (0.00)	118.82*** (0.00)
g	13.0 (1.00)	-4.86*** (0.00)	-0.61 (0.26)	40.81 (0.34)	Δg	65.7*** (0.00)	-0.89 (0.19)	-1.49* (0.07)	39.59 (0.39)
y-l	21.6 (0.98)	4.46 (1.00)	2.20 (0.98)	22.83 (0.97)	Δ(y-l)	196.3*** (0.00)	-2.39*** (0.00)	-3.92*** (0.00)	72.18*** (0.00)
y	65.7** (0.04)	1.00 (0.84)	-1.15 (0.12)	39.49 (0.40)	Δy	510.2*** (0.00)	-1.64*** (0.05)	-5.47*** (0.00)	94.95*** (0.00)
k-l	6.08 (1.00)	6.10 (1.00)	5.51 (1.00)	9.64 (1.00)	Δ(k-l)	106.2*** (0.00)	1.15 (0.87)	-0.27 (0.40)	28.57 (0.87)
k	65.1** (0.04)	-2.42 (0.99)	-0.70 (0.24)	33.88 (0.66)	Δk	95.6*** (0.00)	-1.37* (0.08)	-1.02 (0.15)	37.77 (0.48)
L	7.13 (1.00)	5.42 (1.00)	2.67 (1.00)	14.15 (1.00)	Δl	122.8*** (0.00)	0.88 (0.81)	-1.99** (0.02)	45.15 (0.20)
TFP corrected with human capital	58.9** (0.02)	2.34 (0.99)	-1.08 (0.13)	43.55 (0.24)	ΔTFP corrected with human capital	318.7*** (0.00)	-3.74*** (0.00)	-6.40*** (0.00)	108.21** (0.00)
rd_neigh_distance	30.7 (0.79)	-12.09*** (0.00)	-7.84*** (0.00)	122.31*** (0.00)	Δrd_neigh_distance	20.4 (0.99)	-10.60*** (0.00)	-5.31*** (0.00)	89.20*** (0.00)
rd_neigh_border	23.6 (0.96)	-7.47*** (0.00)	-2.511** (0.01)	57.20** (0.02)	Δrd_neigh_border	27.4 (0.90)	-5.03*** (0.00)	-1.58* (0.05)	40.59 (0.35)
g _neigh_distance	18.4 (1.00)	8.75 (1.00)	8.61 (1.00)	0.28 (1.00)	Δg _neigh_distance	18.4 (0.99)	3.79 (0.99)	4.05 (1.00)	4.39 (1.00)
g _neigh_border	190.2*** (0.00)	0.94 (0.82)	0.01 (0.50)	29.85 (0.82)	Δg _neigh_border	164.5*** (0.00)	-1.18 (0.11)	-2.48*** (0.00)	51.91* (0.06)

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10% probability level. TFP refers to business sector; Valle d'Aosta is excluded for lack of data on human capital. All the tests are carried out with individual fixed effects and individual linear trends. The specified lags of the models are 2. The null hypothesis is Ho: Unit Roots. P-values in parenthesis.

Table 3

TOTAL FACTOR PRODUCTIVITY ESTIMATION RESULTS

Dependent variable: log TFP; FMOLS estimates
Time period: 1985-2001; 19 regions.

Variable	*(1)*	*(2)*	*(3)*	*(4)*
R&D	0.026*** *(0.000)*	0.015*** *(0.000)*	0.054*** *(0.000)*	0.036*** *(0.000)*
Human capital	0.379*** *(0.061)*	0.530*** *(0.097)*	0.486*** *(0.082)*	0.537*** *(0.106)*
Public capital: total	0.109*** *(0.004)*	–	–	–
Public capital: roads	–	0.149*** *(0.007)*	–	–
Public capital: railways	–	–	0.090*** *(0.002)*	–
Public capital: water and electricity	–	–	–	0.020*** *(0.000)*
Time fixed effects	yes	yes	yes	yes
Regional fixed effects	yes	yes	yes	yes
Pedroni's (1999) coint. tests (1)				
Panel ν-Statistic	1.761*	1.805*	1.763*	1.579
Panel ρ-Statistic	0.359	0.404	0.252	0.451
Panel t-Statistic (non- parametric)	-2.721***	-2.567***	-2.892***	-2.585***
Panel t-Statistic (parametric)	-3.572***	-2.391***	-3.812***	-3.825***
Group ρ-Statistic	2.013	2.214	1.888	2.193
Group t-Statistic (non- parametric)	-2.572***	-2.199**	-2.787***	-3.66***
Group t-Statistic (parametric)	-5.187***	-3.510***	-5.841***	-4.608***

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10%. Unreported time and region-specific fixed effects. TFP refers to business sector. All the variables are in logs. Standard error in brackets.

(1) The distribution of Pedroni's cointegration tests is normal; the left tail of the normal distribution is used to reject the null hypothesis, except for the first test, which rejects with large positive values. The null is no cointegration. The cointregration tests do not include heterogeneous trends.

Table 4

BASELINE MODEL WITH SPATIAL SPILLOVERS

Dependent variable: log TFP; FMOLS estimates;
Time period: 1985-2001; 19 regions.

Variable	*(1)*	*(2)*	*(3)*	*(4)*
R&D	0.014*** (0.000)	0.043*** (0.000)	0.006*** (0.000)	0.005*** (0.000)
Human capital	0.341*** (0.035)	0.268*** (0.027)	0.326*** (0.035)	0.399*** (0.044)
Public capital	0.092*** (0.005)	0.186*** (0.001)	0.205*** (0.011)	0.312*** (0.017)
R&D Neighbour_distance	0.733** (0.370)	_	_	_
Public capital Neighbour_distance	1.690 (2.743)	_	_	_
R&D Neighbour_border	_	0.077*** (0.003)	_	_
Public capital Neighbour_border	_	1.668*** (0.333)	_	_
R&D Neighbour_square distance	_	_	0.120*** (0.014)	_
Public Capital Neighbour_square distance	_	_	1.595*** (0.572)	_
R&D Neighbour_exp(-distance)	_	_	_	0.273*** (0.015)
Public capital Neighbour_exp(-distance)	_	_	_	0.846*** (0.238)
Time fixed effects	yes	yes	yes	yes
Regional fixed effects	yes	yes	yes	yes
Pedroni's (1999) coint. tests (1)				
Panel ν-Statistic	-0.922	-0.433	-0.633	-0.931
Panel ρ-Statistic	2.678	2.626	2.644	2.838
Panel t-Statistic (non- parametric)	-3.576***	-3.052***	-3.434***	-3.154***
Panel t-Statistic (parametric)	-2.228**	-1.480	-1.343	-1.185
Group ρ-Statistic	4.255	4.293	4.301	4.475
Group t-Statistic (non- parametric)	-5.002***	-4.066***	-4.459***	-4.320***
Group t-Statistic (parametric)	-5.504***	-5.121***	-4.686***	-4.835***

