How should be the levels of public and private R&D investments to trigger modern productivity growth? Empirical evidence and lessons learned for Italian economy

Mario Coccia

National Research Council (Italy) and Max Planck Institute of Economics (Germany)
CERIS-CNR
via Real Collegio, n. 30, 10024 Moncalieri (Torino) - Italy
Tel.: +39 011 68 24 925; fax : +39 011 68 24 966
m.coccia@ceris.cnr.it

ABSTRACT: Governments in modern economies devote much policy attention to enhancing productivity and continue to emphasize its drivers such as investment in R&D. This paper analyzes the relationship between productivity growth and levels of public and private R&D expenditures. The economic analysis shows that the magnitude of R&D expenditure by business enterprise equal to 1.58% (% of GDP) and R&D expenditure of government and higher education of 1.06 (% of GDP) maximize the long-run impact on productivity growth. These optimal rates are the key to sustain productivity and technology improvements that are more and more necessary to modern economic growth.

KEYWORDS: R&D investment, Productivity growth, Optimization
JEL-CODES: E60, H50, O40, O57

The author wishes to thank Harold Linstone (Portland State University, USA), J.Heijs (Universidad Complutense Madrid, Spain), Nicholas Vonortas (George Washington University and Center for International Science and Technology Policy, Washington D.C., USA), Secondo Rolfo (CERIS, Italy), and participants at IAMOT 2008 Conference (The British University in Dubai), 10th International Conference on Technology Policy and Innovation (Stavanger, Norway), DRUID Conference 2007 (Copenhagen, Denmark), and AISSEC Conference 2007 (Parma, Italy) for their precious comments and suggestions to preliminary drafts of this research. Very special thanks to Silvana Zelli for research assistance. Lastly, thanks to the Italian National Research Council for its financial support to this research.

WORKING PAPER CERIS-CNR
Anno 10, N° 5 – 2008
Autorizzazione del Tribunale di Torino
N. 2681 del 28 marzo 1977

Direttore Responsabile
Secondo Rolfo

Direzione e Redazione
Ceris-Cnr
Istituto di Ricerca sull'Impresa e lo Sviluppo
Via Real Collegio, 30
10024 Moncalieri (Torino), Italy
Tel. +39 011 6824.911
Fax +39 011 6824.966
segreteria@ceris.cnr.it
http://www.ceris.cnr.it

Sede di Roma
Via dei Taurini, 19
00185 Roma, Italy
Tel. 06 49937810
Fax 06 49937884

Sede di Milano
Via Bassini, 15
20121 Milano, Italy
tel. 02 23699501
Fax 02 23699530

Segreteria di redazione
Maria Zittino e Silvana Zelli
m.zittino@ceris.cnr.it

Distribuzione
Spedizione gratuita

Fotocomposizione e impaginazione
In proprio

Stampa
In proprio

Finito di stampare nel mese di Dicembre 2008

CONTENTS

La recherche de la vérité doit être le but de notre activité; c'est le seule fin qui soit digne d'elle ...
H. Poincaré (1935)

INTRODUCTION

Productivity growth depends upon the capacity of country to innovate and more than ever, research investments are the key to innovation (Griffith *et al*., 2004; Mayhew and Neely, 2006; Benum, 2007). As a matter of fact, what is needed now for countries to improve economic growth is to increase the intangible capital accumulation, based on knowledge, through Research and Development (R&D) investments, that have more and more a great influence on competitive advantage of firms and countries (Porter, 1990). Europe and the Unites States of America insisted on the need for enhancing productivity based on R&D investments, but in order to implement effective economic policies, they have to know:

what is the optimal amount of public and private R&D expenditures that maximizes the national productivity growth?

This economic problem has spawned a large theoretical and empirical literature (Hall and Mairesse, 1995; Jones and Williams, 1998; Bartelsman and Doms, 2000; Griffith *et al.,* 2004; Brécard *et al.,* 2006). However, theory alone is unable to provide an answer to optimal magnitude of R&D investment to boost productivity and economic growth in the long run. The purpose of this research is to analyze the relationship between levels of public and private R&D expenditures and productivity growth which can both steer national decisions about economic policies in the right direction and improve the governments' ability in facilitating the process that leads to long run economic growth and wealth increase, driven by accumulation and effective employment of knowledge and technologies (Griffith *et al.,* 2006). Before discussing the main economic problem, let me introduce a review of the literature and present the methodology of research.

1. BACKGROUND

The present-day economic and political debate revolves around the understanding of the causes of countries' economic success, based on strategic drivers that should be pulled in order to increase economic growth in modern economies.

Patterns of economic growth involve the analysis and assessment of productivity[1]. Mayhew and Neely (2006) describe productivity growth as stemming either from gains in static efficiency or gains in dynamic efficiency. *Static efficiency* is equivalent to use existing factors of production as effectively as possible to make markets operate more competitively and efficiently. *Dynamic efficiency* is all about the investment. Moreover, R&D investment if translated into organizational operations allows labour and capital to be put to more productive use. Since productivity growth plays a main role in increasing Gross Domestic Product (GDP), it is important to understand the factors underlying productivity growth, even if quantify their importance is a difficult task. Much of the research that examines the relationship between some factors and productivity growth is limited to showing a correlation between productivity and variables that influence it, and does not determine the causality and magnitude. There is a vast literature dealing with factors affecting productivity growth. Some of the factors that

[1] *Productivity* measures the ratio of outputs to inputs. Labour productivity is defined as 'real' (constant price) output divided by labour inputs (measured in terms of persons or hours).

Multi-factor productivity (MFP) represents the residual portion of output growth that cannot be explained by changes in labour and capital. MFP growth is labour productivity growth minus the effect on productivity of change in the capital-labour ratio (usually more capital per worker, or in other words, capital deepening). MFP growth in the long-run is explained by factors such as technological progress, rising education standards and changes in the socioeconomic environment. In some of the literature MFP is referred to as total factor productivity (TFP).

Capital deepening measures the increase in the value of capital per worker. As capital deepening is measured in volume terms, it also captures the effect of falling Information and Communication Technology (ICT) prices on labour productivity growth.

Growth accounting refers to the disaggregation of labour productivity growth into components, such as MFP growth, the effect of capital deepening and in some studies also the effect of rising education level.

have recently been examined include managerial ability, technology and regulation (Bartelsman and Doms, 2000). Department of Trade and Industry in UK emphasizes the five drivers of productivity growth: investment, innovation, skills, enterprise, and competition (DTI, 2006). Lichtenberg and Siegel (1991) and Hall and Mairesse (1995) documented the correlation between R&D and productivity at micro level. Amendola *et al.* (1993) present a well documented evidence that R&D has an important effect on productivity growth and also on competitiveness, whereas Hall (1996) points out that R&D is often associated with product improvement. Hall and Mairesse (1995) argue that a long history of R&D expenditures is a more potent predictor of productivity growth. According to Brécard *et al.* (2006), R&D produces its full effects on two form of innovation: the global productivity gains of factors and improvements to the quality of products. Growth is led by increased demand due to falling costs and prices and R&D leads simultaneously to an increase in GDP and in the use of factors. Aghion and Howitt (1998) recognise this by noting that "technological knowledge is itself a kind of capital good and it can be accumulated through R&D". Griffith *et al.* (2004) argue that innovation and technology transfer provide two potential sources of productivity growth for countries behind technological frontier. They examines whether R&D has a direct effect on total factor productivity growth (i.e. innovation) in a panel of industries across twelve OECD[2] countries. They state that the greater the potential for technologies to be transferred through R&D and the higher the rates of productivity growth. In short, R&D contributes to total factor productivity (TFP) not only through innovation but also through technology transfer. In addition, they argue that R&D has played a role in the convergence of TFP magnitudes within industries across OECD countries.

A consensus has emerged around the fact that R&D contributes significantly to cross-sectional variation in productivity. Hall (1996) reports an elasticity of 0.1 to 0.15, Griliches (1995) reports an estimated elasticity of output with respect to R&D capital of between 0.06 and 0.1. The impact of R&D on productivity assessed from a macroeconomic perspective is analyzed by Jones and Williams (1998) that formalize a model similar to that of Romer (1990). They calibrate the model and estimate that optimal investment in R&D is two to four times larger than actual investment in the United States of America (USA).

Conversely, Machin and Van Reenen (1998) investigate whether a directly observed measure of technical change (R&D intensity) is closely linked to the growth in the importance of more highly skilled workers in USA and other six OECD countries. They show a significant association between skill upgrading and R&D intensities in all countries. Parisi *et al.* (2006), using a rich firm level data-base for Italy, state that R&D spending is strongly positively associated with the probability of introducing a new product, moreover the effect of fixed investment on the probability of introducing a process innovation is magnified by spending R&D spending internal to the firm. This implies that R&D can affect productivity growth by facilitating the absorption of new technologies.

This relationship between R&D investments technology and productivity growth has affected all modern economic growth literature. As a matter of fact, new growth theory (in the Romer 1990 version) introduces endogenous technological change (as a function of the level of human capital) into the Solow model. The first generation of this model considers the assumption of constant returns to technological knowledge and predicted that long run growth rate of an economy, increases in the level of R&D inputs and thus larger economies should grow at higher rate (Grossman and Helpman, 1991). Jones (1995) finds that first-generation models of endogenous growth are inconsistent with empirical evidence for the USA and refuted the scale effect prediction. To solve the empirical problems associated with these models of economic growth, a second–generation models of endogenous growth have been developed. In particular, economic literature offers two main approaches to remove scale effects: *a)* semi-endogenous theory of Jones (1995), and Segerstrom (1998), which modifies the original theory by incorporating

[2] Organization for Economic Cooperation and Development (OECD).

diminishing returns to the stock of knowledge in R&D. That is, as technology develops and becomes increasingly complex, sustained growth in R&D labour (and human capital such as share of researchers - Ulku, 2007) becomes necessary to maintain a given rate of Total Factor Productivity (TFP) growth. These models of economic growth have been motivated by graphical evidence of a decline in R&D productivity in the USA (Griliches, 1994) and in the UK, Germany and France over 1970-1990 period; *b)* fully endogenous Schumpeterian models of Aghion and Howitt (1998), Dinopoulos and Thompson (1998) maintains the assumption from the first-generation models of constant returns to technological knowledge, and assumes that as an economy grows, proliferation of product varieties reduces the effectiveness of R&D aimed at quality improvement, by causing it to be spread more thinly over a large number of different sectors. In addition, to ensure sustained TFP growth, R&D has to increase over time to counteract the increasing range of products that lowers the productivity effects of R&D activity. The theory is consistent with the observed coexistence of stationary TFP growth and growing R&D labour.

Despite a large amount of economic literature on these topics, the relationship between the levels of public and private R&D investment and productivity growth has not yet been wholly clarified. In particular a main question is:

what is the optimal rate of R&D Expenditures by Business Enterprise and Government, within countries, that boosts productivity growth at aggregate level?

The next section describes data and research methodology to answer this main economic issue for modern economic growth.

