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ABSORPTIVE CAPACITY OF HUMAN CAPITAL AND INTERNATIONAL R&D SPILLOVER ON LABOUR PRODUCTIVITY IN EGYPT

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Abstract

Purpose: The purpose of this paper is to investigate the relationship between labour productivity, human capital and international R&D spillover over the period 1982–2011.

Design/methodology/approach: The study estimates a single equation model which employs long run cointegration analysis and short run analysis (ECM). It is based on annual data collected from the World Bank and the Ministry of Planning in Egypt and OECD database for the period 1982–2011.

Findings: The results show a conventional result for international R&D and human capital. We infer a significant positive role played by international R&D and human capital on labour productivity.

Practical implications: This study highlights an important area for policy decision making, which is stressing the idea that human capital absorptive capacity, enhanced by the quality of education, intensifies the positive effect of R&D spillover on labour productivity. This was determined by our survey of the literature and an empirical model.

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Originality/value: Our study will contribute a different approach to the literature by examining the effect of international R&D spillover and human capital on labour productivity in the Egyptian manufacturing industries. Other studies were conducted by examining the effects of these variables either on total factor productivity or gross domestic product of the recipient countries. These research methods, together with the emphasis on human capital, have rarely been conducted in Egypt.

Keywords: *Labour productivity, Human capital, International R&D, Cointegration, Error Correction Model*

Paper type Research paper

INTRODUCTION

Several theoretical and empirical studies in the economic literature provide evidence of the transfer of knowledge between countries or regions, which has contributed to the productivity growth of other geographic areas (Coe and Helpman, 1995; Coe *et al.*, 2009; Kao *et al.*, 1999; Litchtenberg and Brouno, 1998).

In addition, empirical evidence has also been produced with respect to the direction, the magnitude and the effectiveness of different channels through which such spillover effects are transmitted.

However, few studies have examined the effect of international R&D spillover transmission from industrial countries to developing countries. The ones that were conducted in this respect focussed on the macro level and the overall effect on total factor productivity. Very few empirical studies were conducted on how the international R&D spillover affects labour productivity in developing countries.

The main objective of this current study is to survey the literature on international R&D spillovers transmitted from industrial countries to developing countries and its effect on labour productivity. Then a model will be built whose basic assumption suggests that there might be enough evidence that technology and innovation can be transmitted to the Egyptian manufacturing industries through various channels. However, the magnitude of international R&D spillover can be insignificant for the enhancement of labour productivity if there is a low absorptive capacity of human capital.

Hence, the study will be examining the relationship between the labour productivity of the Egyptian manufacturing industries relative to international R&D capital stock and human capital.

LITERATURE REVIEW

International R&D was originally introduced in several studies, the most significant of which being that of Coe and Helpman (1995, as cited in Coe *et al.*, 2009). They contributed new estimates of R&D spillovers that were different from previous research studies, which only examined spillover across sectors or industries for a single country. Their estimates of R&D spillovers used a pool of macroeconomic data for 21 OECD countries plus Israel over the 1971–1990 time periods. They estimated the relation of a country's total factor productivity as a function of the domestic research and development capital stock and foreign R&D capital stock as a proxy for the stock of knowledge embodied in countries' trade positions. All the measures of foreign and domestic research and development capital were constructed from the business sectors' research and development activities.

The model used the estimated elasticity of total factor productivity in relation to domestic and foreign R&D capital stock. In another study, Coe *et al.* (1997) estimated elasticity of total production function in relation to change in foreign research and development capital stock; imports of machinery and equipments and secondary school enrollment ratio were used. Another contribution of Coe and Helpman's model (1995) is the use of this function as empirical evidence that research and development spending in industrial countries can be transmitted to developing countries and increases these countries› total productivity.

Many studies have advocated this model, however, using advance statistical techniques. Coe *et al.* (2009) adopted the modern panel cointegration method that was not available in the early 1990s. In addition, they did an expansion of panel to the same model.

In another study, Kao *et al.* (1999) used the same model and adopted the methods of OLS, FM and DOLS estimators in panel data. The study concluded that the estimated coefficients in the Coe and Helpman model (1995) are subject to estimation bias, but they have correct signs. However, the results support the argument of international R&D spillover.

Litchtenberg and Brouno (1998) examined two important characteristics of the Coe and Helpman model (1995). They argued that the first characteristic—the foreign R&D weighting scheme—suffers from "aggregation bias", and suggested a less biased weighting scheme. They corrected an indexation bias and found that the more a country enjoys trade openness the greater the probability of gains from R&D spillover.

