DETERMINANTS OF R&D INVESTMENT: A STUDY OF OECD COUNTRIES

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Abstracts: Since Investments in R&D have been identified as a major engine of growth by recent endogenous models, many studies have investigated the determinant R&D intensity. This paper analyzes the impact of determinant factor on the R&D investment with emphasize on openness trade by a panel data model of R&D .the result from OECD countries from 1996-2008 shows that economic growth, openness trade and R&D expenditure that funded by government have positive impact on R&D intensity while openness trade has more effect than others.
Key Words: R&D investment, Openness Trade, Panel Data

Introduction

Since R&D investment is one of the most essential elements in advancing knowledge, increasing productivity, and promoting growth, any country that invests sufficient resources in R&D activities and engages in R&D efficiently has the potential to achieve a desired growth target resulting from R&D. Numerous studies have examined R&D behavior and estimated the efficiency of R&D investment at the firm level (Wakelin, 2001; Koellinger, 2008) as well as output growth at the national level (Paasi, 1998; Fraumeni and Okubo, 2002; Falk, 2007). Neoclassic growth was based on capital accumulation, while what is needed now for countries to shift towards the growth based on Research and Development (R&D) investments and innovation, which have a great influence on firms and countries to increase their competitive advantage. Policymakers devote much attention to enhancing productivity with emphasize on its drivers such as R&D investments. New growth theory (Romer, 1990) introduces endogenous technological change (as a function of the level of human capital) into the Solow model. Most models of endogenous technology change, such as those of Mankiw et al. (1992) and Romer (1994), suggested that human capital and knowledge accumulation by means of education and R&D are major sources of long-term growth.We can see also the role of R&D investment in the work of Griliches (1980), Mansfield (1988), Cohen and Levinthal (1989), Feller (1990), Jovanovic and Nyarko (1995), Adams and Griliches (1996), Stephan (1996), Madden et al. (2001), Fraumeni and Okubo (2002), and Maloney and Rodriguez-Clare (2007) and Okubo, 2002; Falk, 2007).

However, there are several arguments to explain why higher income leads to higher R&D investment. First, according to the acceleration principle of investment, rising GDP implies that businesses in general see rising profits, increased sales and cash flow, and greater use of existing capacity. A large proportion of total R&D is conducted by private firms, which resumably engage in R&D in order to improve profitability. Under this principle R&D capital depends on output, so the variation in R&D investment depends on GDP growth rates (Schmookler, 1966). Second, in the model of R&D-driven growth, the incentives to invest in R&D are also tied to the size of the economy. Larger markets imply stronger incentives to conduct R&D, which in turn lead to faster growth (Romer, 1994). Finally, as consumers grow richer, they tend to allocate a larger share of their income towards differentiated products,

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which are more R&D-intensive (Markusen, 1986). It is expected that the elasticity of R&D per capita with respect to GDP per capita should be high (Braconier, 2000; Furman et al., 2002). Most of the empirical studies regarding national R&D and innovation considered real GDP per capita as a decision variable (Teitel, 1994; Ginarte and Park, 1997; Hu and Mathews, 2005).

The issues of whether open trade policy increase technological progress and growth rate of economy is one of the highly debated issues in the literature. It attracted wider intellectual attention not only because of the main role of trade in an economy, but also due to the ambiguity in the impact of trade on technological progress. The theoretical models examining various channels, through which trade can affect technological progress such as import competition, export and technology import, but they are not unanimous in their predictions. Thus there are some theoretical arguments supporting the move to more openness trade, but there are also equally some theoretical arguments for protecting some industries from international competition; making the issue an important candidate for empirical analysis (Hallak and Levinsohn 2003). Many papers show that innovation declines with competition (see, among others, Arrow (1962), Gilbert and Newbury (1982), Grossman and Helpman (1991), and Aghion and Howitt (1992)). This is not consistent with those paper mentioned above and the other empirical papers (see, for instance, Nickell (1996) and Blundell et al. (1999)). The reduction in trade barriers has two countervailing effects on the profitability of firms. First, the reduction in barriers gives opportunities to the firms to export their products and earn additional profits. Second, there is a possibility that tougher competition diminishes incentives to engage in R&D because residual demands that firms face shrink and then marginal gains of efforts decrease. If the former is more significant than the latter, the efficiencies of firms improve by the reduction in trade barriers. According to Matsushima et.al (2008) the innovation costs and the fixed trade costs play important roles: If a firm decides to engage its R&D activity, it has to incur a fixed innovation cost while If the R&D investment of a firm achieves success, the firm exports its products to foreign markets and has to incur per market fixed trade cost. Their values influence on impact of trade on innovation incentives of firms. If the innovation cost is large or the fixed trade cost is small, openness of trade enhances the innovation incentives of firms while if the innovation cost is small and the fixed trade cost is large, openness of trade diminishes the innovation incentives of firms.