2. METHODOLOGY OF RESEARCH

Since analyses of aggregate productivity across countries are central to many questions concerning long-run economic growth, an important issue is to probe the role of Business Enterprise and Government R&D expenditures underlying productivity growth. A common indicator used to measure R&D investments across countries is represented by Gross Domestic Expenditure on Research and Development (GERD) as a percentage of the Gross Domestic Product (Griffith *et al.*, 2006; Pouris, 2007). Instead, concerning productivity growth, researchers employ two metrics: labour productivity and total factor productivity. In this article I concentrate on the former that has different measures at aggregate level; in particular I use labour productivity per hour worked, since it is the most direct indicator of productive efficiency (van Ark *et al.,* 2008).

This research uses data of Eurostat (2008), which collects some key indicators, relating to general economic background and innovation/research, referring to the 1990s and to the early years of the 21st century. The indicators considered are described in the Table 1.

The geographical area is EU Member States, Candidate Countries, Iceland, Norway, Switzerland, Japan and the USA.

The model hypotheses (Hp), based on theoretical background, are the following:

Hp1: Productivity growth (acronym LPRH) is an indicator of the country's economic growth.

Hp2: R&D*i* is an indicator of the technological performance of the *ith* country and a driver of productivity growth.

Time lag effect: Investments in R&D up to period *n* shall increase the productivity growth from the period *n+1* onwards.

As a matter of fact, the R&D investments is followed by a period of deployment of the effects of innovation, which leads to sustained demand, improved competitiveness and long term economic growth.

TABLE 1: VARIABLES

Abbreviations and period	*Indicators*	*Description*
R&DBUSS 1998-2004	Research and development expenditure: Business enterprise sector (% of GDP)	Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D expenditures include all expenditures for R&D performed within the business enterprise sector (BERD) on the national territory during a given period, regardless of the source of funds. R&D expenditure in BERD is shown as a percentage of GDP (R&D intensity).
R&DGOVEDU 1998-2004	Research and development expenditure: Government sector (% of GDP)	
	Research and development expenditure: Higher education sector (% of GDP)	
GDPPS 1997-2003	GDP per capita in PPS GDP per capita in Purchasing Power Standards (PPS) (EU-27 = 100) Please be aware that this indicator has been rescaled, i.e. data is expressed in relation to EU-27 = 100	Gross domestic product (GDP) is a measure for the economic activity. It is defined as the value of all goods and services produced less the value of any goods or services used in their creation. The volume index of GDP per capita in Purchasing Power Standards (PPS) is expressed in relation to the European Union (EU-27) average set to equal 100. If the index of a country is higher than 100, this country's level of GDP per head is higher than the EU average and vice versa. Basic figures are expressed in PPS, i.e. a common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries. Please note that the index, calculated from PPS figures and expressed with respect to EU27 = 100, is intended for cross-country comparisons rather than for temporal comparisons.
LPRH 1999-2005	Labour productivity per hour worked. GDP in Purchasing Power Standards (PPS) per hour worked relative to EU-15 (EU-15 = 100)	Gross domestic product (GDP) is a measure for the economic activity in an economy. It is defined as the value of all goods and services produced less the value of any goods or services used in their creation. GDP per hour worked is intended to give a picture of the productivity of national economies expressed in relation to the European Union (EU-15) average. If the index of a country is higher than 100, this country level of GDP per hour worked is higher than the EU average and vice versa. Basic figures are expressed in PPS, i.e. a common currency that eliminates the differences in price levels between countries allowing meaningful volume comparisons of GDP between countries. Expressing productivity per hour worked will eliminate differences in the full-time/part-time composition of the workforce.
Countries: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, EU (15 countries), EU (25 countries), EU (27 countries), Euro area (12 countries), Euro area (13 countries), Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, The United Kingdom, The United States of America		

Source: Eurostat (2008)

The conceptual model is:

Relative growth of Labour productivity per hour worked = f (Public or private R&D expenditure as % of the GDP).

The statistical information drawn from the Eurostat data undergo a preliminary process of horizontal and vertical cleaning. The normal distribution of the data is checked by statistics based on arithmetic mean, standard deviation, skewness, and kurtosis, the normal Q-Q plot, Kolmogorov-Smirnov and Shapiro-Wilk tests of normality, using statistics software SPSS. After that we apply a regression analysis on polynomial functions.

In addition, the specification of the model is a cubic and quadratic function since they portray the variables' functional links very well and suitably fit to data scatter. In particular I apply the leading indicator model that is a special case of dynamic linear regression model (Hendry and Richard, 1982; Spanos, 1986):

$$y_{i,t} = \beta_0 + \beta_1 x_{i,t-1} + \varepsilon_{i,t}$$

General specification of the model is:

$$Relative\,Variation\,Labour\,productivity\,\,per\,hour\,worked_{i,t} = \beta_0 + \beta_1 R\&D\_Expenditure_{i,t-1} + \\ + \beta_2 R\&D^2\_Expenditure_{i,t-1} + \beta_3 R\&D^3\_Expenditure_{i,t-1} + \varepsilon_{i,t} \quad [1]$$

Where i subscripts denote countries, t subscripts denote time. In addition, since R&D is inherently a dynamic process and countries will not immediately adjust to long-run levels because of adjustment costs and other factors, a lag of R&D is included in the specification (Van Reenen, 1997). It is clear that the causality between R&D investment and productivity growth may run in both directions and to use time lag between dependent and independent variables may not be sufficient; so as to eliminate the simultaneity bias is applied the two-stage last-squares (2SLS) estimator based on:

- *Stage one:*

R&D expenditure (public or private) is function of a main indicator of economic growth:

$$R\&DExpnd_{i,t-1} = \beta_0 + \beta_1 GDP\,\,per\,capita_{i,t-2} + \varepsilon \quad [2]$$

Remark: Richer and growing countries invest more in R&D (measured by R&D/GDP ratio). $R\hat{\&}DExpnd_{i,t-1}$ represents the fitted values (unstandardized) of this regression analysis and it will become the independent variable in the second stage.

- *Stage two:*

$$LPRH_{i,t} = \beta_0 + \beta_1 R\hat{\&}DExpnd_{i,t-1} + \\ + \beta_2 R\hat{\&}DExpnd^2{}_{i,t-1}\beta_3 R\hat{\&}DExpnd^3{}_{i,t-1} + \varepsilon \quad [3]$$

These models are corrected by the Prais-Winsten estimation method based on the autoregression procedure estimates true regression coefficients from time series with first-order autocorrelated errors; this method eliminates the problems of serial correlation.

The estimation of the parameters and the statistical analysis are performed using the statistics software of SPSS.

Econometrics by regression analysis provides main statistics information through the estimation of model's parameters and goodness of fit of the relationship between productivity growth and R&D investments. Econometric modelling does not provide us any information to achieve the purpose of this research, in other words "*What is the optimal amount of public and private R&D investment to boost productivity growth?*", but the estimated relationships by regression analysis are functions adapt for applying the differential calculus and therefore finding local and/or global optimum that indicates the best research policy to improve productivity and economic growth in the long run. In particular, having estimated the relationships [3], an optimization exercise is performed by noting that the functions of one (real) variable from the econometrically estimated relationships are polynomial functions of an order higher than the first order. Since the functions [3] are continuous and infinitely differentiable, we seek to maximize these objective functions applying the classic mathematical optimization methods (Rudin, 1991)[3].

3. EMPIRICAL ANALYSIS AND OPTIMIZATION

The statistic of Kolmogorov-Smirnov and Shapiro-Wilk test normality of variables such that it is possible to apply the econometric models of parametric estimation. The results are

[3] One of the necessary conditions for the functions of one variable in order to have the solution x=x* to be a maximum or a minimum is:

$$\frac{df(x)}{dx} = 0 \quad for\ x = x^* \qquad (1^*)$$

In this case, x is a stationary point. Moreover, if the function is concave (or convex), then condition (1*) is not only necessary but also sufficient in order for x^* to be an overall (global) maximum (minimum). *P.S.:* Let f be twice differentiable on (a,b), and $f''(x)>0$ for all x in (a, b), then the graph of f is concave upwards (or convex). Similarly if $f''(x)<0$, the graph is concave downwards.

summarized in table 2, whereas figures 1 and 2 display the fitted functions.

Models estimated by 2SLS have been corrected by the Prais-Winsten estimation method that in the models has eliminated the problem of auto-correlation and has provided robustness estimates; in short, the parametric estimates of the models are unbiased estimations, the *t*-test returns meaningfulness of the parameters equal to 1‰. The explanatory power of the model is good, as indicated by high R^2 adjusted values (the coefficient of determination adjusted) that is over 85% in model 1 (with R&D expenditure of business enterprise) and model 2 with R&D expenditure of Government and Higher education sector. The result of the Durbin-Watson test (D-W), after the correction with the Prais-Winsten estimation method, is no serial correlation (5% significance level). In short, the performances of the corrected models are excellent (Table 2).

TABLE 2: PARAMETRIC ESTIMATIONS

Explanatory variables	*Model 1 (2SLS)* *Dependent variable*				*Model 2 (2SLS)* *Dependent variable*			
	$k_{i,t-1}$ = *R&DBUSS* $_{i,t-1}$ *Stage 1*		$y_{i,t}$ = *LPRH* $_{i,t}$ *Stage 2*		$w_{i,t-1}$ = *R&DGOVEDU* $_{i,t-1}$ *Stage 1*		$y_{i,t}$ = *LPRH* $_{i,t}$ *Stage 2*	
$z_{i,t-2}$ = GDPPS	0.013***	*(0.001)*			0.003***	*(0.000)*		
$\hat{k}_{i,t-1}$ = Fit for *R&DBUSS*			21.14	*(16.21)*				
$\hat{k}^2_{i,t-1}$ = Fit for *R&DBUSS*^{2}			73.41***	*(21.01)*				
$\hat{k}^3_{i,t-1}$ = Fit for *R&DBUSS*^{3}			–33.82***	*(8.08)*				
$\hat{w}_{i,t-1}$ = Fit for *R&DGOVEDU*							523.301***	*(81.99)*
$\hat{w}^2_{i,t-1}$ = Fit for *R&DGOVEDU*^{2}							–246.122***	*(75.96)*
Constant	–0.373***	*(0.085)*	34.65***	*(3.53)*	0.242***	*(0.033)*	–126.181***	*(21.54)*
R^2 adjusted	0.62		0.87		0.38		0.87	
Durbin-Watson	1.97		2.01		2.06		2.02	
N. cases	162		162		162		162	

*** Parameter is Significant at 0.001; ** Parameter is Significant at 0.05; * Parameter is Significant at 0.1

Note: Prais-Winsten estimation method based on the autoregression procedure estimates true regression coefficients from time series with first-order autocorrelated errors. Standard errors are in parenthesis. Moreover, *i* subscripts denote countries, *t* subscripts denote time.

z = GDPPS: GDP per Capita in PPS (EU27=100)_1997-2003
k = R&DGOVEDU: R&D Expenditure Government and Education sector 1998_2004
w = R&DBUSS: R&D Expenditure Business enterprises 1998-2004
y = LPRH: Labour productivity per hour worked 1999_2005