Muller and Michaela (1998) argued that the choice of an appropriate model for the behaviour of panel data can affect the results of the Coe and Helpman model (1995). In other words, the choice is between fixed coefficient methods previously used in the model, and the use of a random coefficient model, as in the present study. Applying the model using fixed regression gave unreliable results compared to the use of random coefficient analysis.

The channel through which the international R&D is transmitted was debated in several studies on the macro level (across the borders of countries) and on the micro level (across firms or industries in the same country). Cincera and Bruno (2001) distinguished between rent spillover of technology transfer that occurs from trading transactions of factor imports and machinery that embodies innovative technology on one hand, and international knowledge spillover across countries via foreign direct investment, international research collaboration, scientific publications or brain drain on the other hand. Both are difficult to measure due to high colinearity between them. Wolf and Ishraq (1993) depicted a channel of R&D spillover embodied in new investments that enters a sector in the economy.

The absorptive capacity of a recipient country for international R&D spillover was taken into consideration when analysing the magnitude of impact on productivity. Several determinants of absorptive capacity were suggested, in various studies.

The first priority is the quality of human capital as an important catalyst for absorption. Sunkwark and Young (2006) built their assumption on the idea that domestic human capital is an important factor in understanding the foreign high technology embodied in imported goods and absorbing it for domestic use. McNeil (2007) specified the quality of labour force and capital accumulation as two vital determinants of absorptive capacity of spillover.

The second important factor is the technology gap between countries, where studies questioned the impact of international R&D on total factor productivity with a wide technology gap in developing countries (Blomstrom and Kokko, as cited in Bouoiyour, 2005).

Zhu and Bang (2007) proved that innovation in information technology has played a significant role in facilitating the transmission of international R&D spillovers among OECD countries and Israel, and consequently improving its productivity growth. Finally, Coe *et al.* (2009) added a group of institutional determinants which impact the absorptive capacity of international research and development spillover in recipient countries: ease of doing business and quality of tertiary education systems, the strength of patent protection laws in the country and their effectiveness in copyright protection, and the origin of the countries legal systems. All these determinants were found to be highly correlated to the improvement of total factor productivity through enhancing the absorptive capacity of spillovers.

Other contributions were made to the literature of international R&D spillover by examining its impact on other economic variables. Costa and Stefano (2004), focussed on the effect of technology innovation spillover on economic growth. They made use of the dynamic growth model, which facilitated the evaluation of regional convergence and innovation on the long run labour productivity without the technology index that is usually used in the technology gap model for developing countries.

Borras *et al.* (2011), examined the intersectoral direct and indirect knowledge spillover on a sector›s labour productivity on a disaggregated level. Their interpretation of knowledge included innovation, research and development, and tacit knowledge. Gera *et al.* (1999) presented an empirical model that estimates the effect of information technology investments and R&D spillovers from the information technology sector on labour productivity between Canadian and US industries. They relied on the Coe and Helpman (1995) model on estimating foreign R&D capital and domestic R&D capital. They have agreed on the transmission channels introduced in this model. However they regressed the annual average labour productivity rate of an industry on the information technology and non-information technology investments for five sub periods from 1971 to 1993. They regressed the mean values of the R&D variables

over the same results. Their result showed a significance effect of international R&D spillover from information technology sectors on labour productivity for both sectors, with low significance from non-information technology sectors.

The application of international R&D on the Middle East countries and Egypt was also conducted, but with a narrow scope. McNeil (2007) examined the effect of international R&D spillover on total factor productivity through its diffusion in the imported intermediate products from OECD countries to the Egyptian and Moroccan manufacturing sector. Using the same Coe and Helpman model (1995), the study concluded the significance of cross border research and development spillover on total factor productivity.

Human capital, as mentioned earlier, is a determinant of the magnitude of spillover in the model. Bouoiyour (2005), conducted his study on the Moroccan manufacturing industries, indicating that the channel of spillover is foreign direct investment, which has a significant effect on labour productivity, adding the dimension of the technology gap as a ratio between total factor productivity of foreign firms to the total factor productivity of domestic firms.

The final outcome of this literature survey, from which this paper builds on its basic assumptions, is that international R&D can be transmitted from industrial countries to developing countries through different mechanisms. It can significantly affect total factor productivity given the presence of high absorptive capacity. The main catalyst of this capacity is the quality of human capital, a narrow technology gap and innovation in information technology.

METHODOLOGY

In this section, we first present the empirical model used to estimate the effect of R&D spillovers and human capital on labour productivity growth in the Egyptian manufacturing sector.