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10% Unreported time and region-specific fixed effects. All the variables are in logs. Standard error in brackets. *y_neighbour_distance* is the average of the variable y of the other regions weighted by the distance ($w_{ii*}=(1/d_{ii*})$); *y_neighbour_border* is the average of variable y of the bordering regions; *y_neighbour_square distance* is the average of the variable y of the other regions weighted by the square distance ($w_{ii*}=(1/d_{ii*})^2$); *y_neighbour_exp(-distance)* is the average of the variable y of the other regions weighted by the exponential of distance ($w_{ii*}=exp(-d_{ii*})$).

(1) The distribution of Pedroni's cointegration tests is normal; the left tail of the normal distribution is used to reject the null hypothesis, except for the first test, which rejects with large positive values. The null is no cointegration. The cointregration tests do not include heterogeneous trends.

Table 5

LABOUR PRODUCTIVITY AND OUTPUT ESTIMATION RESULTS

Time period: 1985-2001; 19 regions. FMOLS estimates

Variable	Dependent variable: Labour productivity	Dependent variable: Output
	(1)	*(2)*
R&D	0.043*** (0.000)	0.076*** (0.001)
Human capital	0.393*** (0.045)	0.476*** (0.070)
Public capital	0.192*** (0.007)	0.190*** (0.011)
Private capital/Labour	0.427*** (0.031)	–
Private capital	–	0.146*** (0.019)
Labour	–	0.557*** (0.033)
Time fixed effects	yes	yes
Regional fixed effects	yes	Yes
Pedroni's (1999) coint. tests (1)		
Panel ν-Statistic	0.537	-0.002
Panel ρ-Statistic	1.666	2.276
Panel t-Statistic (non- parametric)	-4.403***	-4.304***
Panel t-Statistic (parametric)	-3.221***	-3.301***
Group ρ-Statistic	2.951	3.760
Group t-Statistic (non- parametric)	-4.604***	-5.558***
Group t-Statistic (parametric)	-5.205***	-4.981***

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10%. Unreported time and region-specific fixed effects. Labour productivity and output refer to business sector. All the variables are in logs. Standard error in brackets.

(1) The distribution of Pedroni's cointegration tests is normal; the left tail of the normal distribution is used to reject the null hypothesis, except for the first test, which rejects with large positive values. The null is no cointegration. The cointregration tests do not include heterogeneous trends.

Table 6

ERROR CORRECTION MODEL RESULTS

Time period: 1985-2001; 19 regions. OLS estimates.

	Dependent variable			
Variable	Δlog TFP_t	Δlog R&D $Capital_t$	Δlog Human capital $_t$	Δlog Public capital $_t$
Intercept	0.013*** (0.003)	0.035*** (0.011)	0.018*** (0.001)	0.004*** (0.001)
Δlog TFP_{t-1}	-0.046 (0.058)	-0.217 (0.197)	0.018 (0.026)	0.039* (0.023)
Δlog R&D capital $_{t-1}$	0.021 (0.015)	0.237*** (0.056)	0.001 (0.006)	0.015*** (0.006)
Δlog Human capital $_{t-1}$	0.070 (0.131)	1.099** (0.429)	-0.134** (0.060)	0.005 (0.052)
Δlog Public capital $_{t-1}$	-0.090 (0.098)	-1.517*** (0.412)	-0.062 (0.045)	0.664*** (0.039)
$\hat{u}_{i,t-1}$	-0.183*** (0.036)	0.254** (0.117)	-0.001 (0.016)	-0.007 (0.014)
Time effects	yes	yes	yes	yes
Regional effects	no	yes	no	no
LR-Test $\chi(18)$ on the significance of regional dummies	28.72*	61.98***	11.66	27.53*
F-test of short-run causality: Ho: $\gamma1=\gamma2=\gamma3=0$	1.115	7.457***	0.786	3.209**
F-test of long-and short-run causality: Ho: $\lambda=\gamma1=\gamma2=\gamma3=0$	7.204***	6.301***	0.668	2.409**
Number of observations	285	285	285	285
R-squared	0. 38	0.46	0.41	0.64

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10% . Δ log y=logy_t-log y_{t-1} for variable y.

Table 7

ROBUSTNESS CHECKS

Dependent variable: log TFP. Time period: 1985-2001; 19 regions. FMOLS estimates.

	Without real estate and business services	TFP with α heterogeneous by region	Physical measure for public capital	R&D calculated with 10% depreciation rate	Only industry	TFP corrected with human capital
R&D	0.018*** (0.000)	0.006*** (0.000)	0.077*** (0.001)	—	0.012*** (0.000)	0.026*** (0.000)
R&D 10%	—	—	—	0.019*** (0.000)	—	—
Human capital	0.329*** (0.059)	0.528*** (0.096)	0.429*** (0.054)	0.447*** (0.082)	0.763 (1.437)	—
Public capital	0.108*** (0.005)	0.013*** (0.001)	—	0.139*** (0.005)	0.239*** (0.021)	0.157*** (0.007)
Kilometres of motorways and roads	—	—	0.183*** (0.011)	—	—	—
Time fixed effects	yes	yes	yes	yes	yes	yes
Regional fixed effects	yes	yes	yes	yes	yes	yes
Pedroni's (1999) coint. tests (1)						
Panel ν-Statistic	1.353	1.918*	1.115	1.853*	2.416***	2.704***
Panel ρ-Statistic	0.080	0.385	0.816	0.189	-0.512	-0.983
Panel t-Statistic (non-parametric)	-4.300***	-2.321***	-2.037**	-2.914***	-5.024***	-3.100***
Panel t-Statistic (parametric)	-2.028**	-2.681***	-1.656*	-3.412***	-3.599***	-3.998***
Group ρ-Statistic	1.674	2.112	2.539	1.837	0.891	0.788
Group t-Statistic (non-parametric)	-5.006***	-2.014**	-1.612*	-2.851***	-6.100***	-2.791***
Group t-Statistic (parametric)	-4.481***	-4.699***	-2.471***	-4.974***	-5.727***	-5.047***

Note: (***) denotes parameters significant at or below, 1%; (**) denotes parameters significant at or below, 5%; (*) indicates the parameters that are significant at or below the 10% Unreported time and region-specific fixed effects. TFP refers to business sector. All the variables are in logs. Standard error in brackets.