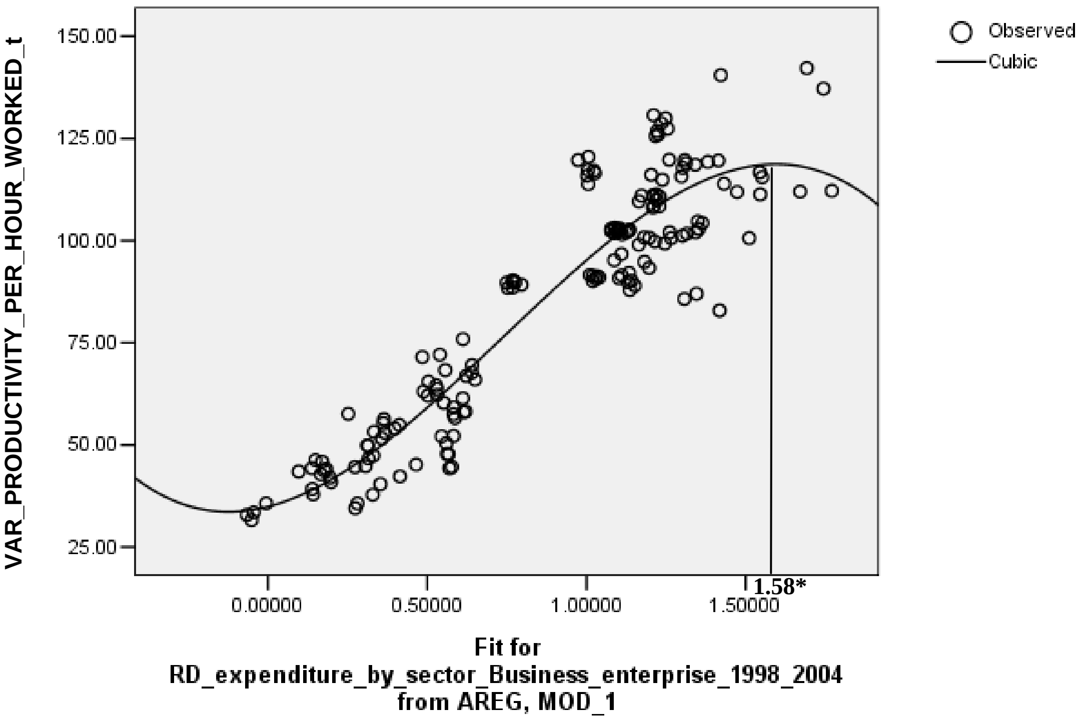

FIGURE 1: REGRESSION OF RELATIVE LABOUR PRODUCTIVITY GROWTH PER HOUR WORKED (T) ON R&D EXPENDITURE OF BUSINESS ENTERPRISE AS % OF THE GDP

The estimated parametric equations are polynomial functions (continuous and differentiable functions) that make it possible to apply classic optimization methods (Rudin, 1991).

Model 1 (table 2) considers $y_{i,t}$ = LPRH at *t*; and explanatory variables Fit for *R&D expenditure by business enterprise* at *t-1* of first, second and third order. It has R^2adj.=87%. The estimated function at stage two is:

$$y_{i,t} = 34.65 + 21.14\hat{k}_{i,t-1} + 73.41\,\hat{k}^2_{i,t-1} - 33.82\,\hat{k}^3_{i,t-1} \quad [4]$$

Necessary condition to calculate the maximum is:

$$\frac{dy}{d\hat{k}} = y'(\hat{k}) = 21.14 + 146.82\hat{k} - 101.46\hat{k}^2 = 0 \quad [5]$$

The first derivative[4] equal to 0 gives us two roots:

$\hat{k}_1 = +1.58$; $\hat{k}_2 = -0.13$; $\{\hat{k}_1; \hat{k}_2\} \in \Re$ (the set of real numbers)

When private R&D expenditure is 1.58 percent; productivity growth is maximized in the following point (Figure 1):

A (R&D Expenditures of Business Enterprises *t–1*; LPRH *t*)

A (1.58; 117.91)

Model 2 considers $y_{i,t}$ = LPRH (*t*); and explanatory variables Fit for *R&D expenditure of government and higher education sector* at *t-1* of first and second order. Estimated relationship (R^2 adj. = 87 percent) is:

[4] The derivative function also gives us the value of the rate of change at every point.

$$y_{i,t} = -126.18 + 523.30\hat{w}_{i,t-1} - 246.12\hat{w}^2_{i,t-1} \qquad [6]$$

$$\frac{dy}{d\hat{w}} = y'(\hat{w}) = 523.30 - 492.24\,\hat{w}$$

Let us set the first derivative equal to 0, which gives us:
$\hat{w} = +1.06 \in \Re$

When public R&D is 1.06 percent, LPRH is maximized in the following point:

B (R&D expenditure of government and higher education sector *t–1*; LPRH *t*)
B (1.06; 168.46).

Moreover
$y'(\hat{w}) > 0$ in $[0; 1.06[$, $y'(\hat{w}) < 0$ in $]1.06; +\infty[$
$y''(\hat{w}) = -492.24 < 0 \Rightarrow y(\hat{w})$ is a concave function downwards (see Figure 2 which is restricted to]0.30; 0.80[ ).

Therefore the point **B** is a global maximum, too.

Model 1 has the cubic term negative, i.e. the increase is less than linear because it is exerting a downward force on the function. In addition, model 1 shows that if Private R&D expenditures increases by 1%, the estimate average productivity growth is given by linear term 21.14, quadratic term 73.41 and cubic term –33.82, which represents the damping factor, in other words the friction of productivity growth due to diminishing returns of R&D investments. Model 2 presents an impact of Public R&D investment on Productivity growth equal to 523.3 and –246.12 (quadratic term).

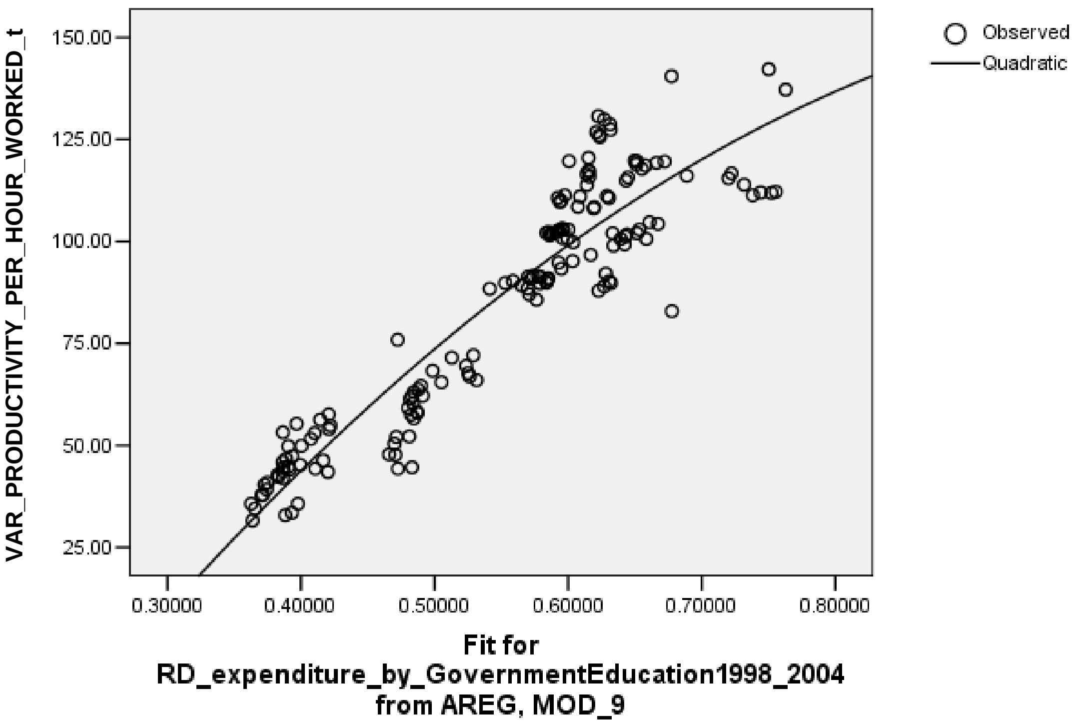

FIGURE 2: REGRESSION OF RELATIVE LABOUR PRODUCTIVITY GROWTH PER HOUR WORKED (T) ON R&D EXPENDITURE OF GOVERNMENT AND HIGHER EDUCATION AS PERCENTAGE OF GDP

4. LESSONS LEARNED AND DISCUSSION

This paper investigates the relationship between levels of public and private R&D expenditures and productivity growth across open economies. Public and private R&D expenditures as percentage of GDP are an important driver of productivity growth, as showed by models. Lessons learned from this research are the following:

- PROPOSITION 1: the relative productivity growth = f (Public R&D Expenditure as % of the GDP) is concave function.
  Proof: The concavity of this function (see graph of f in figure 2 and model 2) is due to diminishing returns to research investments that play a similar role to diminishing returns to capital accumulation into standard neoclassical growth model (Solow, 1956; Cass, 1965).
- PROPOSITION 2: the long run magnitude of Public R&D expenditure as percentage of the GDP that maximizes productivity growth is about 1.06%, whereas the long run magnitude of R&D expenditure of business enterprise as percentage of the GDP that maximizes productivity growth is about 1.58%.
  Proof: See mathematical optimization applied to models.

- REMARK: to maximize national productivity growth it is necessary maximize both R&D expenditure of business enterprise and R&D expenditure of Government-higher education. Both research policy strategies are complementing each others and need to be implemented conjointly.
- REMARK: if the magnitude of Public or Private R&D investment is higher than the optimum levels (proposition 2), the productivity growth is not maximized, thus generating a productivity growth that can be reached with a lower level of R&D expenditures, so that economic resources can be allocated in a more efficient way in other sectors.
- REMARK: to increase productivity and economic growth the long run magnitude of Public R&D expenditure as percentage of the GDP has to be lower than R&D expenditure of business enterprise as percentage of GDP. As a matter of fact, Steil et al. (2002) analyzing the economic and technological performance of a number of countries, find out that in the USA, as well as Japan, Germany, France, and the UK, the Government intervention in R&D investment -particularly in industrial policy and labour market- has been reduced, thus favouring the action of market forces, which have become more and more important in allocating resources. Vincent-Lancrin (2006) describes similar results.

In Europe some governments have concentrated on reforms to achieve static efficiency gains based on supply-side revolution. Relatively little was done specifically to stimulate R&D investments. As the incentive to invest in R&D is determined by the private return and not the social return, R&D is held back in many countries by underdevelopment of financial markets or inappropriate government research policies. This is the reason since some countries do not invest more in R&D. Moreover, the long-run growth in R&D spending is surely linked to growing influence of science in the process of production and greater market competition at home and abroad in knowledge era may force countries to increase R&D expenditures in order to produce new or better product (Scherer, 1992; Van Reenen, 1997). This is the reason why an increasing number of countries have introduced fiscal incentives and subsides for R&D that may increase innovative activity of firms (Heijs *et al*., 2007), as well as they may also alter the strategic interactions between firms that determine market shares.