Second, in almost all OECD countries, governments provide R&D funding to universities and other research institutes in support of basic research (Geuna, 1999). It is thus assumed that the government's budget surplus or deficit is very likely to affect national R&D investment intensity. Furthermore, in most countries, the public sector also performs the duty of engaging in R&D research directly (Bebczuk, 2002). As in the theory of public finance, government

expenditure might have either crowding-in or crowding-out effect on private expenditures (Linnemann and Schabert, 2004). Bebczuk (2002) assumed that government plays an ancillary role in R&D and found that the estimated compensation coefficient was just 0.313

in a sample of 88 countries. Since the motivations and outcomes of public R&D are quite different from those of private R&D, the share of government-performed R&D is thus .17 the percentage shares of GERD performed by the government sector are compiled in OECD: Main Science and Technology Indicators, various issues.

There are a large range of policy instruments that could affect the share of GDP that is invested in R&D. Indirect policies such as competition policy and regulation may be important. Direct policies include direct funding of R&D, investment in human capital formation, extending patents protection and tax credits for R&D.

This paper empirically investigates the determinants of R&D investment at the national level with an emphasis on openness trade. Three major hypotheses regarding the intensity of R&D investment are openness trade, economic growth and government R&D expenditures. The robustness and sensitivity of the effects of openness trade, GDP growth rate and government R&D expenditures on R&D investment are examined using data from 30 OECD countries during the period from 1996 to 2008. The remainder of the paper is organized as follows. Section 2. Provides brief theoretical arguments regarding openness trade R&D determinant and reviews relevant literature on the topic. Variable definitions and a description of the data are provided in Section 4. The empirical results are presented in Section 5. The last section provides research conclusions and policy implications.

1. Literature Review

Guellec and van Pottelsberghe (1997) find a contrary time pattern for the effects of tax credits and direct subsidies in a multi-country study. Their results show Tax credits have a significant effect on expenditure in the short-run, but not the long-run, whereas subsidies have a positive effect on expenditure in the long-run, but not the short-run. Subsidisation rates of 11-19% are estimated to have the strongest effects. Rates above 30% are found to be associated with the substitution of public funds for private funds.

Griffith et al. (2000) provide econometric evidence that R&D expenditure plays a role in assimilating the research discoveries of others as well as its conventional role as a source of innovation. The size of the spillovers depends on one's own R&D activity.

Pottelsberghe and Lichtenberg (2001) investigate econometrically whether foreign direct investment (FDI) also transfers technology across borders.Their results indicates that: (1) FDI transfers technology ; (2) the ratio of foreign-R&D benefits conveyed by outward FDI to foreign-R&D benefits conveyed by imports is higher for large countries than it is for small ones; (3) failure to account for international R&D spillovers leads to upwardly biased estimates of the output elasticity of the domestic R&D capital stock ; and (4) there are much larger transfers of technology from the U.S. to Japan than there are from Japan to the U.S.

Ziets and Fayissa (2002) by using Panel data on 360 U.S. manufacturing firms over the years 1975 to 1987 identify the response of R&D spending to exchange rate changes. Their results show only firms in industries with average R&D spending of at least 3 percent of sales revenue react to an exchange rate appreciation with increased R&D spending and Firms in industries with lower levels of R&D intensity do not. Their finding can be interpreted to mean that only R&D intensive firms react to an increase in competitive pressure with more R&D effort.