(1) The distribution of Pedroni's cointegration tests is normal; the left tail of the normal distribution is used to reject the null hypothesis, except for the first test, which rejects with large positive values. The null is no cointegration. The cointregration tests do not include heterogeneous trends.

References

Acemoglu D. and Angrist J. (2001), "How Large are Human Capital Externalities? Evidence from Compulsory Schooling Laws", *NBER Macroeconomics Annual*, 9-58.

Aschauer D. A. (1989), "Is public expenditure productive?", *Journal of Monetary Economics*, 23, 177-200.

Aschauer D. A. (1990), "Why Is Infrastructure Important?", in A. Munnell, (ed.), *Is There a Shortfall in Public Investment?*, Boston, MA: Federeal Reserve Bank of Boston, 21-50.

Arrow K. J. and M. Kurtz (1970), "Public Investment, the Rate of Return, and Optimal Fiscal policy", The Jon Hopkins Press, Baltimore, MD.

Audretsch D. B. and M. P. Feldman (2005), "Knowledge Spillovers and the Geography of Innovation", in Henderson V. and J.F. Thisse, *Handbook of Urban and Regional Economics: Cities and geography*, vol. 4, Amsterdam: North-Holland.

Baffigi A. (1996), "Archivio con serie regionali e provinciali tratte dall'indagine sulle forze lavoro", Bank of Italy, mimeo.

Bils M. and P.J. Klenow (2000), "Does Schooling Cause Growth?", *American Economic Review*, 90, 1160-1183.

Benhabib J. and M. Spiegel (1994), "The Role of Human Capital in Economic Development Evidence from Aggregate Cross-Country Data", *Journal of Monetary Economics*, 34, 143-173.

Boarnet M. G. (1998), "Spillovers and the Locational Effects of Public Infrastructure", *Journal of Regional Science*, 38, 381-400.

Bonaglia F., E. La Ferrara and M. Marcellino (2000), "Public Capital and Economic Performance: Evidence from Italy", *Giornale degli Economisti e Annali di Economia*, 2, 221-244.

Bottazzi L. and G. Peri (2004), "The Dynamics of R&D and Innovation in the Short and in the Long-Run", *CEPR Discussion Paper*, No. 4479.

Brandolini A., and P. Cipollone (2001), "Multifactor Productivity and Labour Quality in Italy 1981-2000", Bank of Italy, *Temi di discussione*, No. 422.

Canning D. (1999), "Infrastructure's Contribution to Aggregate Output", World Bank, *Policy Research Working Paper*, No 2246, November.

Canning D. and P. Pedroni (2004), "The Effect of Infrastructure on Long-run Economic Growth", Harvard University, mimeo.

Coe D.T. and E. Helpman (1995), "International R&D Spillovers", *European Economic Review*, 39, 859-887.

Coe D.T., E. Helpman and A.W. Hoffmaister (1997), "North-South R&D Spillovers", *Economic Journal,* 107, 134-149.

Cohen J. P. and C. Morrison Paul (2004), "Public Infrastructure Investment, Interstate Spatial Spillovers, and Manufacturing Costs", *Review of Economic and Statistics*, 86, 551-560.

Costa M. and S. Iezzi (2004), "Technology Spillovers and Regional Convergence Process: A Statistical Analysis of the Italian Case", *Statistical Methods and Applications*, 13, 375-398.

Crispolti V. and D. Marconi (2005), "Technology Transfer and Economic Growth in Developing Countries: An Econometric Analysis", Bank of Italy, *Temi di discussione*, No. 564.

Engelbrecht H. J. (1997), "International R&D Spillovers, Human Capital in OECD Economies: An Empirical Investigation", *European Economic Review*, 41, 1479-1488.

Engelbrecht H. J. (2002), "Human Capital and International Knowledge Spillovers in TFP Growth of a Sample of Developing Countries", *Applied Economics,* 34, 831-841.

Everaert G., and F. Heylen (2001), "Public Capital and Productivity Growth: Evidence for Belgium 1953-1996", *Economic Modelling*, 18, 97-116.

Fernald J. G. (1999), "Roads to Prosperity? Assessing the Link between Public capital and Productivity", *American Economic Review*, 89, 619-638.

Frantzen D. (2000), "R&D, Human Capital and International Technology Spillovers: A Cross-country Analysis", *Scandinavian Journal of Economics*, 102, 57-75.

Frantzen D., (2002), "Cross-Sector and Cross-Country Technical Knowledge Spillovers and the Evolution of Manufacturing Productivity: A Panel Data Analysis", *Economie Appliquée*, 55, 31-62.

Garcia-Milà T., J. McGuire and R.H. Porter (1996), "The Effect of Public Capital in State-Level Production Functions Reconsidered", *Review of Economics and Statistics*, 78, 177-180.

Granger C.W. (1988), "Some Recent Development in a Concept of Causality", *Journal of Econometrics*, 38, 199-211.

Griliches Z. (1988), "Productivity Puzzles and R&D: Another Non-explanation", *Journal of Economic Perspectives*, 4, 9-22.

Grossman G. M. and E. Helpman (1991), *Innovation and Growth in the Global Economy*, Cambridge MA: MIT Press.

Hall R. E. and C. I. Jones (1999), "Why Do Some Countries Produce so Much More Output per Worker than Others", *Quarterly Journal of Economics*, 114, 83-116.

Hendry D. F. (1995), *Dynamic Econometrics*, Oxford: Oxford University Press.

