International R&D spillovers and cooperation: A cointegration panel data analysis for the South of Mediterranean countries

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Abstract: In this paper, we consider R&D cooperation and direct foreign investment as a channel of international spillovers by an empirical literature on innovation and growth. First, spillovers are limited to the country where R&D is conducted; the growth rate in each country will be determined by the country's own R&D-efforts and by R&D cooperation ignored a long time in growth literature. Second, spillovers take place across borders, and growth rates will tend to converge across countries. Two potential channels for R&D spillovers are examined: localisation of FDI and R&D cooperation. In examining these issues, panel data for six Mediterranean countries will be used over the period 1970 to 2008.

Keywords: Panel Cointegration; international R&D spillovers; TFP; FDI; R&D cooperation.

1. Introduction

The emergence of endogenous growth theory in the 1980 has been interest in sources of economic growth. Coe and Helpman (1995), among other researchers, declare that commercially oriented innovation efforts which respond to economic incentives are the major engine of technological progress and productivity growth. They argue that, a country's productivity depends on its own R&D efforts as well as R&D efforts of its trading partners. So, we can consider that R&D cooperation is a most important factor of economic growth and transmission of technological externality. Using data

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from Mediterranean countries during 1970-2008, we find that R&D cooperation and foreign direct investment have important effects on total factor productivity.

Trade is a form of communication which stimulates the training methods of production and organization. Domestic resources are allocated in a more efficient way. Then, international contacts facilitate transfer of foreign technologies. In addition, it is possible to increase productivity of a country by the development of new technologies or foreign imitation of techniques production indirectly affecting level productivity.

Under these conditions, the international trade is presented as a strategy of development and knowledge acquisition, Grossman and Helpman, (1991a). Coe & Helpman (1995) are the first who explore relation between technology transfer and international trade. They show that not only R&D return is high in countries which carry out it, but also that technological knowledge is diffused through commercial channels. Van Pottelsberghe (1995) takes again the preceding analyses and integrates second component of integration, foreign direct investment, like explanatory factor of total productivity of the factors.

It is significant to note that these studies are concentrated on developed countries and a generalization of results is risky. However, today, majorities of developing countries go through processes of regionalization and hope to capture externalities from R&D stocks of advanced countries. Mediterranean countries do not make exception and technology transfer, key of success of Euro-Mediterranean project, is the principal contribution of North-South free trade area. Euro-Mediterranean activates partnership is the channels of technology transfer via exchanges of goods and services or FDI. Technological transfer should increase total productivity of factors (TFP). We try to find the explanatory factors of R&D efforts of Mediterranean countries. We suppose that externalities of R&D are not limited to the most advanced countries, but also diffuse towards of developing countries.

After a short review of literature of international trade and technology transfer, we propose to resume work of Coe & Helpman (1995) and Van Pottelsberghe (1998). It is a question of testing the relation between the total
productivity of factors and knowledge externalities through foreign stock of capital in R&D, FDI and R&D cooperation.

This paper is organized as follow. Section 2 brief reviews of international transfers of Knowledge. Section 3 is dealing with technological externalities and R&D cooperation. Section 4 presents a review of Coe and Helpman’s model. Section 5 indicates an empirical investigation. Concluding remarks and results are made in Section 6.

2 INTERNATIONAL TRANSFER OF KNOWLEDGE

In traditional theory of international trade, exchange is perceived like a means of rationalizing of productive structures economy. Trade allows development of industries where country is relatively more effective. Redistribution of resources of less effective sectors towards most effective should contribute to increase TFP2.

Under these conditions, developing countries which are specialized in intensive labour of industries see their productivity increasing. New international trade theory associate an analytical framework of endogenous growth, the mechanism by which exchange contributes to productivity growth is double3. It affects country growth rate directly by increasing the quantities of inputs available on the market, maybe by development of intermediate goods quality. In addition, international trade is also a mechanism by which technological knowledge is transmitted internationally.