Policy makers to increase the economic performance of their countries, they should focus their decisions on the magnitude of public and private R&D investments, which should be about 1.58 (for private R&D expenditures) vs. 1.06 (for public R&D expenditures) in the long run. In achieving these aims the policy makers have to ensure better coordination of research policy and recognise the complex chain of causation that can be triggered by polling on R&D investment. As a matter of fact, productivity growth enhancing can be achieved by a magnitude of public and private R&D expenditures close to these optimal rates that support the competitiveness in the long run, a complex matter based on quality improvements and product niche that should be of vital interest to any government, rather than competitiveness in the short run based on price and cost. Contrary to expectations and to much of the literature (Brécard *et al.,* 2006), it is not true that higher is R&D expenditures as percentage of GDP, higher is productivity growth, since the function *Relative Productivity growth = f (R&D expenditures* as % of the GDP*)* has local concavity due to diminishing returns to R&D investments.

Economic literature has analyzed this aspect and models of R&D-induced growth can serve as empirical templates to assess the potential of different growth policies for countries. Lichtenberg and Van Pottelsberghe de la Potterie (1998), Keller (2002), Guellec and Van Pottelsberghe de la Potterie (2004) have established that the level of TFP is influenced by the R&D stock in the OECD countries. However, only a few studies have examined whether semi-endogenous growth can account for the relationship between R&D expenditure and Total Factor Productivity (TFP). Semi-endogenous growth models relax the assumption of constant returns to technological knowledge and a positive growth in R&D inputs is required to maintain sustained growth in TFP that have been motivated by graphical evidence of a decline in R&D productivity in USA. Schumpeterian theories of endogenous growth have, to some extent, also been motivated by diminishing returns to R&D by assuming that innovations are spread over a larger variety of products and, therefore, that there is a tendency for decreasing returns to R&D (Aghion and Howitt, 1998).

Ha and Howitt (2007) argues that long-run trends in R&D and TFP are more supportive of fully endogenous Schumpeterian growth theory than they are of semi-endogenous growth theory. The distinctive prediction of semi-endogenous theory that sustained TFP growth requires sustained growth of R&D input is not supported by co-integration tests and forecasting exercises, as TFP growth has been stationary even though the growth rate of R&D input has fallen three-fold since the early 1950s in the USA. In contrast, the prediction of Schumpeterian theory that sustained TFP growth requires a sustained fraction of GDP to be spent on R&D, is not contradicted by similar tests. In addition they state that Schumpeterian theory of endogenous growth is more consistent with long-run trends in R&D and TFP than semi-endogenous theory. Zachariadis (2003; 2004) examines the relationship between TFP growth and the share of R&D expenditure in total income and finds support for the Schumpeterian growth models. Madsen (2007) shows that the hypothesis of constant returns to R&D cannot be rejected for 21 industrialized countries and, therefore, challenge the conventional wisdom of diminishing returns to R&D or that R&D is diluted due to an increasing variety of products as the economy grows. The statistical results were supported by graphical evidence which showed that diminishing returns to R&D have been limited to some countries and certain period in history, particularly the 1960s. The results imply that the assumptions underlying semi-endogenous growth theories cannot be maintained and that Schumpeterian theories have to relax the assumption that R&D is spread over an increasing range of goods as the economy is growing to be consistent with the empirical evidence.

This research shows diminishing returns to R&D investments, in addition a main finding is that to increase productivity growth and economic performance of countries in the long run, policy makers should focus their decisions on the total amount of R&D investments and their inner structure respectively that should have a public R&D investment < private one (i.e. 1.58<1.06).

5. CONCLUDING REMARKS

On an international level, converging strategies are adopted in relation to science and technology policies to boost productivity and economic growth (Dodgson and Bessan, 1996; Tassey, 1997). Despite these converging initiatives, the benefits differ greatly among advanced economies in terms of economic performance and productivity growth. Since the mid 1990s, the European Union has experienced a significant slowdown in productivity growth, at a time when productivity growth in the United States significantly accelerated. In particular the United States accelerated average annual productivity growth (measured as GDP per hour worked) of 2.3 percent from 1995-2006; conversely, EU15, labour productivity growth declined from an annual rate of 1.5 percent during the period 1995-2006.

The poor productivity performance of European countries in comparison with the USA has been an important focus for government policy. European Union with 15 countries (EU15) has a R&D expenditure of business enterprise equal to 1.23% of GDP, whereas R&D expenditure of government and higher education is 0.66% of GDP vs. 1.93 and 0.64 in the United States (Table 1A, in appendix). This situation leads to a European growth of labour productivity per hour worked as well as GDP per capita lower than the USA. In addition within the Europe there are larger differences across countries in the levels of R&D Expenditures and labour productivity development. Moreover, according to Borrás (2004), despite institutional efforts, the conceptualization of a European Innovation System is still premature in the European Union. Acemoglu *et al.,* (2006) argue that Europe has reached the productivity frontier by the mid 1990s, it now require a new model of innovation and technological change to make better use of country's own innovative capabilities. Sapir *et al.* (2004) explicitly address the need to speed up the process of Lisbon Agenda (European Commission, 2004). Van Ark *et al.* (2008) show that the European productivity slowdown is attributable to slower emergence of knowledge economy in Europe compared to United States. They consider various explanations which are not mutually exclusive: for instance, lower grow contributions from investment in information and communication technology in Europe, the relatively small share of technology-producing industries in Europe, and slower multifactor productivity growth (which can be viewed as a proxy for advances in technology and innovation). Underlying these explanations are issues related to the functioning of European labour markets and the high level of product market regulation in Europe. In addition, several EU countries are far from reaching the optimum magnitude of public and private R&D investment as % of GDP, because of weak industrial structure and macroeconomic problems that generate a technological and economic delay in the 1990s and early 2000s, leaving Europe far behind in comparison to the US economy. The optimal rate of public and private R&D investment that maximizes the productivity growth in the long run is based on a set of open economies operating in the same geo-socio-economic and politic area. It is important to always consider *social-economical specificity of each country.* In particular, each country has a specificity represented by his macroeconomic (public debt, inflation, real GDP growth), industrial structure (traditional rather than high tech industries) and financial structure, such that, given a fixed level of R&D expenditures (e.g. equal 1.0 percent of GDP for public R&D), this may breed different effects and economic performances within several countries.

Table 2A in Appendix shows that the magnitude and composition of public and private R&D expenditures change with the level of development of nations: *countries with high and medium GDP per capita* have R&D expenditure of business enterprise higher than R&D expenditure of government, whereas *less developed countries* have a R&D expenditure of government > R&D expenditure of business enterprise because of less dynamic industrial structure. As a matter of fact, if we consider the ratio public R&D expenditure –to– Private R&D expenditure, using arithmetic mean of countries over 1998-2005, econometric linear model shows that if GDP per capita increases of 1 percent, this ratio decreases of −0.012 (see table 3A and figure 1A in appendix). These results show that low Total R&D expenditures of government and high R&D expenditure of business enterprise are a necessary condition for countries to pursue high economic growth avenues in modern world wide economic system.

For instance, Italy even if is a developed country (it belongs to G7) has a composition of Public and Private R&D expenditures similar to developing countries (i.e. public R&D expenditures higher then private R&D ones). This wrong research policy applied by Italian

Governments of different coalitions has been producing low economic performances such as low productivity growth and Growth rate of GDP volume over time (see Table 1A).

In short, to achieve high levels of national productivity growth, the maximization of private R&D expenditures has to be a complement to the maximization of public R&D ones. A sustainable research policy strategy to increase economic growth should be based on R&D expenditures of business enterprise higher than government R&D expenditure to maximize long run productivity growth.

The governments realize that it is critical to be aware of the relative importance of different factors that might influence productivity growth. However, it is equally important for researchers to help government more acutely aware that the ultimate impact of any increase in spending on R&D depends critically upon complex, interwoven strings of causations which are not necessarily constant over time and across countries, because of globalization and turbulence of markets. In all, *this* empirical evidence suggests that the underlying political economy of growth that should be adopted to boost productivity gains in the long run and therefore competitive advantage of open economies seems simple at first glance, given a stable socio-economic-financial situation and low public debt: *raising both the long run R&D expenditure of business enterprise as percentage of the GDP at around 1.6%, and R&D expenditure of government and higher education sector at about 1% of GDP, ceteris paribus the stability of their economic systems.* The challenge for policy makers is how to ensure that such mix research policy strategy based on optimal magnitudes of public and private R&D expenditures (as % of GDP) are integrated in national political economy, considering country specificity, to maximize their long-run positive impact on modern economic growth patterns.

REFERENCES

Acemoglu D., Aghion P., Zilibotti F. (2006), “Distance to Frontier, Selection, and Economic Growth”, *Journal of the European Economic Association*, vol. 4, n. 1, pp. 37-74.

Aghion P., Howitt P. (1998), *Endogenous Growth Theory,* MIT Press, Cambridge, MA.

Amendola G., Dosi G., Papagni E. (1993), “The dynamics of international competitiveness”, *Review of World Economics*, vol. 129, n. 3, pp. 451-471.

Bartelsman E.J., Doms M. (2000), “Understanding Productivity: Lessons from Longitudinal Microdata”, *Journal of Economic Literature*, vol. 38, n. 3, pp. 569-594.

Benum E. (2007), “Making Research Count: Norway and the OECD Connection”, *Minerva*, pp. 365-387.

Borrás S. (2004), “Introduction to special issue on a European system of innovation”, *Science and Public Policy*, vol. 31, n. 6, pp. 422-424.

Brécard D., Fougeyrollas A., Le Mouël P., Lemiale L., Zagamé P. (2006), “Macro-economic consequences of European research policy: prospects of Nemesis model in the year 2030”, *Research Policy*, vol. 25, n. 7, pp. 910-924.

Cass D. (1965), “Optimum growth in an aggregative model of capital accumulation”, *The Review of Economic Studies,* vol. 32, n. 3, July, pp. 233-240.

Dinopoulos E., Thompson P. (1998), “Schumpeterian Growth without Scale Effects”, *Journal of Economic Growth*, vol. 3, n. 4, pp. 313-335.

Dodgson M., Bessan J. (1996), *Effective Innovation policy: a new approach,* International Thompson Business Press, London.

DTI (2006), *UK productivity and competitiveness indicators 2006,* Department of trade and industry, London, UK.

European Commission (2004), *The EU Economy 2004 Review* (European Economy n. 6), Luxembourg, Office for Official Publications of the EC.

Eurostat (2008), *Data set*, Brussels, Belgium.

Griffith R., Huergo E., Mairesse J., Peters B. (2006), “Innovation and productivity across four European countries”, *Oxford Review of Economic Policy,* vol. 22, n. 4, pp. 483-498.

Griffith R., Redding S., Van Reenen J. (2004), “Mapping the two Faces of R&D: Productivity growth in a Panel of OECD Industries”, *Review of Economics and Statistics*, vol. 86, n. 4, pp. 883-895.

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

Griliches Z. (1995), “R&D and Productivity: Econometric Results and Measurement Issues”, in P. Stoneman (Ed.), *Handbook of the Economics of Innovation and Technological Change*, Basil Blackwell, Oxford, pp. 52-89.

Grossman M., Helpman E. (1991), *Innovation and Growth in The Global Economy*, The MIT Press, Cambridge, Massachusetts & London, England.

