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Summary : In this paper, we investigate the relationship between private and public investment in R&D. Various models proposed in the literature to take account for several instruments policies as: (subsidies, taxes…) are estimated to verify if private and public R&D spending are complement or substitute.

Our empirical study is based on a dynamic panel model for a sample of (23) countries over the period 1992-2004. This research is dealing with the relationship between private and public investment in R&D. Results based on the GMM method of Arellano and Bond (1991) and the tests of causality and unit root applied to the panel data show a positive and significant relation between private and public R&D.

Keywords: R&D, Complementarity, Substituability, GMM, Dynamic Panel Data.

JEL Classification: C33, O32, O33

I. Introduction

The object of this paper is to give the theoretical and empirical arguments which allow a satisfactory apprehension of the role that the authorities must play in the fields of research and innovation. The activity of R&D represents a significant source of development of new knowledge and technological innovation[1]. The effort towards activity of R&D involves with a great importance and this through several resources devoted to the various sectors and institutions of research. Expenditure of research and development especially constitute a principal source of growth of productivity for innovating countries. Whereas, for countries, where the activity of R&D misses almost technological knowledge and innovations of which they profit are generally resulting from the importation of equipment and goods of intensives investments in technical progress.

There are less works, the object of which is to study the relation between private and public investment in R&D. We propose a model based on the study of this relation through several indicators. The principal message to retrain from results of this work is that sometimes public investment have been just added to private investment and sometimes have just replaced them and tend to exert and effect of crowding out. The governmental policies can contribute to growth. For these reasons, a policy of innovation must be designed so that the State orders its actions according to a hierarchy of responsibilities. Therefore, it is necessary that government must make a favourable environment for innovation and support of the companies in incentive to be innovated because the company itself constitutes a significant factor of innovation and the resources of the latter are varied such as the R&D or the acquisition of technology.

The policies in favour of the R&D and the innovation changed orientation in the industrialized countries since the beginning of the Eighties. The States fiscally supported the companies which financed their expenditure of innovation. Several legislative measures to support the effort of investment, tax treatment, the expenditure R&D innovation are taken. Which roles can be played by authorities in the fields of research and the innovation? In other words, how has to act the State in the fields of the R&D to increase the R&D in private sector?

[1] Grossman and Helpman (1991), Romer (1990).

In this work, we will study the existence of a relation of complementarity or substitutability in the case of (23)[2] countries through an empirical analysis on dynamic panel data. This document brings a new lighting on the public/private relation as regards R&D. This document will be organized in the following way: In the second section, a brief concerning the reason of government aid, i.e. the need for public administrations for supporting the R&D. The third section contains an analysis of the interaction between private and public R&D in theory and in facts. Evaluation methods are presented in section four. Empirical results will be contained in the fifth section. The section number six constitutes the conclusion of this work.

II. Reasons of government help

Today, we can observe an expansion of policies of innovations in the developed countries which devote great investment for R&D. What proves the creation of the climates favourable to the level of these countries for the innovation? It is significant that during these last years, companies of high technology or advanced technology's (pharmaceutical, aeronautical…) expenditure of research and development increased significantly. The role of the governmental policies as regards R&D is not to neglect. Indeed, the policies of innovation define specific actions of the State, which must encourage the accumulation of a qualified labour on the one hand, and to help the companies to prospect the markets on the other hand. This justifies the need for the public administrations for supporting the R&D.

Thus, which are the reasons of the government aid and the mechanisms the alternate ones available to the public administrations to support the R&D? To answer these questions we try to analyze the justification of the government aid with the R&D starting from the economic theories of growth.

1. Neo-classic theory of growth

For Neo-classic theory of growth, technical progress is supposed to be exogenous factors. With the balance of long term, population growth and technical progress determine the level of the growth rate. This implies, according to the basic assumptions, that the long-term growth rate is stable, and given in an exogenous way. Within this framework, the impact of an action of the authorities is practically ignored.

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[2] Countries are : Allemagne, Canada, Belgique, Danemark, Espagne, Finlande, Grèce, Inde, Japon, Norvège, Pays-Bas, Royaume-Uni, Rep-Tchèque, Italie, France, USA, Chine, Brésil, Australie, Israél, Tunisie, Maroc, Egypte.