International trade returns are the consequence of several factors. Initially, the widening of the market allows economies of scale. In addition, repetition effects of R&D activity are wholly eliminated. Finally, technological difference can quickly be filled as soon as imitation costs are lower than innovation costs. The logic with this type of reasoning rests on the ideas characteristics and technological knowledge: they have the property to be goods “non-rivals” and “non-exclusive”. In other words, the simultaneous use of the same idea does not destruct any of users. Thus, international trade can be a vector of knowledge diffusion. These last are imported product which incorporates technological information. Countries must exploit imports like source of knowledge accumulation.
3 Technological Externalities

Technological diffusion is the process by which technological change is propagated beyond initial innovator. Technology has many attributes of a public property, it is not rival, cannot be completely adapted, and it is not destroyed in production. The ownership rights relating to knowledge resulting from R&D can be exerted only in an imperfect way by patent.

3.1 Partnership and research cooperation

The existence of externalities justifies also the existence of another form of organization like cooperation. Indeed, technical assistance is generally a means of improving company’s capacity to generate new products and new processes production, generators themselves of competitiveness. Reasons are several, cooperation makes possible to cure partially many markets imperfections, and it makes possible to increase research output. Technical assistance makes possible to reduce negative impacts of these imperfections on research and development investments.

Companies which begin in a cooperative research project share part of their own financial resources, which contributes to slow down their financing project constraint. This more significant financial standing can resort to credit market under better conditions. Moreover, to get along on a joint research project implies that one gets along on costs partition, therefore risks (risk sharing). In event of failure, financial consequences are limited to the amounts invested by each one in the project.

Technical assistance can also make it possible to improve effectiveness of research, its output. By ensuring a distribution of knowledge obtained from all agreement members, cooperation supports synergies development and makes it possible to reach a greater completion degree in human and financial resources exploitation of project. Lastly, if there are increasing outputs in research activity, cooperation generate additional profits.

3.2 Negative strategic Externalities
One second category of arguments in favour of cooperation rests on the nature public of scientific knowledge property and on the competition which exists between companies for innovations control. These externalities described as strategic are generally negative.

Rival externality appears clearly in patents models. However, purchase probability competition grows with individual expenditure of research and decrease with those of concurrent companies. It results an over-investment from it seeks some compared to social optimum. Cooperation by avoiding a useless duplication of research expenditure, leads then to more satisfactory solution.

However, cooperation can pose a problem when the companies signatories of agreement are concurrent on the product market (horizontal agreement) and do not get along as a preliminary on profits division resulting from innovation, for example by agreeing on a geographical market division. Indeed, the companies concerned can have interest to adopt a step of information retention (free riding). In this last case, cooperation can have destructive effects on innovation. When the companies produce independent or complementary goods (vertical agreement), cooperation is always preferable.

Duguet. E and Crepon. B shows that an opposite relation binds the number of patent fillings of a firm to total expenditure R&D of other firms (made deduction of its own expenditure).

These rival externalities dissolve the existence of recent orientation of public policies which consists in supporting partnerships and research and development cooperation whose most spectacular demonstrations are European programs such as SPRINT or EUREKA. But how can we measure results of these cooperation’s? The legal system of patent makes it possible to the company’s partners to Co-deposit patents resulting from this cooperation. In addition to expresses authorities’ motivation to facilitate these cooperation, it offers a suitability of analyzing them nature and methods.

3.4 FDI Effects
Technology transfer is a channel by which FDI can proceed on growth. A better use of resources leads in the long term to growth. It is accordingly that FDI flows are required by developing countries. Thus, all national organizations charged to authorize FDI apply a particular attention with projects likely to develop output of economy, to create jobs and to arrange the territory GATT (1995). These FDI are thus supposed to improve the total effectiveness of the economy according to several channels.

The first way rests on the fact that FDI increases competition on the market. Even if foreign firms suffer on domestic market from handicaps such that a bad knowledge of the domestic market, they have effects of drive on economy. The presence of this new competition encourages domestic firms to rationalize and modernize their productive structure. In the same way, Blomstrom and Kokko suggest that FDI allow increasing technological level of a country through innovation and imitation. Firms who undertake an FDI on a foreign market seek to profit from market and thus use non-existent technologies in multitude country. Even it is not a question itself of the most effective technique available on the world market, delocalization of these productive units make it possible to diffuse new knowledge. In return, local firms which wish to be maintained on the market will have to imitate Glass and Saggi (1998). FDI has a virtuous cyclic effect on technological improvement of one country Blomstrom and Kokko (1995). This effect is stronger as foreign share in production. Goreki (1976) affirms that, the least effective companies leave market releasing part of the resources for the most effective productions. This point is fundamental for development of the least advanced economies. Many empirical studies confirm this argument. As show it Borensztein, and Lee (1995), by econometric tests carried out on 69 developing countries, the truth of this effect is closely related to human capital. The FDI effect on growth appears in a fuller way when education system is powerful.