Holtz-Eakin D. (1994), "Public-Sector Capital and the Productivity Puzzle", *Review of Economics and Statistics*, 76, 12-21.

Holtz-Eakin D. and M. E. Lovely (1995), "Scale Economies, Returns to Variety, and the Productivity of Public Infrastructure", *Regional Science and Urban Economics*, 26, 105-123.

Holtz-Eakin D. and A. E. Schwartz (1995a), "Infrastructure in a Structural Model of Economic Growth", *Regional Science and Urban Economics*, 25, 131-151.

Holtz-Eakin D. and A. E. Schwartz (1995b), "Spatial Productivity Spillovers from Public Infrastructure: Evidence from State Highways", *International Tax and Public Finance*, 2, 459-468.

Im, K. S., Pesaran, M. H., and Y. Shin (2003), "Testing for Unit Roots in Heterogeneous Panels," *Journal of Econometrics*, 115, 53–74.

Kao, C. and M. H. Chiang (2000), "On the Estimation and Inference of a Cointegrated Regression in Panel Data", in Baltagi et al. (eds), *Nonstationary Panels, Panel Cointegration and Dynamic Panels*, *Advances in Econometrics,* Vol. 15, Elsevier Science, Amsterdam.

Karlsson S. and M. Lothgren (2000), "On the Power and Interpretation of Panel Unit Root Tests", *Economic Letters*, 66*,* 249-255.

Kremers J., N. Ericsson, and J. Dolado (1992), "The Power of Cointegration Tests", *Oxford Bulletin of Economics and Statistics*, 54, 325-348.

Levin, A., Lin, C. F., and C. Chu (2002), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties", *Journal of Econometrics*, 108, 1–24.

Lodde S. (2000) "Education and Growth: Some Disaggregated Evidence from the Italian Regions", *Rivista Internazionale di Scienze Economiche e Commerciali* , 47, 267-293.

Lucas, R. B. (1988), "On the Mechanics of Economic Development", *Journal of Monetary Economics*, 22, 3-42.

Maddala, G.S. and S. Wu (1999), "A Comparative Study of Unit Root Tests with Panel Data and a New Simple Test", *Oxford Bulletin of Economics and Statistics*, 61, 631-652.

Maroccu E., R. Paci and R. Pala (2001), "Estimation of Total Factor Productivity for Regions and Sectors in Italy. A Panel Cointegration Approach", *Rivista Internazionale di Scienze Economiche e Commerciali* , 48, 533-558

Montanaro P. (2003), "Lo stock di capitale pubblico: una stima per regione e tipologia di bene", *Rivista Economica del Mezzogiorno*, 3, 423-462.

Munnell A. H. (1990a), "Why has Productivity Growth Declined? Productivity and Public Investment", *New England Economic Review*, Jan-Feb., 3-22.

Munnell A. H. (1990b), "How does public investment affect regional economic performance?" in A. Munnell, (ed.), *Is there a shortfall in public investment?*, Boston, MA: Federeal Reserve Bank of Boston, 69-103.

Munnell A. H. (1992), "Infrastructure Investment and Economic Growth", *Journal of Economic Perspective*, 6, 189-198.

Pedroni P. (1996), "Fully Modified OLS for Heterogeneous Cointegrated Panels and the Case of Purchasing Power Parity", Indiana University, *Working Papers in Economics*, No. 96-020.

Pedroni P. (1999), "Critical Values for Cointegration Tests in Heterogeneous Panels with Multiple Regressors", *Oxford Bulletin of Economics and Statistics*, 61, 653-70.

Pedroni P. (2000), "Fully Modified OLS for Heterogeneous Cointegrated Panels", in Baltagi et al. (eds.), *Nonstationary Panels, Panel Cointegration and Dynamic Panels*, *Advances in Econometrics,* Vol. 15, Elsevier Science, Amsterdam.

Pedroni P. (2004), "Panel Cointegration: Asymptotic and Finite Sample Properties of Pooled Time Series Tests with an Application to the PPP Hypothesis", *Econometric Theory*, 3, 597-626.

Pereira A. M. and O. Roca-Sagalés (2003), "Spillovers effects of public capital formation: evidence from the Spanish regions", *Journal of Urban Economics*, 53, 28-256.

Phillips, P.C.B. and B. Hansen (1990), "Statistical Inference in Instrumental Variables Regression with I(1) Processes", *Review of Economic Studies*, 57, 99-125.

Phillips, P.C.B. and H. Moon (1999), "Linear Regression Limit Theory for Non-stationary Panel Data", *Econometrica,* 67, 1057-1111.

Picci L. (1999), "Productivity and Infrastructure in the Italian Regions*", Giornale degli Economisti ed Annali di Economia*, No. 3-4, 329-353.

Piselli P. (2001), "Lo stock di capitale nelle regioni italiane: una ricostruzione 1980-1996" Bank of Italy, *mimeo.*

Redding S. (1996), "The Low-Skill, Low-Quality Trap: Strategic Complementarities Between human Capital and R&D", *Economic Journal*, 106, 458-470.

Romer P. M. (1990), "Endogenous Technological Change", *Journal of Political Economy*, 90, 71-102.

Stokey N. (1991), "Human Capital, Product Quality and Growth", *Quarterly Journal of Economics*, 106, 587-616.

Strauss J. and M. Wohart (2004), "The Linkage between Prices, Wages and Labor Productivity: A Panel Study of Manufacturing Industries", *Southern Economic Journal*, 70, 920-941.

Temple J. (1999), "The New Growth Evidence", *Journal of Economic Literature*, 37, 112-156.

van Pottelsberghe de la Potterie B. and F. Licthenberg (2001), "Does Foreign Direct Investment Transfer Technology Across Borders?", *Review of Economics and Statistics*, 3, 490-497.

Xu B. and J. Wang (1999), "Capital Goods Trade and R&D Spillovers in the OECD", *Canadian Journal of Economics,* 32, 1258-1274.

Wang J. and K. Tsai (2003), "Productivity Growth and R&D Expenditure in Taiwan's Manufacturing Firms", *NBER Working Paper*, No. 9724.

RECENTLY PUBLISHED “TEMI” (*).