The neo-classic theory of the growth supposes that the economy starts from a weak relationship between capital and labour. Just as the marginal returns on capital are decreasing. What reduces the encouragement to be invested in the new capital? Thus each new unit of capital produces a lower income and less large savings. In the long run, there will be absence of incentive to invest. In short, we can say that the assumptions which underlie the neo-classic theory are not realistic. The technological change is not always an exogenous factor outside the market, determined by an unknown process. To the 20th centuries, a good number of discoveries and progress were carried out in the commercial sector by companies with lucrative goal and not by public administrations or universities where research is directed by non-commercial forces. Markets are seldom in perfect competition, moreover, the private sector is not capable to produce all the desired goods and services, because some of them are goods public and certain others produce external effects.

2. Endogenous theory growth

The endogenous theory of growth recommends the relaxation of certain neo-classic assumptions and incorporates the failures of the market. However, the economic growth in the long run is directed by the accumulation of the factors of production founded this faith on knowledge, in particular, human capital, training, R&D and innovation. The endogenous models of growth are characterized by a great diversity of the resources selected: The investment in physical capital, in human capital, public capital, and labour division, learning by doing, research and the technological innovation.

The endogenous theory of growth recommends that technical progress rises from the R&D carried out by companies with lucrative goals. Research and Development constitute a significant factor of production process. In short, the assumptions according to which the determining factors of long-term growth are endogenous with the decision-making process constitute one of the principal exemptions from neo-classic theory of growth and involve significant effects on the policy. Indeed, if long-term growth is directed by factors of production based on the knowledge which belongs to the normal structure of costs of the company, then, by changing the cost of these factors by direct subsidies of tax incentives or of marketing policies, the public administrations can influence the long-term growth. These theories provide a framework of analysis of growth and its determinants which can also be used to study the incidence of public policies on economic growth and investments in R&D.

3. R&D investment and market imperfection

Economic theory and empirical proof show that technical progress, because of its incidence on the factors of production, constitutes key element in the long run determining economic growth; in certain countries, it represents even the most significant element. However, it is not a question of an economic justification of the official intervention for allocate the resources in favour of R&D. But, this intervention in a market economy is justified by incapacity of market to distribute resources in an efficient or acceptable way as regards social aspects. With regard to the investment in R&D, external effects and market imperfections testify the incapacity of market, and the effects are felt not only beyond particular companies but also beyond national borders.

In a market economy, a company will not invest in a project if it knows that it can not adapt the possible receipts, however if it cannot adapt a portion of these receipts, it will invest if this portion is enough to make a profitable investment. Asymmetrical information and imperfect competition constitute two other kinds of imperfections of market involving under investment in R&D. For example, asymmetrical information prevents effective operation of capital market. Indeed, it can involve rationing of appropriations as well as abandonment of investments in R&D[3] in projects with strong chances of success thanks to the plan of financing, and the continuation of investments in the project having weak chances of success[4].

III. Complementarity versus substitutability between private and public R&D

Theoretical work did not succeed in slicing on favourable or unfavourable effect using certain political instruments on the level of R&D in private sectors. The results of each model strongly depend on its structure and its assumptions. Empirical work, leads to homogeneous results and identifies a positive effect of public R&D on that private Hall. David. P (1998), Klette and Moen (1998), Scott (1984). With an aim of knowing the relation between public and private R&D we give an overall picture of the activities of R&D in world. Indeed, in this section, we attach more importance to activity of public and private R&D in the most significant poles in world.

[3] Mcfetridge (1996) reviews the literature on various kinds of gaps of the market and their possible incidences on the investment in the R&D.
[4] Himmelberg and Peterson (94), show that in fact mainly internal sources are used for the financing of the R&D since asymmetrical information restricted the external financing.

After the significant increase in the budget of R&D of the States Linked during the Fifties, Blanck and Stigler (1957) were among the first which raise the question about the existing relation between the public and private R&D. Thus, using a sufficiently broad sample of companies, the authors try to test the existence of a relation of complementarity or substitutability between private and public investment as regards R&D. Indeed, the implications of study are still significant until the policies of R&D today because a relation of complementarity is justified for the public funds whereas substitution is observed like a "misallocation".