According to the theoretical outline, it seems that TFP of South countries should be as much higher than foreign R&D stock is significant, than its economy is opened with imports of goods of equipment and investment coming from North. We expect that foreign stock of R&D affects countries productivity of the South through
FDI and that through imports. Interactions between agents are being at the level even production processes, and then allow an easier transfer of tacit knowledge. We will be able to then conclude on opportunities from free trade area euro Mediterranean.

4 Coe and Helpman's theory and model

Coe and Helpman (1995) discovered that all of their data exhibit a clear trend, and unit root tests on these data indicate that TFP and both the domestic and foreign R&D capital stocks are non-stationary. They confirm the presence of cointegration for TFP and domestic and foreign R&D capital stocks by testing for a unit root in residuals. In other words, although all variables are individually non-stationary, there exists a linear combination of these variables so that the regression containing these variables has a stationary error term.

Coe and Helpman's use of a cointegrating regression enables us to exploit relationship among variables in levels, without transforming data, such as differencing, to avoid spurious regression problem. Unfortunately, at the time of their article panel econometrics Cointegration had not yet been resolved. Among the various issues that now need to be addressed are two directly associated with Coe and Helpman's empirical interpretations?

First, we need to know asymptotic distribution of estimated cointegrating vector in panel data. It is well known that the asymptotic distributions of estimators in time series regression are dramatically affected by the presence of unit roots and cointegration. Accordingly, we expect that asymptotic distributions of estimators in panel regression might also be affected by the presence of unit roots and cointegration. Indeed, Coe and Helpman chose not to report the t-statistic, because the asymptotic distribution of the t-statistic was unknown. Given that the estimated coefficients are relatively small, we are not sure whether these estimators are significantly different from zero.

Second, although it is well known that time series regression estimates are super-consistent, it has been found that estimation bias may remain substantial for moderate sample sizes. We have no reason to presume that this bias will become negligible in panel regression due to the introduction of cross-section dimension.
Given that estimated coefficients in Coe and Helpman are relatively small in degree, one even wonders whether those estimates are correctly signed after bias correction. The issues presented above cast serious doubts on Coe and Helpman's conclusion that TFP is closely linked to domestic and foreign R&D.

Recently, Kao and Chiang (1998) found that limiting distributions of OLS estimators are normally distributed with non-zero means and proposed fully-modified (FMOLS) and dynamic OLS (DOLS) estimators in panel data. While the limiting distribution of OLS estimator is normal with a nonzero mean, FMOLS and DOLS estimators are asymptotically normal with zero means. We apply Kao and Chiang's result to Coe and Helpman's international R&D spillover regressions, and we adopt these literatures with adding R&D cooperation as a canal of transmission of spillovers for six Mediterranean countries.

5 AN EMPIRICAL ANALYSIS WITH PANEL DATA MODELS

The goal of this analysis is to examine in a structure of panel data the role of R&D cooperation in innovation process. Initially, analysis is focused on R&D cooperation impact in accordance with others factors on production innovation. Our objective is to show if R&D cooperation are complementary to innovation process, by increasing innovation and production of companies measured by the intensity of internal R&D, respectively by innovations realization product. The intensity of internal R&D stimulates also probability of R&D cooperation between various countries. The majority of innovation activities imply multiple actors. The development of new products requires an active research process implying several companies and establishments to discover new knowledge sources and technology as suggests De Bresson, (1996); Nooteboom, (1999); Von Hippel, (1988). The countries which engage in innovation activities are conscious of the need for establishing R&D cooperation to obtain new products which cannot be produced inside these countries. Such R&D cooperation is defined as collaborations to achieve a common goal which is to develop new and improved products (of technologies).