Guellec D., Van Pottelsberghe de la Potterie B. (2004), “From R&D to Productivity Growth: Do the Institutional Setting and the Sources of Funds of R&D Matter?, *Oxford Bulletin of Economics and Statistics,* vol. 66, n. 3, pp. 353-378.

Ha J., Howitt P. (2007), “Accounting for Trends in Productivity and R&D: A Schumpeterian Critique of Semi-endogenous Growth Theory”, *Journal of Money, Credit and Banking*, vol. 39, n. 4, pp. 733-774.

Hall B.H. (1996), “The Private and Social Returns to Research and Development”, in B.L.R. Smith and C. Barfield, (Eds.), *Technology, R&D, and the Economy*, The Brookings and American Enterprise Institute, Washington, pp. 289-331.

Hall B.H., Mairesse J. (1995), “Exploring the Relationship between R&D and Productivity in French Manufacturing Firms”, *Journal Econometrics*, vol. 65, n. 1, pp. 263-293.

Heijs J., Herrera L., Nieto M. (2007), “Distribution an Effect of R&D Subsidies: A Comparative Analysis According to Firm Size”, DRUID Summer Conference: *Appropriability, Proximity, Routines and Innovation*, Frederiksberg, DK, June 18-20.

Hendry D.F., Richard J.F. (1982), “On the formulation of Empirical Models in Dynamic Econometrics”, *Journal of Econometrics*, vol. 20, n. 1, pp. 3-33.

Jones C.I. (1995), “R&D-based models of Economic Growth”, *Journal of Political Economy*, vol. 103, n. 4, pp. 759-784.

Jones C.I., Williams J.C. (1998), “Measuring The Social Return To R&D”, *The Quarterly Journal of Economics*, vol. 113, n. 4, pp. 1119-1135.

Keller W. (2002), “Trade and the Transmission of Technology”, *Journal of Economic Growth*, vol. 7, n. 1, pp. 5-24.

Lichtenberg F.R., Siegel D. (1991), “The Impact of R&D Investment on Productivity. New Evidence Using Linked R&D-LRD Data”, *Economic Inquiry*, vol. 29, n. 2, pp. 203-229.

Lichtenberg F.R., Van Pottelsberghe de la Potterie B. (1998), “International R&D Spillovers: A Comment”, *European Economic Review*, vol. 42, n. 8, pp. 1483-1491.

Machin S., Van Reenen J. (1998), “Technology and Changes in skill Structure: Evidence from Seven OECD Countries”, *The Quarterly of Economics*, vol. CXIII, n. 4, pp. 1215-1244.

Madsen J. (2007), “Are there diminishing returns to R&D?”, *Economics Letters*, vol. 95, n. 2, pp. 161-166.

Mayhew K., Neely A. (2006), “Improving productivity-opening the black box”, *Oxford Review of Economic Policy,* vol. 22, n. 4, pp. 445-456.

Poincaré H. (1935) *La science et l'hypothèse*, Paris: Ernest Flammarion Editeur.

Parisi M.L., Schiantarelli F., Sembenelli A. (2006), “Productivity, innovation and R&D: micro evidence from Italy”, *European Economic Review,* vol. 50, n. 8, pp. 2037-2061.

Porter M.E. (1990), *The competitive advantage of nations,* Billing & Sons, Ltd, Worcester.

Pouris A. (2007), “Estimating R&D Expenditures in the Higher Sector”, *Minerva*, vol. XLV, n. 1, pp. 3-16.

Romer P.M. (1990), “Endogenous technological change”, *Journal of Political Economy*, vol. 98, n. 5, pp. S71-S102.

Rudin W. (1991), *Principles of mathematical analysis,* Mc Graw-Hill, New York.

Sapir A., Aghion P., Bertola G., Helwig M., Pisani-Ferry J., Rosati D., Vinals J., Wallace H. (2004), *An Agenda for a Growing Europe: The Sapir Report*, Oxford, Oxford University Press.

Scherer F.M. (1992), *International High Technology Competition*, Harvard University Press, Cambridge.

Segerstrom P. (1998), "Endogenous growth without Scale Effects", *American Economic Review*, December, vol. 88, n. 5, pp. 1290-1310.

Solow R. (1956), "A contribution to the theory of economic growth", *Quarterly Journal of Economics,* vol. 70, n. 1, pp. 65-94.

Spanos A. (1986), *Statistical foundations of econometric modelling,* Cambridge University Press, Cambridge.

Steil B., Victor D.G., Nelson R.R. (2002), (Eds) *Technological Innovation and Economic Performance*, Princeton University Press, Princeton, Oxford.

Tassey G. (1997), *The economics of R&D policy,* Quorum books, Westport, CT.

Ulku H. (2007), "R&D, innovation and output: evidence from OECD and non OECD countries", *Applied Economics*, vol. 39, n. 3, pp. 291-307.

Van Ark B., O'Mahony M., Timmer M.P. (2008), "The productivity Gap between Europe and the United States: Trends and Causes", *Journal of Economic Perspectives*, vol. 22, n. 1, pp. 25-44.

Van Reenen J. (1997), "Why has Britain had slower R&D growth?", *Research Policy*, vol. 26, n. 4-5, pp. 493-507.

Vincent-Lancrin S. (2006), "What is changing in Academic Research: Trends and Futures Scenarios", European Journal of Education, vol. 41, n. 2, pp. 169-202.

Zachariadis M. (2003), "R&D, Innovation, and Technological Progress: A test of the Schumpeterian Framework without Scale Effects", *Canadian Journal of Economics*, vol. 36, n. 3, pp. 566-586.

Zachariadis M. (2004), "R&D-induced Growth in the OECD?", *Review of Development Economics,* vol. 8, n. 3, pp. 423-439.

APPENDIX A

TABLE 1A: ARITHMETIC MEAN OF VARIABLES PER COUNTRIES

Arithmetic mean

Country	*GDP per capita in PPS 1997-2004*	*R&D Expenditure: Business Enterprises 1998-2005*	*R&D Government and higher education sector 1998-2005*	*R&D Expenditure:* Business minus *Government and higher education expenditures*	*Labour productivity per hour worked 1999-2005*	*Growth rate of GDP volume 1997-2004*
Austria	130.9	1.41	0.69	0.72	99.5	2.2
Belgium	124.6	1.36	0.54	0.82	127.9	2.3
Cyprus	88.9	0.06	0.21	−0.15	68.2	3.6
Czech Republic	71.8	0.76	0.46	0.30	48.4	2.0
Denmark	129.6	1.59	0.75	0.85	102.7	1.9
Estonia	47.3	0.24	0.49	−0.25	39.3	7.2
EU (15 countries)	114.7	1.23	0.66	0.57	100.0	2.3
EU (25 countries)	104.7	1.19	0.65	0.54	91.0	2.5
EU (27 countries)	100.0	1.19	0.65	0.54	-	2.4
Euro area (12 countries)	113.6	1.18	0.66	0.51	102.6	2.2
Euro area (13 countries)	113.3	1.18	0.66	0.51	102.3	2.2
Finland	115.1	2.30	0.97	1.33	95.4	3.7
France	114.9	1.36	0.78	0.58	117.3	2.4
Germany	119.5	1.71	0.75	0.96	109.7	1.4
Greece	79.1	0.19	0.43	−0.24	68.6	4.2
Hungary	57.9	0.34	0.47	−0.13	50.6	4.6
Iceland	133.6	1.41	1.20	0.21	84.6	4.2
Ireland	131.1	0.81	0.37	0.45	115.0	7.6
Italy	115.6	0.53	0.55	−0.02	96.0	1.5
Japan	117.0	2.26	0.74	1.52	-	0.9
Latvia	39.1	0.15	0.28	−0.13	32.2	6.7
Lithuania	42.9	0.12	0.53	−0.42	39.4	6.2
Luxembourg	236.7	1.45	0.17	1.28	154.3	5.1
Malta	80.0	0.26	0.19	0.07	76.1	0.2
The Netherlands	131.5	1.04	0.71	0.33	117.8	2.7
Norway	154.6	0.92	0.71	0.22	141.6	2.7
Poland	48.6	0.20	0.40	−0.20	43.7	4.1
Portugal	77.2	0.23	0.44	−0.21	58.7	2.6
Romania	29.0	0.26	0.14	0.13	-	4.2
Slovakia	53.2	0.37	0.24	0.13	52.3	3.4
Slovenia	78.9	0.85	0.55	0.30	64.0	3.9
Spain	98.2	0.52	0.45	0.08	89.4	3.9
Sweden	121.7	2.92	0.93	1.99	101.2	3.0
Switzerland	143.1	2.03	0.66	1.37	101.0	1.7
The United Kingdom	118.2	1.18	0.59	0.59	88.8	3.0
USA	156.8	1.93	0.64	1.29	113.4	3.2

Source: Eurostat (2008)

TABLE 2A: STATISTICS OF COUNTRIES PER LEVEL OF GDP PER CAPITA

Level of GDP per capita	*Variables*	*Mean Statistic*	*Std. Deviation Statistic*
HIGH	GDP per capita in PPS 1997-2004	125.89	18.68
	Labour productivity per hour worked 1999-2005	107.94	13.80
	Growth rate of GDP volume 1997-2004	3.09	2.18
	R&D Expenditure Business Enterprise 1998-2005	1.39	0.41
	R&D Government and higher education 1998-2005	0.70	0.19
	Valid N (list wise)	84	
MEDIUM	GDP per capita in PPS 1997-2004	82.28	9.68
	Labour productivity per hour worked 1999-2005	66.58	13.76
	Growth rate of GDP volume 1997-2004	3.21	1.73
	R&D Expenditure Business Enterprise 1998-2005	0.44	0.30
	R&D Government and higher education 1998-2005	0.42	0.13
	Valid N (list wise)	36	
LOW	GDP per capita in PPS 1997-2004	47.98	7.32
	Labour productivity per hour worked 1999-2005	43.75	7.74
	Growth rate of GDP volume 1997-2004	4.77	2.69
	R&D Expenditure Business Enterprise 1998-2005	0.25	0.11
	R&D Government and higher education 1998-2005	0.39	0.12
	Valid N (list wise)	37	

TABLE 3A: PARAMETRIC ESTIMATIONS OF MODEL

		Estimated relationship			
$k_i=$	*2.25****	$-0.012y_i$***	R^2 *adj. = 27.3%*	F = 13.79 (sig. 0.001)	*N=35*
	(0.367)	(0.003)	*S= (0.798)*		

*** Parameter is Significant at 0.001 level

Notes: The second column is the estimate of the constant and of β_i. Underneath them, in parentheses, their standard error. The third column has adjusted R^2 of the regression and below it, the standard error of the regression. In the last column the *F* test and its significance level.