Through time and with the improved scientific methods, it became clearly that the final situation towards the effect of the public funds of R&D cannot be made. Thus, in general, two fields can be identified and which are used to analyze the relation between private investment and public in research and development with knowing quantitative and qualitative studies: On the one hand; for the qualitative studies, data are frequently based on the investigations. On the other hand; for the quantitative studies, they are based on macro and micro-economic information of a significant number of companies.

In this last context, David. Toole et al. (1999)[5] give highlights of economic surveys with an aim of analyzing the net impact of public research and development on private R&D. Thus, such illustrative example of statistics of the found results, and among 14 studies, only two indicates a substitution effect at the overall level. On the level of the companies, results are less clear, i.e. in 9 studies sur19, there is a substitution effect.

Today, several activities of R&D are carried out on the level of the services sector. On the one hand, this is due to the external sources of the strategies of manufacturing industries in the Eighties. On the other hand, the transformation of information and technology of communication get more opportunities for innovating sectors. So the governments help more and more activities of R&D in several sectors with an aim of stimulating technological performances of their countries. Thus, several examples can be quoted. At this level, for the Nineties and more precisely in 1999, the total expenditure of R&D of Germany is 47 billion dollars where 66% of this amount is invested by private industries, 18% by government and the remainder are invested by foreign companies.

Thus, an international comparison on behalf of public programs of R&D shows that Germany is one of principal countries which grant funds for the technological performance.

[5] David Toole et al. (1999).

At this level, manufacturing industry plays a very significant role concerning R&D. From there, a question emerges up to what point evolution of public funds of R&D makes it possible to stimulate R&D carried out by private sector, and on which level results are checked?

Recently, an econometric micro study[6] tackled the question of the impact of political instruments about activity of R&D deprived on the level of companies. This study aims at detailing the influences of several determinants which can have an impact on private R&D; Klette et al. (2000) tried to test the effect of this impact on several levels.

In the Nineties, with Busom (2000) and Wallsten (1999), other problems were posed: namely the endogenity and causality. In the same way, the form, which is described by Lichtenberg (1987), Klette and Moen (1998) are connected to the decisions of public funds. Busom (2000) applies dummies variables in its model suggested to measure the impact of government aid to R&D carried out by private sector. In its turn, Lach (2000) could test the impact of programs of R&D on the amount of investment in both cases, with or without public supports.

Several other studies are more precisely interested in testing the effects of public subsidies in R&D on the amount of deprived investment like that of Czanitzki and Fier (2001), Klette and Moen (1998) etc…The major goal of these studies is to know if public subsidies of research and development can have an effect of reduction or increase in the expenditure of R&D. The results suggest that public subsidies of R&D on the level of several industries showed that there is a small tendency to the effect of ousting "Crowding out". In addition, it seems not to have any effect or degree of complementarity.

In the following section we empirically test fundamental relation which we seek to analyze in the case of (23) countries for the period 1992-2004, in other words we test the existence of a relation of complementarity and to check this result.

IV. Empirical validation: Dynamic panel data

There are several econometrics approaches, so we are going to follow a typical approach while holding account of some determinants of private research and development. The theoretical works that studied this question propose models founded on several political instruments. These works show that these policies can have a negative/ positive impact on the

[6] That of Klette and Moen (2000).

expenses deprived in R&D. Nevertheless, very little study to these days, value the impact of these research efforts. As for the empiric works, they showed a positive effect of political instruments on private level of research and development. However, these works come up against several limits essentially bound to the used methods econometrics and to the choices of indicators that represent the variable private R&D.

The objective of this work is to test the impact of an action of public policies empirically on the evolution of R&D in private sector while trying to surmount limits. The modelling that we follow to measure the effect of the R&D deprived on the public one; while taking into account some determinants of private R&D; is the one of Bettina and al (2002). This modelling has also been applied by: Busom (1999) and Lach (2000). The gait of these authors can be summarized like follows:

Private R&D = ß * public R&D + control variables + e

The underlying logic is simple:

If the coefficient β* has a positive sign we can say that public R&D are complementary for private R&D. In other words, an increase of 1% of public research and development level entails a growth of β*% of private R&D. On contrary, if β* has a negative sign we can say that there is a relation of substitutability between public and private R&D. In this part we try, to give a general setting for the models to estimate while putting accent on some remarks and inconveniences of these models. We apply a dynamic panel data model. Finally, after having estimated the model we analyze results.