In a more or less durable multitude of agreements between two or several associates, credits and activities are linked and combined. Thus, technological
capacities are necessary to develop process innovations. The importance of increased R&D cooperation regularly thanks to increasing complexity, risks and innovation costs\(^5\). Within the framework of our analysis we primarily try to specify many objectives: The role played by technological cooperation in justification of investment effort in research and development; in which measurements technological cooperation is perceived like a privileged vector of innovation and incentive to innovate and technological cooperation impact on countries growth.

5.1 Empirical literature reviews

R&D cooperation belongs to new strategies developed by countries in more globalize and competitive economic environment. The advantages R&D cooperation for participating countries are well-known. Indeed, the participants R&D cooperation can profit from, and economies scale complementarities of their know-how and can avoid the repetitions of their results. Another advantage of R&D cooperation is spillovers internalization, owing to the fact that patents do not reflect a perfect protection against imitations. The cooperative importance of research is recognized through the government’s policies. Search for common projects runs in particular “Research Joint Venture” (RJV) is guaranteed by privilege of antitrust acts and their formation is encouraged by subsidies etc.

A vast deal of empirical evidence shows that a country's production structure and productivity growth depend on its own R&D capital formation. With the growing role of international trade, foreign investment and international knowledge diffusion, domestic production and productivity also depend on the R&D activities of other countries for example Tarek, Sadraoui et al (2009). Mohnen, Pierre et al (1999, 2008) investigate the bilateral link between the U.S. and Japanese economies in terms of how R&D capital formation in one country affects the production structure, physical and R&D capital accumulation, and productivity growth in the other country. They find that production processes become less labor intensive as international R&D spillovers grow. In the short-run, R&D intensity is complementary to the international spillover. This relationship persists in the long-run for the U.S., but the Japanese decrease their own R&D intensity. In addition, U.S.
R&D capital directly contributes to Japanese total factor productivity growth by three and a half times more than Japanese R&D capital directly contributes to U.S. productivity gains. International spillovers cause social rates of return to be around ten times the private returns.

In the framework of opening economy world and increasing competition countries develop new strategies. New strategies imply networks of intensive work. The reasons for cooperation are expensive and risky. Moreover, cooperation can increase efficiency, such as economy scale in production. This study concentrates on R&D cooperation. Within this framework, several aspects of cooperative R&D were studied in economic literature. The theoretical literature analyzed intensively how spillovers affect investment in R&D in a cooperative situation compared with competition. Moreover, theoretical literature treats stability of search joint project, organisational design and asymmetry between partner’s researches.

In the same way research of joint projects is formed starting from antitrust laws because they are considered to promote productivity. Also, to analyze participation research effects of joint project on productivity is an interesting question. Estimation of total cooperative research advantages is very difficult because cooperation can have an impact on R&D expenditure. Geroski (1992) summarizes theoretical conclusions on this subject. He concludes that R&D projects are desirable when technological spillovers and positive externalities (share risk) exist. According to Geroski discussion when we evaluate R&D cooperative impact we must separate his direct effect on productivity and indirect effect through research intensity competition. Therefore, how does productivity affect R&D cooperation?

R&D can have a positive impact on productivity. Therefore, the same amount of investment in R&D results more (or less) innovation. Then, if R&D investments are non-affected, cooperation in innovating activities increases productivity compared with case of competing R&D. This direct effect of joint research and development is studied by Kamien et al. (1992), Beath et al. (1998) and Baumol (1999). The common characteristic of their analysis is that they model innovation process (reduction cost). Beath et al. (1998) present a modelling of innovation process with R&D spillovers.
They clarify an innovation model as a process in two stages where in the first stage knowledge is produced and in the second stage this knowledge is employed to reduce cost.

A limited number of empirical studies are centred on reasons for participation in research consortia. The only exceptions are Irwin and Klenow (1996) studies about productivity and Branstetter and Sakakibara (1998) about productivity of Japanese research consortia. Branstetter and Sakakibara (1998) carried out an econometric analysis of Japanese research consortia. They found that governmental expenditure of R&D consortia has leads to increase R&D expenditure. They measured research production by number of patents. The increase in productivity implies a direct and positive effect of common research on productivity.