Griffth and Reenen (2002) examine the impact of fiscal incentives on the level of R&D investment. An econometric model of R&D investment is estimated using a new panel of data on tax changes and R&D spending in nine OECD countries over a 19-year period (1979–1997). They find evidence that tax incentives are effective in increasing R&D intensity.. They estimate that a 10% fall in the cost of R&D stimulates just over a 1% rise in the level of R&D in the short-run, and just under a 10% rise in R&D in the long-run.

Matsushima et.al (2008) constructs a model in which international trade influences on R&D activities of firms. They show that trade openness influences on the R&D activities of firms, if innovation costs and fixed trade costs are intermediate values. If the fixed trade costs are relatively high and the innovation cost is relatively low, trade openness diminishes the R&D activities of firms. Meanwhile relations between several exogenous parameters and the effect of trade openness are discussed.

Wang (2010) investigates the determinants of R&D investment at the national level with an emphasis on the roles of patent rights protection, international technology transfer through trade and FDI, and economic growth, in addition to the essentials ofhumancapital accumulation and the number of scientific researchers. The results of the EBA tests on data from 26 OECD countries from 1996 to 2006 showed that tertiary education and the proportion of scientific researchers in a country were robust determinants that had positive effects on R&D intensity. Foreign technology inflows had a robust and negative impact on domestic R&D. Patent rights protection and the income growth rate are fragile determinants of R&D investment.

Huang and Yang (2009) investigate the effect of tax incentives on R&D activities in Taiwanese manufacturing firms. Specifically, they assess the potential R&D-enhancing effect on recipients of R&D tax credits compared with their non-recipient counterparts. Moreover,they examine the potential difference in the R&D-enhancing effect between high-tech and non-high-tech firms. Utilizing a firm-level panel dataset during 2001 and 2005, empirical results obtained by propensity score matching show that recipients of R&D tax credits appear on average to have 93.53% higher R&D expenditures and a 14.47% higher growth rate for R&D expenditures than non-recipients with similar characteristics. The R&D-enhancing effect of R&D tax credits is not found to be particularly relevant to high-tech or non-high-tech firms. they further employ a generalized method of moment (GMM) of the panel fixed model to control for the endogeneity of R&D tax credits and firm heterogeneity in determining R&D expenditure. Various estimates based on the entire sample and high-tech-firms are quite similar and there is a significantly R&D-enhancing effect of R&D tax credits. This result suggests that the R&D preferential policy has induced more R&D expenditure by firms in Taiwan. While the existence of the R&D-enhancing effect brought on by tax incentives is intuitive, the estimates can provide insightful implications for the R&D tax policy.

2. Data And Methodology

Aghion and Howitt suggest that R&D intensity is the proper empirical measure for the R&D input of the innovation function in the context of their endogenous growth model. So, a common indicator used to measure R&D investments across countries is represented by GERD: Gross Domestic Expenditures on Research and Development as a percentage of Gross Domestic Product (GDP).

In the section, we present a formal regression analysis to examine how R&D intensity is influenced by openness trade, economic growth and government R&D expenditures. Our analytical approach is to use panel data to estimate models in which R&D intensity at country i in year t ($GERD_{i,t}$) is specified to be a function of the openness trade at the country i in the year t ($OPEN_{i,t}$), economic growth at the i country in the year t ($GDP_{i,t}$), R&D expenditures founded by government at the country i in the year t (), country fixed effects (μ_i), time fixed effects (γ_t), and a random error term ($\varepsilon_{i,t}$).

Although our descriptive statistics span the 1996–2008 period for OECD countries. we use the OECD's Science and Technology indicators and Economic Outlook database for the period 1996–2008, available for download at www.sourceoecd.org and UN data (www. unesco.org).

3. Findings And Discussion

Tests of normality, Kolmogorov–Smirnov and Shapiro–Wilks, applied on variables show a level of significance equal to 1‰ and Wooldridge test confirm no autocorrelation in residuals, such that it is possible to apply correctly the econometric models of parametric estimations and have made the results robust and unbiased. The results are summarized in Table (1).

The model specified in Equation (1) is estimated by econometric panel procedure fixed effects (FE), where the results are obtained by Stata 11. The results are reported in Tables (1).