In our survey we present in fact, a brief of empirical literature on the relation private and public R&D. We propose empirical tests on Panel of (23) countries between 1992 and 2004. We specify for it a dynamic model, which we estimate by different methods, notably Generalized Moments Method (GMM).

1. Dynamic panel data model: Definition and evaluations method

Dynamic models are characterized by presence of one or several endogenous variables delayed among explanatory variables. Our specified model is a dynamic panel model is given by:

$$y_{it} = \alpha\, y_{it-1} + \beta' x_{it} + \mu_i + \nu_{it} \qquad (1)$$

Under another forms one writing our model as below:

$$R_{it} = \alpha R_{it-1} + \beta_1 G_{it} + \beta_2 M_{it} + \beta_3 VA_{it} + \beta_4 IDE_{it} + \mu_i + \nu_{it} \quad (2)$$

Where;

y_{it-1} : Endogenous variable appears in the regression as being a retarded explanatory variable. In other words, present stocks of research and development of country (i) are explained by stocks of research of the period (t-1).

X: Represent the vector of exogenous variables; these variables are added value (VA), public research (G), import (M), foreign direct investment (IDE) and private research;

(α, β): Designate parameters to estimate;

μ_i : Constitute individual heterogeneity as: μ_i i.i.d. ~ N [(0, 1)];

And: $v_{i,t}$ is stochastic term as: $v_{i,t}$~ i.i.d. [(0, 1)].

$y_{i,t}$ is the logarithm of volume of R&D in country (i). $x_{i,t}$ is determinant vector of R&D. μ_i is the specific effect of country (i). This specific effect can be a stationary or uncertain effect.

2. Methods of evaluation

The evaluation of the model by traditional methods (Ordinary Least Square "OLS" and within) gives biased and non convergent values because of inter-relationship between retarded endogenous variable and individual heterogeneity. We try to demonstrate for the case of a simple model the inconveniences of these methods of evaluations.

In summary, the bias is positive and increases with the variance of the specific effect. Indeed, $y_{i,t}$ is function of $v_{i,t}$ and $y_{i,t-1}$ is also. $y_{i,t-1}$ is an explanatory variable correlated with stochastic term. It introduces a bias in the value of ordinary least squares. Even as putting hypothesis that stochastic terms are not correlated, this value is non convergent.

Our model should not be estimated by the method of OLS and LSDV due to the fact that estimating by these methods led to ad hoc results. Which are then adequate methods to estimate our model? We propose below two methods which consist in obtaining consistent estimators.

2.1. Anderson and Hsiao (1982) Method

Anderson and Hsiao (1982) proposed, initially, to write the model from first difference to eliminate individual heterogeneity. They propose for the transformation two instruments.

$$y_{it} - y_{it-1} = \alpha\left(y_{it-1} - y_{it-2}\right) + \left(\nu_{it} - \nu_{it-1}\right) \quad (3)$$

$$\hat{\alpha}_{vi}(1) = \frac{\sum_{i=1}^{N}\sum_{t=3}^{T}(y_{it}-y_{it-1})(y_{it-2}-y_{i.-3})}{\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it}-y_{i.-2})(y_{it-2}-y_{i.-3})} \quad (4)$$

And

$$\hat{\alpha}_{vi}(2) = \frac{\sum_{i=1}^{N}\sum_{t=3}^{T}(y_{it}-y_{it-1})y_{it-2}}{\sum_{i=1}^{N}\sum_{t=1}^{T}(y_{it}-y_{i.-2})y_{it-2}} \quad (5)$$

The two values are convergent when N and $T \to \infty$. However, an inter-relationship always persists between endogenous variable in first difference and residual term. Authors proposed to resort to the method of instrumental variables to surmount this problem. Thus, they propose to use instrument endogenous variable with two lags or his first differences. These instruments are correlated with explanatory variable and are not with residual term. To get more efficient results, Arellano and Bond (1991) approach permits to get a value of generalized moments "GMM" more efficient.