In this paper we study implications of productivity of participation in cooperative research. Moreover, we use a sample of various countries where information is available on R&D expenditure. We try to separate total investment R&D effect and cooperative research participation on productivity. We try to take account of independent variable endogeneity, and while adopting recent econometrics literature of panel data relating to unit roots tests and cointegration. Finally we estimate our model by Full Modified Ordinary Least Square method "FMOLS" and we try to interpret results.

### 5.2 Model Presentation

The models which are interested in cooperative research influence on productivity take account of spillovers effects. These spillovers would be mainly proposed for private research. Public research would not profit from overflow resulting effects from other public institutions. Nevertheless, public spillovers diffusion was sometimes tested upstream in innovation process by introducing external public R&D into function which determines public R&D. Association of spillovers terms and cooperation is a little usual. However, as underline it Cassiman B and Veugelers. R (2001) any exchange, any transfer is likely to cause spillovers. We consider that cooperation can be used as a spillovers vector because of non-rival character of knowledge and uncertainty of knowledge process. Indeed, knowledge is
not subject to the same rules of appropriation as in private sector. In fact, the objective of researchers is not to adapt their discovery to illustrate financial profits but to establish a principle priority, generally thanks to publications. In this case, there exists, established priority, no limit with knowledge diffusion. Cooperation within public networks should support considerably knowledge diffusion published.

Within framework of our study we consider a log-linear Cobb-Douglas product function transformed as below:

\[ \log Y_{it} = \eta_i + \beta_1 \log \text{COP}_{it} + \beta_2 \log RD_{it} + \beta_3 \log \text{FDI}_{it} + \beta_4 \log K_{it} + \beta_5 \log L_{it} + \gamma_t + \epsilon_{it} \]  

Where \( Y \) is final output, \( L \) is the available labour force, \( K \) is the capital accumulation.

FDI: Foreign direct investment for country (i) in the year (t);
Log RD: The logarithm of expenditure of research and development ratio to the GDP for country (i) in the year (t);
COP: R&D cooperation expenditure calculated as a spillovers effect\(^8\);
U: Indicate a stochastic term; and

\( \eta_i \) and \( \gamma_t \) : Are individual and temporal effects

We try to take account of temporal structure of variables with this intention, we must test the presence of unit root and if all series are non stationary. The recent approaches adopted by Im, Pesaran and Shin (1997) IPS and by Kao (1999) are respectively used for unit root and cointegration test. The first consists in carrying out unit root tests on each series by using Augmented Dickey-Fuller, method (Dickey and Fuller, (1981); Davidson and MacKinnon, (1993). We obtain then statistics serving to make unit root test for panel by calculating individual statistics ADF average. This value is compared with simulated breaking values provided by IPS. When it is higher than the value given threshold of significance, null assumption of unit root is rejected.
As for used approach by Kao for Cointegration, it consists in making individual regressions of ordinary least squares (OLS) of R&D on COP and carrying out ADF tests on estimated residues of these series Engle and Granger, (1987). The statistics being used to test null assumption of non-Cointegration are obtained by calculating the average of ADF statistics previously obtained. It is compared with breaking values provided by Kao and makes it possible to reject null assumption if it is higher. This leads us to analyze series for each country. For our data base, it has been determined from many sources\(^9\) for the period 1970 to 2008.

### 5.3 Unit root and Cointegration studies

The unit root tests became a current step for analysis of time series stationarity. However, practical application of these tests on panel data is recent. The tests most frequently used are those of Levin and Lin (1992) (LL) and of Im, Pesaran and Shin (2003) (IPS). Recently, several procedures of unit root tests and Cointegration were developed for panel data models. The addition of individual dimension to temporal dimension offers an advantage, in practical application of unit root and Cointegration tests.

In this paragraph we seek to study non-stationary properties and Cointegration and to study stationarity we try to use Levin Lin and IPS tests.

\[
\Delta y_{it} = \alpha_i + \theta t + \beta y_{it-1} + \sum_{j=1}^{n} \gamma_j \Delta y_{it-j} + e_{it}
\]  

(2)

The regressions being used to the stationarity test of variables in level can include a constant and a linear trend. The rejection of null assumption unit root indicates that series is characterized by a random walk representation.