N. 572 – *Incentives in universal banks,* by Ugo Albertazzi (January 2006).

N. 573 – *Le rimesse dei lavoratori emigrati e le crisi di conto corrente,* by M. Bugamelli and F. Paternò (January 2006).

N. 574 – *Debt maturity of Italian firms,* by Silvia Magri (January 2006).

N. 575 – *Convergence of prices and rates of inflation,* by F. Busetti, S. Fabiani and A. Harvey (February 2006).

N. 576 – *Stock market fluctuations and money demand in Italy, 1913-2003,* by Massimo Caruso (February 2006).

N. 577 – *Skill dispersion and firm productivity: an analysis with employer-employee matched data,* by S. Iranzo, F. Schivardi and E. Tosetti (February 2006).

N. 578 – *Produttività e concorrenza estera,* by M. Bugamelli and A. Rosolia (February 2006).

N. 579 – *Is foreign exchange intervention effective? Some micro-analytical evidence from the Czech Republic,* by Antonio Scalia (February 2006).

N. 580 – *Canonical term-structure models with observable factors and the dynamics of bond risk premiums*, by M. Pericoli and M. Taboga (February 2006).

N. 581 – *Did inflation really soar after the euro cash changeover? Indirect evidence from ATM withdrawals,* by P. Angelini and F. Lippi (March 2006).

N. 582 – *Qual è l’effetto degli incentivi agli investimenti? Una valutazione della legge 488/92*, by R. Bronzini and G. de Blasio (March 2006).

N. 583 – *The value of flexible contracts: evidence from an Italian panel of industrial firms,* by P. Cipollone and A. Guelfi (March 2006).

N. 584 – *The causes and consequences of venture capital financing. An analysis based on a sample of Italian firms*, by D. M. Del Colle, P. Finaldi Russo and A. Generale (March 2006).

N. 585 – *Risk-adjusted forecasts of oil prices*, by P. Pagano and M. Pisani (March 2006).

N. 586 – *The CAPM and the risk appetite index: theoretical differences and empirical similarities*, by M. Pericoli and M. Sbracia (March 2006).

N. 587 – *Efficiency vs. agency motivations for bank takeovers: some empirical evidence*, by A. De Vincenzo, C. Doria and C. Salleo (March 2006).

N. 588 – *A multinomial approach to early warning system for debt crises,* by A. Ciarlone and G. Trebeschi (May 2006).

N. 589 – *An empirical analysis of national differences in the retail bank interest rates of the euro area*, by M. Affinito and F. Farabullini (May 2006).

N. 590 – *Imperfect knowledge, adaptive learning and the bias against activist monetary policies*, by Alberto Locarno (May 2006).

N. 591 – *The legacy of history for economic development: the case of Putnam’s social capital,* by G. de Blasio and G. Nuzzo (May 2006).

N. 592 – *L’internazionalizzazione produttiva italiana e i distretti industriali: un’analisi degli investimenti diretti all’estero,* by Stefano Federico (May 2006).

N. 593 – *Do market-based indicators anticipate rating agencies? Evidence for international banks,* by Antonio Di Cesare (May 2006).

N. 594 – *Entry regulations and labor market outcomes: Evidence from the Italian retail trade sector,* by Eliana Viviano (May 2006).

N. 595 – *Revisiting the empirical evidence on firms’ money demand,* by Francesca Lotti and Juri Marcucci (May 2006).

N. 596 – *Social interactions in high school: Lesson from an earthquake*, by Piero Cipollone and Alfonso Rosolia (September 2006).

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

"TEMI" LATER PUBLISHED ELSEWHERE

1999

L. GUISO and G. PARIGI, *Investment and demand uncertainty*, Quarterly Journal of Economics, Vol. 114 (1), pp. 185-228, **TD No. 289 (November 1996)**.

A. F. POZZOLO, *Gli effetti della liberalizzazione valutaria sulle transazioni finanziarie dell'Italia con l'estero*, Rivista di Politica Economica, Vol. 89 (3), pp. 45-76, **TD No. 296 (February 1997)**.

A. CUKIERMAN and F. LIPPI, *Central bank independence, centralization of wage bargaining, inflation and unemployment: theory and evidence*, European Economic Review, Vol. 43 (7), pp. 1395-1434, **TD No. 332 (April 1998)**.

P. CASELLI and R. RINALDI, *La politica fiscale nei paesi dell'Unione europea negli anni novanta*, Studi e note di economia, (1), pp. 71-109, **TD No. 334 (July 1998)**.

A. BRANDOLINI, *The distribution of personal income in post-war Italy: Source description, data quality, and the time pattern of income inequality*, Giornale degli economisti e Annali di economia, Vol. 58 (2), pp. 183-239, **TD No. 350 (April 1999)**.

L. GUISO, A. K. KASHYAP, F. PANETTA and D. TERLIZZESE, *Will a common European monetary policy have asymmetric effects?*, Economic Perspectives, Federal Reserve Bank of Chicago, Vol. 23 (4), pp. 56-75, **TD No. 384 (October 2000)**.

2000

P. ANGELINI, *Are banks risk-averse? Timing of the operations in the interbank market*, Journal of Money, Credit and Banking, Vol. 32 (1), pp. 54-73, **TD No. 266 (April 1996).**

F. DRUDI and R. GIORDANO, *Default Risk and optimal debt management*, Journal of Banking and Finance, Vol. 24 (6), pp. 861-892, **TD No. 278 (September 1996)**.

F. DRUDI and R. GIORDANO, *Wage indexation, employment and inflation*, Scandinavian Journal of Economics, Vol. 102 (4), pp. 645-668, **TD No. 292 (December 1996)**.

F. DRUDI and A. PRATI, *Signaling fiscal regime sustainability*, European Economic Review, Vol. 44 (10), pp. 1897-1930, **TD No. 335 (September 1998)**.

F. FORNARI and R. VIOLI, *The probability density function of interest rates implied in the price of options*, in: R. Violi, (ed.) , Mercati dei derivati, controllo monetario e stabilità finanziaria, Il Mulino, Bologna, **TD No. 339 (October 1998)**.

D. J. MARCHETTI and G. PARIGI, *Energy consumption, survey data and the prediction of industrial production in Italy*, Journal of Forecasting, Vol. 19 (5), pp. 419-440, **TD No. 342 (December 1998)**.