2. 2. Arellano and Bond (1991) approach

Arellano and Bond (1991) are the first in 1991 that proposed an extension of GMM introduced initially by Hansen (1982), to the case of panel data for a simple model AR (1):

$$y_{it} = \alpha\, y_{it-1} + \mu_i + v_{it} \quad (6)$$

Where $|\gamma| \prec 0$

We consider the case where temporal dimension is small while individual dimension (N) is important. We consider that individual effects are stationary and we assume traditional hypotheses of residues:

In difference models (6) can be written as below:

$$\Delta y_{it} = \alpha\, \Delta y_{it-1} + u_{it} \qquad |\gamma| \prec 0 \quad (7)$$

Where $u_{it} = v_{it} - v_{it-1}$.

We test for every individual of the linear restrictions of type:

$$E\left[(\Delta y_{it} - \alpha \Delta y_{it-1})y_{it-j}\right] = 0 \qquad for \quad j = 2,...,t; t = 3,...T \quad (8)$$

The gait of Arellano and Bond, in presence of the exogenous variables, consists in estimating the model in difference:

$$\Delta y_{it} = \sum_{k=1}^{p} \alpha_k \Delta y_{i(t-k)} + \beta'(L) X_{it} + \Delta v_{it} \quad (9)$$

Moment conditions and instruments matrix are given respectively by:

$$\begin{cases} E\left(y_{it-\tau}\Delta v_{is}\right)=0 \quad \text{pour } \tau \geq 2,\ t=2,3,....T \\ E\left(X_{it-\tau}\Delta v_{it}\right)\neq 0 \quad pour\, \tau \geq 2,\ t=2,3,....T \end{cases} \qquad (10)$$

$$Z=\begin{pmatrix} Z_{ip} & 0 & 0 \ldots . . & 0 \\ 0 & Z_{ip+1} & . \ldots . . & . \\ . & . & . \ldots . . & . \\ \Delta X_{ip+2} & \Delta X_{ip+3} & . \ldots . . & \Delta X_{iT} \end{pmatrix} \qquad (11)$$

The preceding dynamic model (9) can be rewritten for each individual in the following form:

$$y_i = W_i \delta + \tau_i \mu_i + V_i \qquad (12)$$

Where τ is a vector of parameter and W_i is a matrix that contains the retarded dependent variable and explanatory variables. The method proposed by these author's permits to get a GMM in two stages is written in following form:

$$\hat{\delta} = \left[\left(\sum_i W_i^{*'} Z_i\right) A_N \left(\sum_i Z'_i W_i^{*}\right)\right]^{-1} \left(\sum_i W_i^{*'} Z_i\right) A_N \left(\sum_i Z_i y_i^{*}\right) \qquad (13)$$

However, to have previous value GMM, it is necessary to pass by a first stage that consists in making wished transformation (first difference or orthogonal deviation), to find and to use instruments matrix and to achieve a first evaluation named "evaluation of first stage". This stage corresponds to an evaluation that permits to provide estimated residues after transformation. In the first stage, the values are gotten while using H_i as:

$$H_i = \hat{v}_i^{*} \hat{v}_i^{*'} \qquad (14)$$

$$H_i = \begin{pmatrix} 2 & -1 & \ldots\ldots\ldots & 0 \\ -1 & 2 & . & . \\ 0 & . & . & -1 \\ 0 & 0 & \ldots\ldots -1 & 2 \end{pmatrix}$$

And

$$A_N = \left(\frac{1}{N}\sum_i Z_i^{'} H_i Z_i\right)^{-1} = Z'(I_N \otimes H)Z \qquad (15)$$

The objective of transformation is, as at Anderson and Hsiao (1982), to eliminate individual heterogeneity of the model. The number of instrument increases in the time for every individual. In the case where exist explanatory variables x_{it} in the model correlated with heterogeneity individual μ_i . Optimal instruments matrix corresponding Z_i is equal to:

$$\begin{pmatrix} y_{i1} & x_{i1} & x_{i2} & 0 & 0 & 0 & 0 & .. & 0 & 0 & 0 \; .... & 0 & 0 \\ 0 & 0 & 0 & y_{i1} & x_{i1} & x_{i2} & x_{i3} & .. & 0 & 0 & 0 \; ..... & 0 & . \\ . & . & . & . & . & . & . & .. & . & . & . \; ..... & . & . \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & .. & y_{i1} & y_{i(T-2)} & x_{i1} \; .... & ... & x_{i(T-1)} \end{pmatrix}$$