k_i = R&D Expenditure of Government and Higher Education as percentage of GDP − (*minus*) R&D Expenditure of Business enterprises as percentage of GDP, arithmetic mean over 1998-2005 period

y_i = GDP per capita in PPS, arithmetic mean over 1997-2004 period

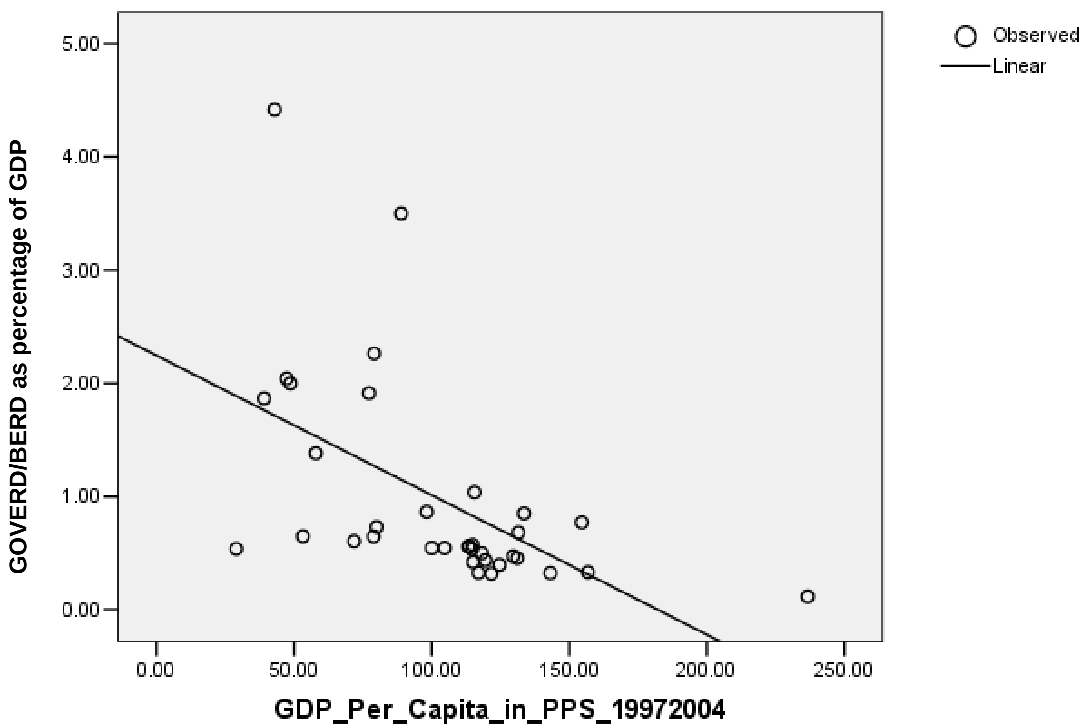

FIGURE 1A: REGRESSION OF R&D EXPENDITURE OF GOVERNMENT AND HIGHER EDUCATION SECTOR AS PERCENTAGE OF GDP (GOVERD) – TO – R&D EXPENDITURE OF BUSINESS ENTERPRISE (BERD) RATIO ON GDP PER CAPITA IN PPS

WORKING PAPER SERIES (2008-1993)

2008

1/08 *Nouveaux instruments d'évaluation pour le risque financier d'entreprise*, by Greta Falavigna

2/08 *Drivers of regional efficiency differentials in Italy: technical inefficiency or allocative distortions?,* by Fabrizio Erbetta and Carmelo Petraglia

3/08 *Modelling and measuring the effects of public subsidies on business R&D: theoretical and econometric issues,* by Giovanni Cerulli

4/08 *Investimento pubblico e privato in R&S: effetto di complementarietà o di sostituzione?*, by Mario Coccia

5/08 *How should be the levels of public and private R&D investments to trigger modern productivity growth? Empirical evidence and lessons learned for italian economy*, by Mario Coccia

6/08 *Democratization is the determinant of technological change,* by Mario Coccia

7/08 *Produttività, progresso tecnico ed efficienza nei paesi OCSE*, by Alessandro Manello

8/08 *Best performance-best practice nelle imprese manifatturiere italiane*, by Giuseppe Calabrese

9/08 *Evaluating the effect of public subsidies on firm R&D activity: an application to Italy using the community innovation survey*, Giovanni Cerulli and Bianca Potì

10/08 *La responsabilité sociale, est-elle une variable influençant les performances d'entreprise?*, by Greta Falavigna

2007

1/07 *Macchine, lavoro e accrescimento della ricchezza: Riflessioni sul progresso tecnico, occupazione e sviluppo economico nel pensiero economico del Settecento e Ottocento*, by Mario Coccia

2/07 *Quali sono i fattori determinanti della moderna crescita economica?Analisi comparativa delle performance dei paesi*, by Mario Coccia

3/07 *Hospital Industry Restructuring and Input Substitutability: Evidence from a Sample of Italian Hospitals*, by Massimiliano Piacenza, Gilberto Turati and Davide Vannoni

4/07 *Il finanziamento pubblico alla ricerca spiazza l'investimento privato in ricerca? Analisi ed implicazioni per la crescita economica dei paesi*, by Mario Coccia

5/07 *Quanto e come investire in ricerca per massimizzare la crescita economica? Analisi e implicazioni di politica economica per l'Italia e l'Europa*, by Mario Coccia

6/07 *Heterogeneity of innovation strategies and firms' performance*, by Giovanni Cerulli and Bianca Potì

7/07 *The role of R/D expenditure: a critical comparison of the two (R&S and CIS) sources of data*, by Bianca Potì, Emanuela Reale and Monica Di Fiore

8/07 *Sviluppo locale e leadership. Una proposta metodologica*, by Erica Rizziato

9/07 *Government R&D funding: new approaches in the allocation policies for public and private beneficiaries*, by Bianca Potì and Emanuela Reale

10/07 *Coopération et gouvernance dans deux districts en transition*, by Ariel Mendez and Elena Ragazzi

11/07 *Measuring Intersectoral Knowledge Spillovers: an Application of Sensitivity Analysis to Italy*, by Giovanni Cerulli and Bianca Potì

2006

1/06 *Analisi della crescita economica regionale e convergenza: un nuovo approccio teorico ed evidenza empirica sull'Italia*, by Mario Coccia

2/06 *Classifications of innovations: Survey and future directions*, by Mario Coccia

3/06 *Analisi economica dell'impatto tecnologico*, by Mario Coccia

4/06 *La burocrazia nella ricerca pubblica.* PARTE I *Una rassegna dei principali studi*, by Mario Coccia and Alessandro Gobbino

5/06 *La burocrazia nella ricerca pubblica.* PARTE II *Analisi della burocrazia negli Enti Pubblici di Ricerca*, by Mario Coccia and Alessandro Gobbino

6/06 *La burocrazia nella ricerca pubblica.* PARTE III *Organizzazione e Project Management negli Enti Pubblici di Ricerca: l'analisi del CNR*, by Mario Coccia, Secondo Rolfo and Alessandro Gobbino

7/06 *Economic and social studies of scientific research: nature and origins*, by Mario Coccia

8/06 *Shareholder Protection and the Cost of Capital: Empirical Evidence from German and Italian Firms*, by Julie Ann Elston and Laura Rondi

9/06 *Réflexions en thème de district, clusters, réseaux: le problème de la gouvernance*, by Secondo Rolfo

10/06 *Models for Default Risk Analysis: Focus on Artificial Neural Networks, Model Comparisons, Hybrid Frameworks*, by Greta Falavigna

11/06 *Le politiche del governo federale statunitense nell'edilizia residenziale. Suggerimenti per il modello italiano*, by Davide Michelis

12/06 *Il finanziamento delle imprese Spin-off: un confronto fra Italia e Regno Unito*, by Elisa Salvador

13/06 SERIE SPECIALE IN COLLABORAZIONE CON HERMES: *Regulatory and Environmental Effects on Public Transit Efficiency: a Mixed DEA-SFA Approach*, by Beniamina Buzzo Margari, Fabrizio Erbetta, Carmelo Petraglia, Massimiliano Piacenza

14/06 *La mission manageriale: risorsa delle aziende*, by Gian Franco Corio

15/06 *Peer review for the evaluation of the academic research: the Italian experience*, by Emanuela Reale, Anna Barbara, Antonio Costantini

2005

1/05 *Gli approcci biologici nell'economia dell'innovazione*, by Mario Coccia

2/05 *Sistema informativo sulle strutture operanti nel settore delle biotecnologie in Italia*, by Edoardo Lorenzetti, Francesco Lutman, Mauro Mallone

3/05 *Analysis of the Resource Concentration on Size and Research Performance. The Case of Italian National Research Council over the Period 2000-2004*, by Mario Coccia and Secondo Rolfo

4/05 *Le risorse pubbliche per la ricerca scientifica e lo sviluppo sperimentale nel 2002*, by Anna Maria Scarda

5/05 *La customer satisfaction dell'URP del Cnr. I casi Lazio, Piemonte e Sicilia*, by Gian Franco Corio

6/05 *La comunicazione integrata tra uffici per le relazioni con il pubblico della Pubblica Amministrazione*, by Gian Franco Corio

7/05 *Un'analisi teorica sul marketing territoriale. Presentazione di un caso studio. Il "consorzio per la tutela dell'Asti"*, by Maria Marenna

8/05 *Una proposta di marketing territoriale: una possibile griglia di analisi delle risorse*, by Gian Franco Corio

9/05 *Analisi e valutazione delle performance economico-tecnologiche di diversi paesi e situazione italiana*, by Mario Coccia and Mario Taretto

10/05 *The patenting regime in the Italian public research system: what motivates public inventors to patent,* by Bianca Potì and Emanuela Reale

11/05 *Changing patterns in the steering of the University in Italy: funding rules and doctoral programmes,* by Bianca Potì and Emanuela Reale

12/05 *Una "discussione in rete" con Stanley Wilder*, by Carla Basili

13/05 *New Tools for the Governance of the Academic Research in Italy: the Role of Research Evaluation*, by Bianca Potì and Emanuela Reale

14/05 *Product Differentiation, Industry Concentration and Market Share Turbulence***,** by Catherine Matraves, Laura Rondi

15/05 *Riforme del Servizio Sanitario Nazionale e dinamica dell'efficienza ospedaliera in Piemonte*, by Chiara Canta, Massimiliano Piacenza, Gilberto Turati

16/05 SERIE SPECIALE IN COLLABORAZIONE CON HERMES: *Struttura di costo e rendimenti di scala nelle imprese di trasporto pubblico locale di medie-grandi dimensioni*, by Carlo Cambini, Ivana Paniccia, Massimiliano Piacenza, Davide Vannoni

17/05 *Ricerc@.it - Sistema informativo su istituzioni, enti e strutture di ricerca in Italia*, by Edoardo Lorenzetti, Alberto Paparello

2004

1/04 *Le origini dell'economia dell'innovazione: il contributo di Rae*, by Mario Coccia

2/04 *Liberalizzazione e integrazione verticale delle utility elettriche: evidenza empirica da un campione italiano di imprese pubbliche locali*, by Massimiliano Piacenza and Elena Beccio

3/04 *Uno studio sull'innovazione nell'industria chimica*, by Anna Ceci, Mario De Marchi, Maurizio Rocchi

4/04 *Labour market rigidity and firms' R&D strategies*, by Mario De Marchi and Maurizio Rocchi

5/04 *Analisi della tecnologia e approcci alla sua misurazione*, by Mario Coccia

6/04 *Analisi delle strutture pubbliche di ricerca scientifica: tassonomia e comportamento strategico*, by Mario Coccia