A. BAFFIGI, M. PAGNINI and F. QUINTILIANI, *Localismo bancario e distretti industriali: assetto dei mercati del credito e finanziamento degli investimenti*, in: L.F. Signorini (ed.), Lo sviluppo locale: un'indagine della Banca d'Italia sui distretti industriali, Donzelli, **TD No. 347** (**March 1999)**.

A. SCALIA and V. VACCA, *Does market transparency matter? A case study*, in: Market Liquidity: Research Findings and Selected Policy Implications, Basel, Bank for International Settlements, **TD No. 359 (October 1999)**.

F. SCHIVARDI, *Rigidità nel mercato del lavoro, disoccupazione e crescita*, Giornale degli economisti e Annali di economia, Vol. 59 (1), pp. 117-143, **TD No. 364 (December 1999)**.

G. BODO, R. GOLINELLI and G. PARIGI, *Forecasting industrial production in the euro area*, Empirical Economics, Vol. 25 (4), pp. 541-561, **TD No. 370 (March 2000)**.

F. ALTISSIMO, D. J. MARCHETTI and G. P. ONETO, *The Italian business cycle: Coincident and leading indicators and some stylized facts*, Giornale degli economisti e Annali di economia, Vol. 60 (2), pp. 147-220, **TD No. 377 (October 2000)**.

C. MICHELACCI and P. ZAFFARONI, *(Fractional) Beta convergence*, Journal of Monetary Economics, Vol. 45, pp. 129-153, **TD No. 383 (October 2000)**.

R. DE BONIS and A. FERRANDO, *The Italian banking structure in the nineties: testing the multimarket contact hypothesis*, Economic Notes, Vol. 29 (2), pp. 215-241, **TD No. 387 (October 2000)**.

2001

M. CARUSO, *Stock prices and money velocity: A multi-country analysis,* Empirical Economics, Vol. 26 (4), pp. 651-72, **TD No. 264 (February 1996)**.

P. CIPOLLONE and D. J. MARCHETTI, *Bottlenecks and limits to growth: A multisectoral analysis of Italian industry,* Journal of Policy Modeling, Vol. 23 (6), pp. 601-620, **TD No. 314 (August 1997)**.

P. CASELLI, *Fiscal consolidations under fixed exchange rates,* European Economic Review, Vol. 45 (3), pp. 425-450, **TD No. 336 (October 1998)**.

F. ALTISSIMO and G. L. VIOLANTE, *Nonlinear VAR: Some theory and an application to US GNP and unemployment,* Journal of Applied Econometrics, Vol. 16 (4), pp. 461-486, **TD No. 338 (October 1998)**.

F. NUCCI and A. F. POZZOLO, *Investment and the exchange rate*, European Economic Review, Vol. 45 (2), pp. 259-283, **TD No. 344 (December 1998)**.

L. GAMBACORTA, *On the institutional design of the European monetary union: Conservatism, stability pact and economic shocks,* Economic Notes, Vol. 30 (1), pp. 109-143, **TD No. 356 (June 1999)**.

P. FINALDI RUSSO and P. ROSSI, *Credit costraints in italian industrial districts,* Applied Economics, Vol. 33 (11), pp. 1469-1477, **TD No. 360 (December 1999)**.

A. CUKIERMAN and F. LIPPI, *Labor markets and monetary union: A strategic analysis,* Economic Journal, Vol. 111 (473), pp. 541-565, **TD No. 365 (February 2000)**.

G. PARIGI and S. SIVIERO, *An investment-function-based measure of capacity utilisation, potential output and utilised capacity in the Bank of Italy's quarterly model*, Economic Modelling, Vol. 18 (4), pp. 525-550, **TD No. 367 (February 2000)**.

F. BALASSONE and D. MONACELLI, *Emu fiscal rules: Is there a gap?,* in: M. Bordignon and D. Da Empoli (eds.), Politica fiscale, flessibilità dei mercati e crescita, Milano, Franco Angeli, **TD No. 375 (July 2000)**.

A. B. ATKINSON and A. BRANDOLINI, *Promise and pitfalls in the use of "secondary" data-sets: Income inequality in OECD countries*, Journal of Economic Literature, Vol. 39 (3), pp. 771-799, **TD No. 379 (October 2000)**.

D. FOCARELLI and A. F. POZZOLO, *The determinants of cross-border bank shareholdings: An analysis with bank-level data from OECD countries*, Journal of Banking and Finance, Vol. 25 (12), pp. 2305-2337, **TD No. 381 (October 2000)**.

M. SBRACIA and A. ZAGHINI, *Expectations and information in second generation currency crises models,* Economic Modelling, Vol. 18 (2), pp. 203-222, **TD No. 391 (December 2000)**.

F. FORNARI and A. MELE, *Recovering the probability density function of asset prices using GARCH as diffusion approximations,* Journal of Empirical Finance, Vol. 8 (1), pp. 83-110**, TD No. 396 (February 2001)**.

P. CIPOLLONE, *La convergenza dei salari manifatturieri in Europa,* Politica economica, Vol. 17 (1), pp. 97-125, **TD No. 398 (February 2001)**.

E. BONACCORSI DI PATTI and G. GOBBI, *The changing structure of local credit markets: Are small businesses special?,* Journal of Banking and Finance, Vol. 25 (12), pp. 2209-2237, **TD No. 404 (June 2001)**.

CORSETTI G., PERICOLI M., SBRACIA M., *Some contagion, some interdependence: more pitfalls in tests of financial contagion,* Journal of International Money and Finance, 24, 1177-1199, **TD No. 408 (June 2001)**.

G. MESSINA, *Decentramento fiscale e perequazione regionale. Efficienza e redistribuzione nel nuovo sistema di finanziamento delle regioni a statuto ordinario,* Studi economici, Vol. 56 (73), pp. 131-148, **TD No. 416 (August 2001)**.

2002

R. CESARI and F. PANETTA, *Style, fees and performance of Italian equity funds*, Journal of Banking and Finance, Vol. 26 (1), **TD No. 325 (January 1998)**.

L. GAMBACORTA, *Asymmetric bank lending channels and ECB monetary policy*, Economic Modelling, Vol. 20 (1), pp. 25-46, **TD No. 340 (October 1998)**.