Arellano and Bond (1991) propose a test verifying the absence of autocorrelation of first and second order. Thus, if distribution is non auto-correlated, this test gives a value of residues differentiated negative and significant to first order and non significant to the second order. This test that is based on auto-covariance of residues follows a normal law N (0,1) under hypothesis H_0. Otherwise, authors propose the test of validity of instruments of Sargan (1988). The statistical test Sis equal to:

$$S = \left(\sum \hat{v}_i^{*'} Z_i\right) A_N \left(\sum Z'_i \hat{v}_i^{*}\right) \qquad (16)$$

V. Empirical results

1. Anderson and Hsiao (1982) Method

By Anderson and Hsiao method our model in first difference becomes:

$$R_{it} - R_{it-1} = \alpha\left(R_{it} - R_{it-1}\right) + \beta_1\left(G_{it} - G_{it-1}\right) + \beta_2\left(M_{it} - M_{it-1}\right) + \beta_3\left(y_{it} - y_{it-1}\right)$$

$$+ \beta_4\left(IDE_{it} - IDE_{it-1}\right) + \nu_{it} - \nu_{it-1} \qquad (17)$$

The evaluation of (17) when we use $y_{i,t-2}$ and $y_{i,t-2}$ - $y_{i,t-3}$ as instrument gives results in tables 1 and 2 respectively

Insert tables 1 and 2

After we have estimate model by Anderson and Hsiao (1982) method and to get more efficient results, we try to apply the approach of Arellano and Bond (1991) that permits to get a generalized moment GMM more efficient.

2. Arellano and Bond (1991) in first difference

The evaluation that we present in table 3 corresponds to the GMM evaluation of Arellano and Bond (1991). The empirical evaluations confirm the positive effect of the R&D on growth of R&D of different country (positive and significant effect in all evaluations). However, identification of effects of other variables is far from being obvious according to different evaluations, a positive and significant effect in of Anderson and Hsiao evaluation of which public research are affected of a positive and significant value (0.034631350) with a (T-Stat = 2.11157) in the same way (1.91820030) with a (T-Stat = 1.90250), therefore these results verify the existence of a positive and significant relation between the two variables. For GMM method in first difference the variable spends public research is positive and significant (1.20891059), (T-Stat = 2.90728).

Insert table 3

3. Unit root test

Levin and Lin (1992), consider the following model:

$$y_{i,t} = \rho_i y_{i,t-1} + Z'_{it}\gamma + u_{i,t} \qquad (i=1, \dots, N;\ t=1, \dots, T) \qquad (18)$$

Where, $Z_{i,t}$ is the deterministic component and $u_{i,t}$ is a stationary process.

μ_i is the fixed effect,

The Levin and Lin (LL) tests assume that $u_{i,t}$ are iid $(0,\sigma^2_u)$ and $\rho_i=\rho$ for all *i*. The LL test is restrictive in the sense that it requires ρ to be homogeneous across *i*. Im, Pesaran and Shin (1997) (IPS) allow for a heterogeneous coefficient of $y_{i,t-1}$ and propose an alternative testing procedure based on averaging individual unit root test statistics. IPS suggested an average of the augmented Dickey-Fuller (ADF) tests when $u_{i,t}$ is serially correlated with different series. Correlation properties across cross-sectional units, i.e;

$$u_{i,t} = \sum_{j=1}^{p_i} \alpha_{ij} u_{it-j} + \varepsilon_{it} .$$

Substituting this $u_{i,t}$ in (1) we get:

$$y_{i,t} = \rho_i y_{it-1} + \sum_{j=1}^{p_i} \alpha_{ij} \Delta y_{it-j} + z'_{it}\gamma + \varepsilon_{it} \qquad (19)$$

The null and for all i the alternative hypothesis are:

$$H_o: \rho_i = 1$$

$$H_a: \rho_i < 1$$

For at least one i. The IPS t-bar statistic is defined as the average of the individual ADF statistic as:

$$\bar{t} = \frac{1}{N}\sum_{i=1}^{N} t_{\rho i} \tag{20}$$

Where $t_{\rho i}$ is the individual t-statistic of testing H_o: $\rho_i = 1$ in (19). It is known for a fixed N as $T \to \infty$

$$t_{\rho i} \Rightarrow \frac{\int_0^1 W_{iz} dW_{iz}}{\left[\int_0^1 W_{iz}^2\right]^{1/2}} = t_{iT} \tag{21}$$