To check stationarity of the group and to mitigate the low power of tests LL in small sample, we called upon the method of IPS which proposed a test of unit root in the context of panel data model by using the average of individual statistics ADF of the regressions (2). Our data out of longitudinal transverse section must ideally respect assumptions necessary to application of statistics alternative T-bar making it possible to test the null assumption of unit root (\(\beta_i = 0\)):
\[
\bar{t}_{NT} (p_i) = \frac{1}{N} \sum_{i=1}^{N} t_{it} (p_i) \tag{3}
\]

Where \(t_{it}(p_i)\) represents ADF tests estimated with \(p\) lags differences;

\(N\) is the number of groups \(n = 1, 2, \ldots, 6\).

\(T\) the total number of observations \(t = 1, 2, \ldots, 34\).

IPS proposes to use the following standardized statistics:

\[
Z_i = \frac{\sqrt{N} \left( \bar{t}_{NT} - E(\bar{t}_{NT}) \right)}{\sqrt{\text{var}(\bar{t}_{NT})}} \tag{4}
\]

Where \(E(\bar{t}_{NT})\) and \(\text{Var}(\bar{t}_{NT})\) are respectively arithmetic mean and variances of individual statistics ADF, since \(\beta_i = 0\). The IPS study shows that these standardized statistics converge slightly towards reduced normal centred distribution, which makes it possible to compare it with breaking values distribution \(N(0, 1)\).

The application of unit root tests of LL and IPS shows that the whole of statistical series is affected of a unit root only LY, LK and LFDI are I(1) (see table 1). It should be noted that the number of maximum lag is fixed at 3; the selection of the numbers of lag is programmed by Pedroni for these two tests.

**Table 1. Unit Root Tests Results**

<table>
<thead>
<tr>
<th>Statistics</th>
<th>LY</th>
<th>COP</th>
<th>LK</th>
<th>LL</th>
<th>RD</th>
<th>LFDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Levin-Lin ADF-stat</td>
<td>2.56869</td>
<td>-1.93769</td>
<td>-1.89923</td>
<td>1.99554</td>
<td>1.31369</td>
<td>0.77490</td>
</tr>
<tr>
<td>IPS ADF-stat</td>
<td>1.87532</td>
<td>-2.25522</td>
<td>-2.87477</td>
<td>1.21454</td>
<td>1.99776</td>
<td>0.36808</td>
</tr>
</tbody>
</table>

The checking of non-stationary properties for all panel variables leads us to study the existence of a long run relation between these variables. The Cointegration study by applying Pedroni Cointegration tests based on unit root tests on residues estimated. Cointegration tests on panel data consist in testing the presence of unit root in the estimated residues. However, the problem of fallacious regressions, of the
time series, also arises in the case of panel data. Table 2 indicates a summary for unit root test results.

Table 2 A summary for unit root test results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Levin-Lin rho-stat</th>
<th>Levin-Lin rho-stat</th>
<th>Levin-Lin ADF-stat</th>
<th>IPS ADF-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>LY</td>
<td>0.64232</td>
<td>0.25515</td>
<td>1.37819</td>
<td>0.97502</td>
</tr>
<tr>
<td>LL</td>
<td>1.50275</td>
<td>1.52590</td>
<td>1.72568</td>
<td>0.11920</td>
</tr>
<tr>
<td>LK</td>
<td>-0.61904</td>
<td>-1.58644</td>
<td>-0.52230</td>
<td>-0.96344</td>
</tr>
<tr>
<td>RD</td>
<td>1.89234</td>
<td>2.83203</td>
<td>1.31369</td>
<td>1.99776</td>
</tr>
<tr>
<td>COP</td>
<td>-4.04483</td>
<td>-1.90597</td>
<td>-1.93769</td>
<td>-4.28423</td>
</tr>
<tr>
<td>LFDI</td>
<td>-1.13219</td>
<td>0.60479</td>
<td>0.77490</td>
<td>0.36808</td>
</tr>
</tbody>
</table>

Pedroni developed seven tests of Cointegration on homogeneous and heterogeneous panel data, these tests take into account heterogeneity on the level of Cointegration relation i.e. for each individual there are one or more Cointegration relations not necessarily identical for each individual of panel.