7/04 *Ricerca teorica vs. ricerca applicata. Un'analisi relativa al Cnr*, by Mario Coccia and Secondo Rolfo

8/04 *Considerazioni teoriche sulla diffusione delle innovazioni nei distretti industriali: il caso delle ICT*, by Arianna Miglietta

9/04 *Le politiche industriali regionali nel Regno Unito*, by Elisa Salvador

10/04 *Going public to grow? Evidence from a panel of Italian firms*, by Robert E. Carpenter and L. Rondi

11/04 *What Drives Market Prices in the Wine Industry? Estimation of a Hedonic Model for Italian Premium Wine*, by Luigi Benfratello, Massimiliano Piacenza and Stefano Sacchetto

12/04 *Brief notes on the policies for science-based firms*, by Mario De Marchi, Maurizio Rocchi
13/04 *Countrymetrics e valutazione della performance economica dei paesi: un approccio sistemico*, by Mario Coccia
14/04 *Analisi del rischio paese e sistemazione tassonomica*, by Mario Coccia
15/04 *Organizing the Offices for Technology Transfer*, by Chiara Franzoni
16/04 *Le relazioni tra ricerca pubblica e industria in Italia*, by Secondo Rolfo
17/04 *Modelli di analisi e previsione del rischio di insolvenza: una prospettiva delle metodologie applicate*, by Nadia D'Annunzio e Greta Falavigna
18/04 *SERIE SPECIALE: Lo stato di salute del sistema industriale piemontese: analisi economico-finanziaria delle imprese piemontesi*, Terzo Rapporto 1999-2002, by Giuseppe Calabrese, Fabrizio Erbetta, Federico Bruno Rolle
19/04 *SERIE SPECIALE: Osservatorio sulla dinamica economico-finanziaria delle imprese della filiera del tessile e dell'abbigliamento in Piemonte*, Primo rapporto 1999-2002, by Giuseppe Calabrese, Fabrizio Erbetta, Federico Bruno Rolle
20/04 *SERIE SPECIALE: Osservatorio sulla dinamica economico-finanziaria delle imprese della filiera dell'auto in Piemonte,* Secondo Rapporto 1999-2002, by Giuseppe Calabrese, Fabrizio Erbetta, Federico Bruno Rolle

2003

1/03 *Models for Measuring the Research Performance and Management of the Public Labs,* by Mario Coccia, March
2/03 *An Approach to the Measurement of Technological Change Based on the Intensity of Innovation,* by Mario Coccia, April
3/03 *Verso una patente europea dell'informazione: il progetto EnIL*, by Carla Basili, June
4/03 *Scala della magnitudo innovativa per misurare l'attrazione spaziale del trasferimento tecnologico,* by Mario Coccia, June
5/03 *Mappe cognitive per analizzare i processi di creazione e diffusione della conoscenza negli Istituti di ricerca*, by Emanuele Cadario, July
6/03 *Il servizio postale: caratteristiche di mercato e possibilità di liberalizzazione*, by Daniela Boetti, July
7/03 *Donne-scienza-tecnologia: analisi di un caso di studio*, by Anita Calcatelli, Mario Coccia, Katia Ferraris and Ivana Tagliafico, July
8/03 SERIE SPECIALE. OSSERVATORIO SULLE PICCOLE IMPRESE INNOVATIVE TRIESTE. *Imprese innovative in Friuli Venezia Giulia: un esperimento di analisi congiunta*, by Lucia Rotaris, July
9/03 *Regional Industrial Policies in Germany*, by Helmut Karl, Antje Möller and Rüdiger Wink, July
10/03 SERIE SPECIALE. OSSERVATORIO SULLE PICCOLE IMPRESE INNOVATIVE TRIESTE. *L'innovazione nelle new technology-based firms in Friuli-Venezia Giulia*, by Paola Guerra, October
11/03 SERIE SPECIALE. *Lo stato di salute del sistema industriale piemontese: analisi economico-finanziaria delle imprese piemontesi,* Secondo Rapporto 1998-2001, December
12/03 SERIE SPECIALE. *Osservatorio sulla dinamica economico-finanziaria delle imprese della meccanica specializzata in Piemonte*, Primo Rapporto 1998-2001, December
13/03 SERIE SPECIALE. *Osservatorio sulla dinamica economico-finanziaria delle imprese delle bevande in Piemonte*, Primo Rapporto 1998-2001, December

2002

1/02 *La valutazione dell'intensità del cambiamento tecnologico: la scala Mercalli per le innovazioni*, by Mario Coccia, January
2/02 SERIE SPECIALE IN COLLABORAZIONE CON HERMES. *Regulatory constraints and cost efficiency of the Italian public transit systems: an exploratory stochastic frontier model*, by Massimiliano Piacenza, March
3/02 *Aspetti gestionali e analisi dell'efficienza nel settore della distribuzione del gas*, by Giovanni Fraquelli and Fabrizio Erbetta, March
4/02 *Dinamica e comportamento spaziale del trasferimento tecnologico*, by Mario Coccia, April
5/02 *Dimensione organizzativa e performance della ricerca: l'analisi del Consiglio Nazionale delle Ricerche*, by Mario Coccia and Secondo Rolfo, April
6/02 *Analisi di un sistema innovativo regionale e implicazioni di policy nel processo di trasferimento tecnologico,* by Monica Cariola and Mario Coccia, April
7/02 *Analisi psico-economica di un'organizzazione scientifica e implicazioni di management: l'Istituto Elettrotecnico Nazionale "G. Ferraris"*, by Mario Coccia and Alessandra Monticone, April
8/02 *Firm Diversification in the European Union. New Insights on Return to Core Business and Relatedness*, by Laura Rondi and Davide Vannoni, May
9/02 *Le nuove tecnologie di informazione e comunicazione nelle PMI: un'analisi sulla diffusione dei siti internet nel distretto di Biella,* by Simona Salinari, June
10/02 *La valutazione della soddisfazione di operatori di aziende sanitarie,* by Gian Franco Corio, November
11/02 *Analisi del processo innovativo nelle PMI italiane*, by Giuseppe Calabrese, Mario Coccia and Secondo Rolfo, November

12/02 *Metrics della Performance dei laboratori pubblici di ricerca e comportamento strategico*, by Mario Coccia, September

13/02 *Technometrics basata sull'impatto economico del cambiamento tecnologico*, by Mario Coccia, November

2001

1/01 *Competitività e divari di efficienza nell'industria italiana*, by Giovanni Fraquelli, Piercarlo Frigero and Fulvio Sugliano, January

2/01 *Waste water purification in Italy: costs and structure of the technology*, by Giovanni Fraquelli and Roberto Giandrone, January

3/01 SERIE SPECIALE IN COLLABORAZIONE CON HERMES. *Il trasporto pubblico locale in Italia: variabili esplicative dei divari di costo tra le imprese*, by Giovanni Fraquelli, Massimiliano Piacenza and Graziano Abrate, February

4/01 *Relatedness, Coherence, and Coherence Dynamics: Empirical Evidence from Italian Manufacturing*, by Stefano Valvano and Davide Vannoni, February

5/01 *Il nuovo panel Ceris su dati di impresa 1977-1997*, by Luigi Benfratello, Diego Margon, Laura Rondi, Alessandro Sembenelli, Davide Vannoni, Silvana Zelli, Maria Zittino, October

6/01 *SMEs and innovation: the role of the industrial policy in Italy*, by Giuseppe Calabrese and Secondo Rolfo, May

7/01 *Le martingale: aspetti teorici ed applicativi*, by Fabrizio Erbetta and Luca Agnello, September

8/01 *Prime valutazioni qualitative sulle politiche per la R&S in alcune regioni italiane*, by Elisa Salvador, October

9/01 *Accords technology transfer-based: théorie et méthodologie d'analyse du processus, by Mario Coccia,* October

10/01 *Trasferimento tecnologico: indicatori spaziali*, by Mario Coccia, November

11/01 *Does the run-up of privatisation work as an effective incentive mechanism? Preliminary findings from a sample of Italian firms*, by Fabrizio Erbetta, October

12/01 SERIE SPECIALE IN COLLABORAZIONE CON HERMES. *Costs and Technology of Public Transit Systems in Italy: Some Insights to Face Inefficiency*, by Giovanni Fraquelli, Massimiliano Piacenza and Graziano Abrate, October

13/01 *Le NTBFs a Sophia Antipolis, analisi di un campione di imprese*, by Alessandra Ressico, December

2000

1/00 *Trasferimento tecnologico: analisi spaziale,* by Mario Coccia, March

2/00 *Poli produttivi e sviluppo locale: una indagine sulle tecnologie alimentari nel mezzogiorno,* by Francesco G. Leone, March

3/00 *La mission del top management di aziende sanitarie,* by Gian Franco Corio, March

4/00 *La percezione dei fattori di qualità in Istituti di ricerca: una prima elaborazione del caso Piemonte,* by Gian Franco Corio, March

5/00 *Una metodologia per misurare la performance endogena nelle strutture di R&S,* by Mario Coccia, April

6/00 *Soddisfazione, coinvolgimento lavorativo e performance della ricerca,* by Mario Coccia, May

7/00 *Foreign Direct Investment and Trade in the EU: Are They Complementary or Substitute in Business Cycles Fluctuations?*, by Giovanna Segre, April

8/00 *L'attesa della privatizzazione: una minaccia credibile per il manager?*, by Giovanni Fraquelli, May

9/00 *Gli effetti occupazionali dell'innovazione. Verifica su un campione di imprese manifatturiere italiane*, by Marina Di Giacomo, May

10/00 *Investment, Cash Flow and Managerial Discretion in State-owned Firms. Evidence Across Soft and Hard Budget Constraints*, by Elisabetta Bertero and Laura Rondi, June

11/00 *Effetti delle fusioni e acquisizioni: una rassegna critica dell'evidenza empirica*, by Luigi Benfratello, June

12/00 *Identità e immagine organizzativa negli Istituti CNR del Piemonte*, by Paolo Enria, August

13/00 *Multinational Firms in Italy: Trends in the Manufacturing Sector*, by Giovanna Segre, September

14/00 *Italian Corporate Governance, Investment, and Finance*, by Robert E. Carpenter and Laura Rondi, October

15/00 *Multinational Strategies and Outward-Processing Trade between Italy and the CEECs: The Case of Textile-Clothing*, by Giovanni Balcet and Giampaolo Vitali, December

16/00 *The Public Transit Systems in Italy: A Critical Analysis of the Regulatory Framework*, by Massimiliano Piacenza, December

1999

1/99 *La valutazione delle politiche locali per l'innovazione: il caso dei Centri Servizi in Italia,* by Monica Cariola and Secondo Rolfo, January

2/99 *Trasferimento tecnologico ed autofinanziamento: il caso degli Istituti Cnr in Piemonte,* by Mario Coccia, March

3/99 *Empirical studies of vertical integration: the transaction cost orthodoxy,* by Davide Vannoni, March

4/99 *Developing innovation in small-medium suppliers: evidence from the Italian car industry,* by Giuseppe Calabrese, April

5/99 *Privatization in Italy: an analysis of factors productivity and technical efficiency,* by Giovanni Fraquelli and Fabrizio Erbetta, March