EMPIRICAL MODEL

The empirical model depends on the Cobb-Douglas production function. This model was developed by Cörvers (1997) and Gera *et al.* (1999):

$$Y_{t=}\ L_t^{\alpha_1} H_t^{\alpha_2} K_t^{\alpha_3} RD_t^{\alpha_4} e^{\theta t} \quad (1)$$

Where α_1, α_2, α_3, and α_4 are the output elasticities of labour input, human capital, capital stock and international R&D capital respectively and α_4 represents the rate of exogenous technical change. All the other variables are explained in Table 1.

From equation 1, we can derive the following equation that expresses the labour productivity growth rate of the manufacturing sector in Egypt.

$$\left(\frac{\dot{y}}{y}\right) = \beta_{0+}\beta_1\left(\frac{\dot{L}}{L}\right) + \beta_2\left(\frac{\dot{H}}{H}\right) + \beta_3\left(\frac{\dot{K}}{K}\right) + \beta_4\left(\frac{\dot{RD}}{RD}\right) + \epsilon \quad (2)$$

Where is the labour productivity growth; is growth rate of the human capital; is the growth rate of the capital stock and is the growth rate of the international R&D.

MEASUREMENT OF R&D SPILLOVERS

We calculated the international R&D as follows:

First, we calculated R&D expenditures for the G7 countries (US, UK, German, France, Italy, Japan and Canada) by using the STAN dataset.

Variable	Description	Expected sign	Source of data
Y	Labour productivity in manufacturing sector in Egypt. Y= GDP in manufacturing sector divided by employment.	Dependent variable	Ministry of planning in Egypt, annual series.
L	Employment level in manufacturing sector in Egypt.	-	Ministry of planning in Egypt, annual series.
H	Years of primary schooling.	+	World Bank
K	Capital stock. It is calculated from the investment data via the PIM technique.	+	Ministry of planning in Egypt, annual series.
RD	International R&D, which is calculated from the R&D expenditure data via the PIM technique.	+	STAN dataset, OECD.

Table 1. Sources and descriptions of data

Second, we calculated the values of R&D at constant prices.

Third, we transferred these data from flows to stock by using the Perpetual Inventory Method (PIM)[3] and applying equation 3 for the benchmark year and equation 4 for the other years.

$$RD = \frac{RD\ flow\ in \frac{1982}{83}}{Average\ annual\ growth\ rate + Depreciation\ rate} \quad (3)$$

$$RD_{i=} RD_{i-1(1-Depreciation\ rate)} + RD\ flow\ in\ year\ i \quad (4)$$

MEASUREMENT OF CAPITAL STOCK IN EGYPT

We calculated the international R&D as follows:

First, we collected the investment data for the manufacturing sector in Egypt during the period 1982/83–2010/11.

Second, we calculated the values of investments at constant prices.

Third, we transferred these data from flows to stock by using the Perpetual Inventory Method (PIM) by applying equation 5 for the benchmark year and equation 6 for the other years (Elshamy, 2009).

$$K = \frac{Investment\ flow\ in \frac{1982}{83}}{Average\ annual\ growth\ rate + Depreciation\ rate} \quad (5)$$

$$K_{i=} K_{i-1\ (1-Depreciation\ rate)} + Investment\ flow\ in\ year\ i \quad (6)$$

EMPIRICAL RESULTS

This section discusses the estimated results of equation 2. Regression was performed on a time series data consisting of 29 years (1982/83–2010/11) for the manufacturing sector in Egypt. First we conducted the cointegration analysis. Table 2 shows the results of the Augmented Dickey Fuller (ADF) test on the first difference based upon the Mackinnon *P* values at various lag lengths. The preferred lag length is based upon the

[3] For more details of this method, see Elshamy (2009)

Akaike information Criterion (AIC). These indicate that cointegration is generally accepted.

Table 2 shows the estimation results using cointegration analysis. We find that the labour productivity has a positive and significant relationship with the growth rate of human capital; capital stock and international R&D. However, the relationship between the labour productivity and the growth rate of the employment is negative and significant. All these results are correct according to the economic theory.

Details of these findings can be interpreted as follows: in the Egyptian manufacturing sector, international R&D has a positive influence on labour productivity, with a 1% rise in international R&D increasing labour productivity by 5.6 %. Moreover, in the Egyptian manufacturing sector, human capital has a positive influence on labour productivity, with a 1% rise in human capital increasing labour productivity by 1.2 %.