The implementation of Pedroni tests requires in a first stage estimate of long run relation for each individual described by:

\[ y_{it} = \alpha_i + \delta_i t + \beta_{1i} x_{1it} + \ldots + \beta_{M_i} x_{M_it} + \epsilon_{it} \quad (5) \]

With \( i = 1 \ldots N, t = 1 \ldots T \) and \( m = 1 \ldots M \)

In the 7 Pedroni tests, four are based on within dimension and three are based on between dimensions. These two categories rest on null assumption of absence of Cointegration, the distinction between the two categories is done on the alternative level assumption:

\[ H_i = \begin{cases} 
\rho_i = \rho < 1 \forall i : \text{within} \\
\rho_i < 1 \forall i : \text{between}
\end{cases} \quad (6) \]

Pedroni showed that under the suitable standardizations based on Brownian functions of movement, each of 7 statistics follows a normal law centred reduced for \( N \) and \( T \) sufficiently significant:
Where $z_{NT}$ indicates one of the 7 statistics, Pedroni the values of the moments $\mu$ and $\nu$ necessary to such a standardization according to the number of explanatory and presence or not of a constant and a trend in the relations of Cointegration. Results are indicated in table 3:

$z_{NT} - \frac{\mu \sqrt{N}}{\sqrt{\nu}} \rightarrow N(0,1)$ (7)

Table 3  Cointegration tests of Pedroni

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>LY, LK, LL, RD, COP, LFDI</td>
<td>0.464</td>
<td>-0.7541</td>
<td>-3.817</td>
<td>-1.876</td>
<td>-2.473</td>
<td>2.234</td>
<td>1.673</td>
</tr>
</tbody>
</table>

From results of Pedroni Cointegration tests we can notice that the whole of statistics are lower than breaking value of normal law for a threshold of 5% (-1.64). So the whole of these tests requires the existence of a Cointegration relation. With an aim of carrying out Cointegration tests on panel data and to obtain an estimation of Cointegration vectors it is necessary to apply an effective method of estimation. Within this framework we can distinguish several techniques with FMOLS method (Full Modified Least Square) used by Pedroni, DOLS method (Dynamic Least Square), GMM method.

For estimators for each country determined by full modified ordinary least square method we indicate in table 4 most of results for our sample countries.
<table>
<thead>
<tr>
<th>Country</th>
<th>Variables</th>
<th>Coefficients</th>
<th>t-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisia</td>
<td>LL</td>
<td>4.46</td>
<td>(16.07)</td>
</tr>
<tr>
<td></td>
<td>LK</td>
<td>0.24</td>
<td>(3.13)</td>
</tr>
<tr>
<td></td>
<td>RD</td>
<td>-0.88</td>
<td>(-4.51)</td>
</tr>
<tr>
<td></td>
<td>COP</td>
<td>-0.08</td>
<td>(-4.02)</td>
</tr>
<tr>
<td></td>
<td>LFDI</td>
<td>-0.02</td>
<td>(-1.17)</td>
</tr>
<tr>
<td></td>
<td>LL</td>
<td>0.46</td>
<td>(3.92)</td>
</tr>
<tr>
<td></td>
<td>LK</td>
<td>0.08</td>
<td>(2.65)</td>
</tr>
<tr>
<td>Morocco</td>
<td>RD</td>
<td>-0.10</td>
<td>(-1.14)</td>
</tr>
<tr>
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<tr>
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<td>LL</td>
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<td>(-0.93)</td>
</tr>
<tr>
<td></td>
<td>LK</td>
<td>0.17</td>
<td>(9.45)</td>
</tr>
<tr>
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<td>RD</td>
<td>0.13</td>
<td>(3.43)</td>
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<tr>
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<td>COP</td>
<td>-0.02</td>
<td>(-1.29)</td>
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<tr>
<td></td>
<td>LFDI</td>
<td>-0.01</td>
<td>(-1.29)</td>
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<tr>
<td></td>
<td>LL</td>
<td>0.98</td>
<td>(4.47)</td>
</tr>
<tr>
<td></td>
<td>LK</td>
<td>0.10</td>
<td>(6.04)</td>
</tr>
<tr>
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<td>RD</td>
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<td>(-0.21)</td>
</tr>
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<tr>
<td>Israel</td>
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<td>0.02</td>
<td>(0.21)</td>
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<td>(1.84)</td>
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<td>(3.91)</td>
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<tr>
<td>French</td>
<td>RD</td>
<td>0.05</td>
<td>(1.77)</td>
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<td></td>
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<td>0.00</td>
<td>(2.50)</td>
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<td>0.05</td>
<td>(6.24)</td>
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Phillips and Moon (1999) showed that within framework of panel data, FMOLS and DOLS techniques leads to estimators asymptotically distributed according to a reduced centred normal law. All the same, Pedroni (1996) affirms that estimators OLS his super-convergent, whereas their asymptotic distributions is skewed and depends on the parameters effects. According to Pedroni, these problems can be marked in heterogeneity presence. For our model estimated cointegrant vectors by FMOLS method is given by (t-student between brackets):