C. GIANNINI, *"Enemy of none but a common friend of all"? An international perspective on the lender-of-last-resort function*, Essay in International Finance, Vol. 214, Princeton, N. J., Princeton University Press, **TD No. 341 (December 1998)**.

A. ZAGHINI, *Fiscal adjustments and economic performing: A comparative study*, Applied Economics, Vol. 33 (5), pp. 613-624, **TD No. 355 (June 1999)**.

F. ALTISSIMO, S. SIVIERO and D. TERLIZZESE, *How deep are the deep parameters?*, Annales d'Economie et de Statistique,.(67/68), pp. 207-226, **TD No. 354 (June 1999)**.

F. FORNARI, C. MONTICELLI, M. PERICOLI and M. TIVEGNA, *The impact of news on the exchange rate of the lira and long-term interest rates,* Economic Modelling, Vol. 19 (4), pp. 611-639, **TD No. 358 (October 1999**).

D. FOCARELLI, F. PANETTA and C. SALLEO, *Why do banks merge?*, Journal of Money, Credit and Banking, Vol. 34 (4), pp. 1047-1066, **TD No. 361 (December 1999)**.

D. J. MARCHETTI, *Markup and the business cycle: Evidence from Italian manufacturing branches,* Open Economies Review, Vol. 13 (1), pp. 87-103, **TD No. 362 (December 1999**).

F. BUSETTI, *Testing for stochastic trends in series with structural breaks*, Journal of Forecasting, Vol. 21 (2), pp. 81-105, **TD No. 385 (October 2000)**.

F. LIPPI, *Revisiting the Case for a Populist Central Banker*, European Economic Review, Vol. 46 (3), pp. 601-612, **TD No. 386 (October 2000)**.

F. PANETTA, *The stability of the relation between the stock market and macroeconomic forces*, Economic Notes, Vol. 31 (3), **TD No. 393 (February 2001)**.

G. GRANDE and L. VENTURA, *Labor income and risky assets under market incompleteness: Evidence from Italian data,* Journal of Banking and Finance, Vol. 26 (2-3), pp. 597-620, **TD No. 399 (March 2001)**.

A. BRANDOLINI, P. CIPOLLONE and P. SESTITO, *Earnings dispersion, low pay and household poverty in Italy, 1977-1998,* in D. Cohen, T. Piketty and G. Saint-Paul (eds.), The Economics of Rising Inequalities, pp. 225-264, Oxford, Oxford University Press, **TD No. 427 (November 2001)**.

L. CANNARI and G. D'ALESSIO, *La distribuzione del reddito e della ricchezza nelle regioni italiane*, Rivista Economica del Mezzogiorno (Trimestrale della SVIMEZ), Vol. XVI (4), pp. 809-847, Il Mulino, **TD No. 482 (June 2003)**.

2003

F. SCHIVARDI, *Reallocation and learning over the business cycle*, European Economic Review, , Vol. 47 (1), pp. 95-111, **TD No. 345 (December 1998)**.

P. CASELLI, P. PAGANO and F. SCHIVARDI, *Uncertainty and slowdown of capital accumulation in Europe*, Applied Economics, Vol. 35 (1), pp. 79-89, **TD No. 372 (March 2000).**

P. ANGELINI and N. CETORELLI, *The effect of regulatory reform on competition in the banking industry,* Federal Reserve Bank of Chicago, Journal of Money, Credit and Banking, Vol. 35, pp. 663-684, **TD No. 380 (October 2000)**.

P. PAGANO and G. FERRAGUTO, Endogenous growth with intertemporally dependent preferences, Contribution to Macroeconomics, Vol. 3 (1), pp. 1-38, **TD No. 382 (October 2000).**

P. PAGANO and F. SCHIVARDI, *Firm size distribution and growth*, Scandinavian Journal of Economics, Vol. 105 (2), pp. 255-274, **TD No. 394 (February 2001)**.

M. PERICOLI and M. SBRACIA, *A Primer on Financial Contagion*, Journal of Economic Surveys, Vol. 17 (4), pp. 571-608, **TD No. 407 (June 2001)**.

M. SBRACIA and A. ZAGHINI, *The role of the banking system in the international transmission of shocks,* World Economy, Vol. 26 (5), pp. 727-754, **TD No. 409 (June 2001)**.

E. GAIOTTI and A. GENERALE, *Does monetary policy have asymmetric effects? A look at the investment decisions of Italian firms*, Giornale degli Economisti e Annali di Economia, Vol. 61 (1), pp. 29-59, **TD No**. **429 (December 2001)**.

L. GAMBACORTA, *The Italian banking system and monetary policy transmission: evidence from bank level data*, in: I. Angeloni, A. Kashyap and B. Mojon (eds.), Monetary Policy Transmission in the Euro Area, Cambridge, Cambridge University Press, **TD No. 430 (December 2001).**

M. EHRMANN, L. GAMBACORTA, J. MARTÍNEZ PAGÉS, P. SEVESTRE and A. WORMS, *Financial systems and the role of banks in monetary policy transmission in the euro area,* in: I. Angeloni, A. Kashyap and B. Mojon (eds.), Monetary Policy Transmission in the Euro Area, Cambridge, Cambridge University Press, **TD No. 432 (December 2001)**.

F. SPADAFORA, *Financial crises, moral hazard and the speciality of the international market: further evidence from the pricing of syndicated bank loans to emerging markets,* Emerging Markets Review, Vol. 4 (2), pp. 167-198, **TD No. 438 (March 2002)**.

D. FOCARELLI and F. PANETTA, *Are mergers beneficial to consumers? Evidence from the market for bank deposits*, American Economic Review, Vol. 93 (4), pp. 1152-1172, **TD No. 448 (July 2002)**.

E.VIVIANO, *Un'analisi critica delle definizioni di disoccupazione e partecipazione in Italia,* Politica Economica, Vol. 19 (1), pp. 161-190, **TD No. 450 (July 2002)**.

M. PAGNINI, *Misura e Determinanti dell'Agglomerazione Spaziale nei Comparti Industriali in Italia,* Rivista di Politica Economica, Vol. 3 (4), pp. 149-196, **TD No. 452 (October 2002)**.