Table 1: The impact of R&D determinants on R&D intensity

	β_1	β_2	β_3
Estimate	.176	.013	.011
Standard Error	.060	.003	.005
P-Value	.004	.000	.035

As regards to table 1 we find that openness trade, GDP growth and R&D that funded by government have positive and significant effect on R&D intensity. By comparing between three effective factors on R&D intensity we discover the effect of openness trade among all factors is the most. The magnitude of the effect indicates that an increase of 10% in the openness trade, GDP growth and government R&D expenditures, respectively amounts to a 17.6%, 1.3% and 1.1% increase in R&D intensity.

Conclusions and Implications

In this paper we have sought to show the main determinant of R&D by using a panel data model for 30 OECD countries over the period 1996-2008, we find that openness trade, GDP growth and government R&D expenditures have positive effect on R&D intensity while the main explanations for R&D is openness trade .so policymakers should be focus on the solutions that leads to reduce trade restrictions to increase openness trade. Unlike so many studies that show negative effect of openness trade our results confirm positive effect of openness trade on R&D so we can say that innovation cost is greater than trade cost in OECD countries.

R&D effort results in a wider variety of products and higher product quality. It raises productivity, increases value-added, and further increases GDP growth. While R&D activity promotes GDP growth, GDP growth could also induce stronger incentives for R&D investment. Teitel (1994) and Ginarte and Park (1997) considered real GDP per capita, which is implied as an indicator of returns to R&D investment, as a decision variable.

Investment of government in R&D is necessary especially in Market failures that can provide a rationale for government intervention to support private R&D. If the private rate of return is below the social rate of return, as might be expected if firms are unable to fully appropriate the rents on their innovations, then expenditure on R&D could be lower than socially optimal. Equally, if firms experience significant external financial constraints, with agency costs limiting the funds available from external investors, then expenditure may again be lower than optimal, especially by smaller firms. Meanwhile governments have two policy tools to provide favorable tax treatment for those firms undertaking R&D or to directly subsidize private R&D projects. While the former is a more market-oriented approach, leaving decisions on the level and timing of expenditure to the private sector, there is mixed evidence on its effectiveness Governments may also support private R&D indirectly if there are spillovers from government-funded research in universities and publicly funded research centers.

APPENDIX

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xtreg  gerd openees goverd gdp ,fe
Fixed-effects (within) regression              Number of obs      =      297
Group variable: id                            Number of groups   =       30
R-sq:  within  = 0.1227                       Obs per group: min =        2
       between = 0.3885                                      avg =      9.9
        overall = 0.2944                                     max =       13
                                                F(3,264)         =    12.30
corr(u_i, Xb)  = -0.6676                        Prob > F          =   0.0000
------------------------------------------------------------------------------
       gerd |      Coef.          Std. Err.      t     P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    openees |   .1764232     .0608199    2.90    0.004     .0566695    .2961769
     gov      |   .0135031     .0034035     3.97   0.000     .0068016    .0202046
        gdp |    .0111837     .005273       2.12    0.035     .0008012    .0215663
      _cons |     1.285861    .0755497    17.02   0.000     1.137104    1.434618
-------------+----------------------------------------------------------------
    sigma_u |  1.0063046
    sigma_e |  .17411245
        rho |  .97093366   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(29, 264) =   179.27            Prob > F = 0.0000

xtreg  gerd openees goverd gdp ,re
Random-effects GLS regression                  Number of obs      =      297
Group variable: id                            Number of groups   =       30
R-sq:  within  = 0.1221                       Obs per group: min =        2
       between = 0.3808                                      avg =      9.9
        overall = 0.2912                                     max =       13
Random effects u_i ~ Gaussian                   Wald chi2(3)      =    24.24
corr(u_i, X)       = 0 (assumed)                Prob > chi2       =   0.0000

------------------------------------------------------------------------------
       gerd |      Coef.          Std. Err.      z      P>|z|     [95% Conf. Interval]
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openees	.1488027	.0612216	2.43	0.015	.0288106	.2687948
gov	.0105664	.0034591	3.05	0.002	.0037867	.0173461
gdp	.0108971	.005497	1.98	0.047	.0001233	.021671
_cons	1.384198	.1568075	8.83	0.000	1.076861	1.691535
sigma_u	.71465586					
sigma_e	.17411245					
rho	.94396959 (fraction of variance due to u_i)					

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