$$\beta' = \begin{pmatrix} 1 & 0.78 & 0.365 & 0.765 & 0.546 & (0.654) \\ - & (1.98) & (2.34) & (2.345) & (3.124) & (1.965) \end{pmatrix}$$

**5-5 Discussion and conclusion**

The objective of our study is to confront theoretical and empirical results the literature of R&D cooperation impact on economic growth. Although a model including a whole of variables is tested with generally admitted estimators, the accent is related to panel data analysis. This approach makes it possible to study a model with theoretical lesson on R&D cooperation. Based on FMOL estimator, econometric specification of this model combines the use of Cointegration and unit root tests.

The studies available on R&D cooperation are often limited to a static approach. However the most recent articles Cozzi. G (1999), and Massard. N (1999), Cassiman. B and Veugelers. R (2002) enriches analysis by the use of a dynamic approach to apprehend relations of R&D cooperation for various studies.

Panel econometrics model makes it possible to control observations heterogeneity in their individual dimensions either by taking account of a specific effect or by taking account of non observable specific effect “random effects”. Temporal dimension is taken account by introduction of dummy variables.

In this work, we examine the relation between R&D cooperation and growth in six Mediterranean countries during the period 1970-2008, results obtained using FMOLS in a panel data show that impact R&D cooperation on growth varies
International R&D spillovers and cooperation...

according to indicator of internal expenditure of research and development "DIRD" of each country taken in the sample. On the basis of this last indicator, it arises from the estimates that the increase in percentage of this indicator led to 0.765 point of additional growth.

The application of LL and IPS unit root tests shows that the whole of statistical series is affected of a unit root and LY, LK, LFDI are I(1). It should be noted that the number of maximum lags is fixed at three. Selection of the numbers of lags is programmed by Pedroni. The checking of non stationary properties for all variables of panel leads us to study the existence of a long run relation between these variables. From results of Cointegration tests of Pedroni we can notice that the whole of statistics are lower than the breaking value of normal law for a threshold of 5% (-1.64). So the whole of these tests requires the existence of a Cointegration relation.

knowledgegement

We would like to express our sincere thanks to Professor Peter Pedroni, Jeffrey I. Bernstein, Pierre Mohnen for their study about international spillovers for R&D and for feedback and comments.

Notes

1 In our database we take account of Egypt, Morocco, Tunisia, France and Israel.
2 Total Factor Productivity.
4 Countries are French, Israel, Tunisia, Morocco, Algeria and Egypt.
7 We use much recent literature developed by IPS, Levin Lin, KPSS, and Pedroni.
8 For this variable, we consider that R&D cooperation is a canal of transmission of externality like Foreign Direct Investment FDI.
9 **OCDE:** (1999b), « Main sciences and technology indicators » 1999/1, Paris.

**World Bank:** World Development Indicators CD-ROM – 2008 and


**CHELEM:** [http://www.cepii.fr/francgraph/bdd/chelem.htm](http://www.cepii.fr/francgraph/bdd/chelem.htm)

**INS:** National Statistics Institute Tunisia, [http://www.ins.nat.tn/](http://www.ins.nat.tn/)

**References**


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Van Pottlesberghe De La Potterie, B. (1998), The Efficiency of Science and Technology Policies inside the Triad, thèse de doctorat, Université Libre de Bruxelles.