IPS assumes that t_{iT} are iid are have finite mean variance. Then

$$\frac{\sqrt{N}\left(\frac{1}{N}\sum_{i=1}^{N} t_{iT} - E[t_{iT} / \rho_i = 1\right)}{\sqrt{Var[t_{iT} / \rho_{i=1}]}} \Rightarrow N(0,1) \tag{22}$$

As $N \to \infty$ central limit theorem. Hence

$$t_{IPS} = \frac{\sqrt{N}\left(\bar{t} - E[t_{iT} / \rho_i = 1)\right.}{\sqrt{Var[t_{iT} / \rho_{i=1}]}} \Rightarrow N(0,1) \qquad (23)$$

As $T \to \infty$ followed by $N \to \infty$ sequentially, the values of $E[t_{iT}/\rho_i=1]$ and $Var[t_{iT}/\rho_i=1]$ have been computed by IPS simulations for different values of T and ρ'_is. As applying the test on our complete model our results is summarized in table 4

Insert table 4

The application of the tests of unit root LL and IPS shows that the whole of the statistical series is affected of a unit root. It should be noted that the number of maximum delay is fixed at 3; the selection of the numbers of delay for each individual is programmed by Pedroni for these two tests.

VI. Conclusion

In our survey, we tried to put accent on private and public investment in R&D, for the case of (23) country which presents different levels of R&D. We tried to clarify relation that exists between private and public research. This empirical survey wanted to give account, the effects of different determinants on private investment in R&D and to know if public and private investments in R&D are complement or substitute.

Econometric approach consists in the regression of some measures of private R&D on public R&D with some control variables. The evaluation that we presented in our work corresponds to GMM evaluation of Arellano and Bond (1991). We prefer to refer to results of this evaluation because it permits to eliminate rigorous way all bias to none observed individual heterogeneity and offer, a better efficiency of results. Empiric evaluations confirm a positive effect of public R&D in different country (positive and meaningful effect in all evaluations). Results of our empiric survey are relative for our sample and they go in the sense of results of ulterior studies, which showed that there is a positive and meaningful relation between private and public investment in R&D.

Some studies put in value of other factors that can be important as: competition in the market, public politics and cooperation concerning R&D between firms. Cooperation in R&D is a part of the new strategies developed by firms in more global and competitive economic environment. These last factors are not to disregard and can be subject of a future research concerning the relation between public and private investment in R&D.

Appendix

Table 1: Anderson and Hsiao method

	Coeff	T-Stat	Signif
R (-2)	1.043741733	2.61851	*0.01862671*
G	0.034631350	2.11157	*0.01255140*
M	0.117410800	3.10834	*0.00507352*
VA	0.261604184	1.09045	*0.02905193*
IDE	*0.068683520*	*2.10772*	0.01555534

Table 2: Anderson and Hsiao method

	Coeff	T-Stat	Signif
R (-2)-R (-3)	4.02020750	2.11480	*0.0226709*
G	1.91820030	1.90250	*0.03925921*
M	1.86404603	2.34064	*0.01364196*
VA	1.25706985	2.84950	*0.02590034*
IDE	*0.55898626*	*3.09396*	*0.02520837*

Table 3: Arellano and Bond method in first difference

	Coeff	**T-Stat**	**Signif**
R(-1)	0.52001865	0.46582	*0.64180074*
G	1.20891059	2.90728	*0.03425802*
M	1.36345220	2.36785	*0.01333684*
VA	1.15210478	1.29346	*0.36944694*
IDE	*1.14085022*	*2.15794*	*0.02465192*

Sargan test: Ch^2 (20) =25.78 (0.001)

Table 4: Unit root Tests

Statistics	**R**	**G**	**M**	**VA**	**IDE**
Levin-Lin ADF stat	3.83805	-1.40533	-0.10589	-1.52279	-1.27014
IPS ADF stat	2.61779	-0 28466	-1.08827	-0.17841	-0.19014

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