6/99 *New Technology Based-Firms in Italia: analisi di un campione di imprese triestine,* by Anna Maria Gimigliano, April

7/99 *Trasferimento tacito della conoscenza: gli Istituti CNR dell'Area di Ricerca di Torino,* by Mario Coccia, May

8/99 *Struttura ed evoluzione di un distretto industriale piemontese: la produzione di casalinghi nel Cusio,* by Alessandra Ressico, June

9/99 *Analisi sistemica della performance nelle strutture di ricerca,* by Mario Coccia, September

10/99 *The entry mode choice of EU leading companies (1987-1997),* by Giampaolo Vitali, November

11/99 *Esperimenti di trasferimento tecnologico alle piccole e medie imprese nella Regione Piemonte,* by Mario Coccia, November

12/99 *A mathematical model for performance evaluation in the R&D laboratories: theory and application in Italy,* by Mario Coccia, November

13/99 *Trasferimento tecnologico: analisi dei fruitori,* by Mario Coccia, December

14/99 *Beyond profitability: effects of acquisitions on technical efficiency and productivity in the Italian pasta industry,* by Luigi Benfratello, December

15/99 *Determinanti ed effetti delle fusioni e acquisizioni: un'analisi sulla base delle notifiche alle autorità antitrust,* by Luigi Benfratello, December

1998

1/98 *Alcune riflessioni preliminari sul mercato degli strumenti multimediali,* by Paolo Vaglio, January

2/98 *Before and after privatization: a comparison between competitive firms,* by Giovanni Fraquelli and Paola Fabbri, January

3/98 **Not available**

4/98 *Le importazioni come incentivo alla concorrenza: l'evidenza empirica internazionale e il caso del mercato unico europeo,* by Anna Bottasso, May

5/98 *SEM and the changing structure of EU Manufacturing, 1987-1993,* by Stephen Davies, Laura Rondi and Alessandro Sembenelli, November

6/98 *The diversified firm: non formal theories versus formal models,* by Davide Vannoni, December

7/98 *Managerial discretion and investment decisions of state-owned firms: evidence from a panel of Italian companies,* by Elisabetta Bertero and Laura Rondi, December

8/98 *La valutazione della R&S in Italia: rassegna delle esperienze del C.N.R. e proposta di un approccio alternativo,* by Domiziano Boschi, December

9/98 *Multidimensional Performance in Telecommunications, Regulation and Competition: Analysing the European Major Players,* by Giovanni Fraquelli and Davide Vannoni, December

1997

1/97 *Multinationality, diversification and firm size. An empirical analysis of Europe's leading firms,* by Stephen Davies, Laura Rondi and Alessandro Sembenelli, January

2/97 *Qualità totale e organizzazione del lavoro nelle aziende sanitarie,* by Gian Franco Corio, January

3/97 *Reorganising the product and process development in Fiat Auto,* by Giuseppe Calabrese, February

4/97 *Buyer-supplier best practices in product development: evidence from car industry,* by Giuseppe Calabrese, April

5/97 *L'innovazione nei distretti industriali. Una rassegna ragionata della letteratura,* by Elena Ragazzi, April

6/97 *The impact of financing constraints on markups: theory and evidence from Italian firm level data,* by Anna Bottasso, Marzio Galeotti and Alessandro Sembenelli, April

7/97 *Capacità competitiva e evoluzione strutturale dei settori di specializzazione: il caso delle macchine per confezionamento e imballaggio,* by Secondo Rolfo, Paolo Vaglio, April

8/97 *Tecnologia e produttività delle aziende elettriche municipalizzate,* by Giovanni Fraquelli and Piercarlo Frigero, April

9/97 *La normativa nazionale e regionale per l'innovazione e la qualità nelle piccole e medie imprese: leggi, risorse, risultati e nuovi strumenti,* by Giuseppe Calabrese, June

10/97 *European integration and leading firms' entry and exit strategies,* by Steve Davies, Laura Rondi and Alessandro Sembenelli, April

11/97 *Does debt discipline state-owned firms? Evidence from a panel of Italian firms,* by Elisabetta Bertero and Laura Rondi, July

12/97 *Distretti industriali e innovazione: i limiti dei sistemi tecnologici locali,* by Secondo Rolfo and Giampaolo Vitali, July

13/97 *Costs, technology and ownership form of natural gas distribution in Italy,* by Giovanni Fraquelli and Roberto Giandrone, July

14/97 *Costs and structure of technology in the Italian water industry,* by Paola Fabbri and Giovanni Fraquelli, July

15/97 *Aspetti e misure della customer satisfaction/dissatisfaction,* by Maria Teresa Morana, July

16/97 *La qualità nei servizi pubblici: limiti della normativa UNI EN 29000 nel settore sanitario,* by Efisio Ibba, July

17/97 *Investimenti, fattori finanziari e ciclo economico,* by Laura Rondi and Alessandro Sembenelli, rivisto sett. 1998

18/97 *Strategie di crescita esterna delle imprese leader in Europa: risultati preliminari dell'utilizzo del data-base Ceris "100 top EU firms' acquisition/divestment database 1987-1993",* by Giampaolo Vitali and Marco Orecchia, December

19/97 *Struttura e attività dei Centri Servizi all'innovazione: vantaggi e limiti dell'esperienza italiana,* by Monica Cariola, December

20/97 *Il comportamento ciclico dei margini di profitto in presenza di mercati del capitale meno che perfetti: un'analisi empirica su dati di impresa in Italia,* by Anna Bottasso, December

1996

1/96 *Aspetti e misure della produttività. Un'analisi statistica su tre aziende elettriche europee,* by Donatella Cangialosi, February

2/96 *L'analisi e la valutazione della soddisfazione degli utenti interni: un'applicazione nell'ambito dei servizi sanitari,* by Maria Teresa Morana, February

3/96 *La funzione di costo nel servizio idrico. Un contributo al dibattito sul metodo normalizzato per la determinazione della tariffa del servizio idrico integrato,* by Giovanni Fraquelli and Paola Fabbri, February

4/96 *Coerenza d'impresa e diversificazione settoriale: un'applicazione alle società leaders nell'industria manifatturiera europea,* by Marco Orecchia, February

5/96 *Privatizzazioni: meccanismi di collocamento e assetti proprietari. Il caso STET,* by Paola Fabbri, February

6/96 *I nuovi scenari competitivi nell'industria delle telecomunicazioni: le principali esperienze internazionali,* by Paola Fabbri, February

7/96 *Accordi, joint-venture e investimenti diretti dell'industria italiana nella CSI: Un'analisi qualitativa,* by Chiara Monti and Giampaolo Vitali, February

8/96 *Verso la riconversione di settori utilizzatori di amianto. Risultati di un'indagine sul campo,* by Marisa Gerbi Sethi, Salvatore Marino and Maria Zittino, February

9/96 *Innovazione tecnologica e competitività internazionale: quale futuro per i distretti e le economie locali,* by Secondo Rolfo, March

10/96 *Dati disaggregati e analisi della struttura industriale: la matrice europea delle quote di mercato,* by Laura Rondi, March

11/96 *Le decisioni di entrata e di uscita: evidenze empiriche sui maggiori gruppi italiani,* by Alessandro Sembenelli and Davide Vannoni, April

12/96 *Le direttrici della diversificazione nella grande industria italiana,* by Davide Vannoni, April

13/96 *R&S cooperativa e non-cooperativa in un duopolio misto con spillovers,* by Marco Orecchia, May

14/96 *Unità di studio sulle strategie di crescita esterna delle imprese italiane*, by Giampaolo Vitali and Maria Zittino, July. **Not available**

15/96 *Uno strumento di politica per l'innovazione: la prospezione tecnologica,* by Secondo Rolfo, September

16/96 *L'introduzione della Qualità Totale in aziende ospedaliere: aspettative ed opinioni del middle management,* by Gian Franco Corio, September

17/96 *Shareholders' voting power and block transaction premia: an empirical analysis of Italian listed companies,* by Giovanna Nicodano and Alessandro Sembenelli, November

18/96 *La valutazione dell'impatto delle politiche tecnologiche: un'analisi classificatoria e una rassegna di alcune esperienze europee,* by Domiziano Boschi, November

19/96 *L'industria orafa italiana: lo sviluppo del settore punta sulle esportazioni,* by Anna Maria Gaibisso and Elena Ragazzi, November

20/96 *La centralità dell'innovazione nell'intervento pubblico nazionale e regionale in Germania,* by Secondo Rolfo, December

21/96 *Ricerca, innovazione e mercato: la nuova politica del Regno Unito,* by Secondo Rolfo, December

22/96 *Politiche per l'innovazione in Francia,* by Elena Ragazzi, December

23/96 *La relazione tra struttura finanziaria e decisioni reali delle imprese: una rassegna critica dell'evidenza empirica,* by Anna Bottasso, December

1995

1/95 *Form of ownership and financial constraints: panel data evidence on leverage and investment choices by Italian firms,* by Fabio Schiantarelli and Alessandro Sembenelli, March

2/95 *Regulation of the electric supply industry in Italy,* by Giovanni Fraquelli and Elena Ragazzi, March

3/95 *Restructuring product development and production networks: Fiat Auto,* by Giuseppe Calabrese, September

4/95 *Explaining corporate structure: the MD matrix, product differentiation and size of market,* by Stephen Davies, Laura Rondi and Alessandro Sembenelli, November

5/95 *Regulation and total productivity performance in electricity: a comparison between Italy, Germany and France,* by Giovanni Fraquelli and Davide Vannoni, December
6/95 *Strategie di crescita esterna nel sistema bancario italiano: un'analisi empirica 1987-1994,* by Stefano Olivero and Giampaolo Vitali, December
7/95 *Panel Ceris su dati di impresa: aspetti metodologici e istruzioni per l'uso,* by Diego Margon, Alessandro Sembenelli and Davide Vannoni, December

1994

1/94 *Una politica industriale per gli investimenti esteri in Italia: alcune riflessioni,* by Giampaolo Vitali, May
2/94 *Scelte cooperative in attività di ricerca e sviluppo,* by Marco Orecchia, May
3/94 *Perché le matrici intersettoriali per misurare l'integrazione verticale?,* by Davide Vannoni, July
4/94 *Fiat Auto: A simultaneous engineering experience,* by Giuseppe Calabrese, August

1993

1/93 *Spanish machine tool industry,* by Giuseppe Calabrese, November
2/93 *The machine tool industry in Japan,* by Giampaolo Vitali, November
3/93 *The UK machine tool industry,* by Alessandro Sembenelli and Paul Simpson, November
4/93 *The Italian machine tool industry,* by Secondo Rolfo, November
5/93 *Firms' financial and real responses to business cycle shocks and monetary tightening: evidence for large and small Italian companies,* by Laura Rondi, Brian Sack, Fabio Schiantarelli and Alessandro Sembenelli, December

Free copies are distributed on request to Universities, Research Institutes, researchers, students, etc.
Please, write to:
MARIA ZITTINO, Working Papers Coordinator
CERIS-CNR, Via Real Collegio, 30; 10024 Moncalieri (Torino), Italy
Tel. +39 011 6824.914; Fax +39 011 6824.966; m.zittino@ceris.cnr.it; http://www.ceris.cnr.it