F. BUSETTI and A. M. ROBERT TAYLOR, *Testing against stochastic trend and seasonality in the presence of unattended breaks and unit roots*, Journal of Econometrics, Vol. 117 (1), pp. 21-53, **TD No. 470 (February 2003)**.

2004

F. LIPPI, *Strategic monetary policy with non-atomistic wage-setters,* Review of Economic Studies, Vol. 70 (4), pp. 909-919, **TD No. 374 (June 2000)**.

P. CHIADES and L. GAMBACORTA, *The Bernanke and Blinder model in an open economy: The Italian case,* German Economic Review, Vol. 5 (1), pp. 1-34, **TD No. 388 (December 2000)**.

M. BUGAMELLI and P. PAGANO, *Barriers to Investment in ICT,* Applied Economics, Vol. 36 (20), pp. 2275-2286, **TD No. 420 (October 2001)**.

A. BAFFIGI, R. GOLINELLI and G. PARIGI, *Bridge models to forecast the euro area GDP*, International Journal of Forecasting, Vol. 20 (3), pp. 447-460,**TD No. 456 (December 2002)**.

D. AMEL, C. BARNES, F. PANETTA and C. SALLEO, *Consolidation and Efficiency in the Financial Sector: A Review of the International Evidence*, Journal of Banking and Finance, Vol. 28 (10), pp. 2493-2519, **TD No. 464 (December 2002)**.

M. PAIELLA, *Heterogeneity in financial market participation: appraising its implications for the C-CAPM,* Review of Finance, Vol. 8, pp. 1-36, **TD No. 473 (June 2003)**.

E. BARUCCI, C. IMPENNA and R. RENÒ, *Monetary integration, markets and regulation*, Research in Banking and Finance, (4), pp. 319-360, **TD No. 475 (June 2003)**.

G. ARDIZZI, *Cost efficiency in the retail payment networks: first evidence from the Italian credit card system*, Rivista di Politica Economica, Vol. 94, (3), pp. 51-82, **TD No. 480 (June 2003)**.

E. BONACCORSI DI PATTI and G. DELL'ARICCIA, *Bank competition and firm creation*, Journal of Money Credit and Banking, Vol. 36 (2), pp. 225-251, **TD No. 481 (June 2003)**.

R. GOLINELLI and G. PARIGI, *Consumer sentiment and economic activity: a cross country comparison,* Journal of Business Cycle Measurement and Analysis, Vol. 1 (2), pp. 147-172, **TD No. 484 (September 2003)**.

L. GAMBACORTA and P. E. MISTRULLI, *Does bank capital affect lending behavior?*, Journal of Financial Intermediation, Vol. 13 (4), pp. 436-457, **TD No. 486 (September 2003)**.

G. GOBBI and F. LOTTI, *Entry decisions and adverse selection: an empirical analysis of local credit markets,* Journal of Financial services Research, Vol. 26 (3), pp. 225-244, **TD No. 535 (December 2004)**.

F. CINGANO and F. SCHIVARDI, *Identifying the sources of local productivity growth*, Journal of the European Economic Association, Vol. 2 (4), pp. 720-742, **TD No. 474 (June 2003)**.

C. BENTIVOGLI and F. QUINTILIANI, *Tecnologia e dinamica dei vantaggi comparati: un confronto fra quattro regioni italiane*, in C. Conigliani (a cura di), *Tra sviluppo e stagnazione: l'economia dell'Emilia-Romagna*, Bologna, Il Mulino, **TD No. 522 (October 2004)**.

E. GAIOTTI and F. LIPPI, *Pricing behavior and the introduction of the euro:evidence from a panel of restaurants*, Giornale degli Economisti e Annali di Economia, 2004, Vol. 63(3/4):491-526, **TD No. 541 (February 2005)**.

2005

L. DEDOLA and F. LIPPI, *The monetary transmission mechanism: evidence from the industries of 5 OECD countries*, European Economic Review, 2005, Vol. 49(6): 1543-69, **TD No. 389 (December 2000)**.

G. DE BLASIO and S. DI ADDARIO, *Do workers benefit from industrial agglomeration?* Journal of regional Science, Vol. 45 n.4, pp. 797-827, **TD No. 453 (October 2002).**

M. OMICCIOLI, *Il credito commerciale: problemi e teorie,* in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 494 (June 2004)**.

L. CANNARI, S. CHIRI and M. OMICCIOLI, *Condizioni del credito commerciale e differenzizione della clientela,* in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 495 (June 2004)**.

P. FINALDI RUSSO and L. LEVA, *Il debito commerciale in Italia: quanto contano le motivazioni finanziarie?,* in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 496 (June 2004)**.

A. CARMIGNANI, *Funzionamento della giustizia civile e struttura finanziaria delle imprese: il ruolo del credito commerciale,* in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 497 (June 2004)**.

G. DE BLASIO, *Credito commerciale e politica monetaria: una verifica basata sull'investimento in scorte,* in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 498 (June 2004)**.

G. DE BLASIO, *Does trade credit substitute bank credit? Evidence from firm-level data.* Economic notes, Vol. 34 n.1, pp. 85-112, **TD No. 498 (June 2004).**

A. DI CESARE, *Estimating Expectations of Shocks Using Option Prices*, The ICFAI Journal of Derivatives Markets, Vol. II (1), pp. 42-53, **TD No. 506 (July 2004).**

M. BENVENUTI and M. GALLO, P*erché le imprese ricorrono al factoring? Il caso dell'Italia*, in L. Cannari, S. Chiri e M. Omiccioli (a cura di), *Imprese o intermediari? Aspetti finanziari e commerciali del credito tra imprese in Italia*, Bologna, Il Mulino, **TD No. 518 (October 2004)**.

P. DEL GIOVANE and R. SABBATINI, *L'euro e l'inflazione. Percezioni, fatti e analisi,* Bologna, Il Mulino, **TD No. 532 (December 2004).**

2006

R. BRONZINI and G. DE BLASIO, *Evaluating the impact of investment incentives: The case of Italy's Law 488/92.* Journal of Urban Economics, vol. 60, n. 2, pag. 327-349, **TD No. 582 (March 2006).**

A. DI CESARE, *Do market-based indicators anticipate rating agencies? Evidence for international banks*, Economic Notes, No. 35, pp. 121-150, **TD No. 593 (May 2006).**