Table 3 shows the Error Correction Mechanism (ECM). It indicates the same results as those for cointegration. Most importantly, of course, the lagged error is negative and significant. This confirms the acceptance

Dependent variable (growth of labour productivity)	**Coefficients**	**Significance**
Independent variables		
Constant	0.007	*
Growth of labour input	-0.411	***
Growth of human capital	0.012	**
Growth of capital input	0.019	*
International R&D spillover	0.056	***
CDRW	1.75	
ADF Tests	Favoured lag length=2	Favoured lag length=2
ADF(0)	0.004	0.003
ADF(1)	0.052	0.022
ADF(2)	0.041	0.006
ADF(3)	0.031	0.004

***=significant at 1%
**=significant at 5%
*=significant at 10%
ADF figures show the Mackinnon approx P-value

Table 2. Cointegration analysis

Dependent variable (LFDI)	Coefficients	Significance
Independent variables		
Constant	0.006	*
Growth of labour input	-0.366	**
Growth of human capital	0.009	**
Growth of capital input	0.	*
International R&D spillover	0.048	**
Lagged error	-0.116	***
No. of observations	29	
F-statistics	8.33	***
Adjusted R2	0.76	
DW	2.15	
AR(1)	1.42	
ARCH(1)	1.82	
Normality	2.12	

***=significant at 1%
**=significant at 5%
*=significant at 10%

Table 3. Error Correction Mechanism (ECM)

of the long–run relationship; which is further validated given there are no problems with any of the diagnostic tests presented: (the AR(1) test for first order residual autocorrelation, the ARCH(1) test for autogressive conditional hetroscedasticity and the Jarque-Beta test for normality).

CONCLUSIONS

This paper empirically analyses the relationship between labour productivity, human capital and international R&D spillover over the period 1982–2011 by estimating a single model equation which employs long run cointegration analysis and short run analysis (ECM). The analysis uses annual data from 1982–2011.

Conventional results for international R&D and human capital are found. It is inferred from the significant role played by international R&D that human capital has strongly shaped labour productivity. These results are consistent with all literature surveyed in this research paper, which supports the basic assumption that there is international research and development spillover which is transmitted from industrial countries to developing countries like Egypt. In addition, this spillover affects labour productivity, given the quality of human capital formation in Egypt.

The more developed the educational level of human capital in the industrial sector the more significant role it would play in absorbing international R&D spillover and benefiting labour productivity.

REFERENCES

Borras, B.G., Serrano, D. and Simarro, P. (2011), "Direct and indirect intersectoral knowledge and labour productivity in the Spanish economy", University of Valencia. Retrieved from: www.webmeets.com/SAEe/2011/prog/getpdf.asp?p:d

Bouoiyour, J. (2005), "Labour productivity, technological gap and spillovers. Evidence from Moroccan manufacturing industries", *African Finance Journal*, Vol. 7 No. 2, pp. 1-17.

Cincera, M. and Bruno, P. (2001), "International R&D spillovers: A survey", *Cahier Economiques de Bruxells,* Vol. 69 No. 1, pp. 169-180.

Coe, D. and Elhanan, H. (1995), "International R&D Spillovers", *European Economic Review,* Vol. 39 No. 5, pp. 859-887.

Coe, D., Elhanan, H. and Alexander, H. (1997), "North-South R&D Spillovers", *The Economic Journal,* Vol. 107 No. 440, pp. 134-149.

Coe, D., Elhanan, H. and Alexander, H. (2009), "International R&D Spillovers and Institutions", *European Economic Review*, Vol. 53 No. 7, pp. 723-741.

Cörvers, F. (1997),"The impact of human capital on labour productivity in manufacturing sectors of the European Union", *Applied Economics*, Vol. 29, pp. 975-987. RePEc:dgr:umaror:1996001

Costa, M. and Stefano, I. (2004), "Technology spillover and Regional Convergence Process: A statistical analysis of the Italian case", *Statistical Methods and Application*, Vol. 13 No. 3, pp. 375-398.

Elshamy, H. (2009), "Productivity growth in the manufacturing sector in Egypt", *Conference of the Scottish Economic Society*, held from 22/4/2009 to 24/4/2009, Perth, Scotland.

Gera, S., Wulong, G. and. Frank, L. (1999), "Information technology and labour productivity growth: An empirical analysis for Canada and the USA", *The Canadian Journal of Economics, Working paper series,* (Canada. Industry Canada), Vol. 32 No. 20, pp. 384-407.

Kao, C., Min-Hsien, C. and Bangtian, C. (1999), "International R&D spillovers: An application of estimation inference in panel cointegration", *Center for Policy Research Working Paper (4)* RePEc:max:cprwps:4

Litchtenberg, F. and Brouno, P. (1998), "International R&D Spillovers: A comment", *European Economic Review*, Vol. 42 No. 8, pp. 1483-1491.

McNeil, L. (2007), "The international diffusion of technological knowledge: industry level evidence from Egypt and Morocco", Howard University, Washington DC. Retrieved from www.unidep.org/Release3/.../IDEP-AFEA-07-12.pd

Muller, W. and Michaela, N. (1998), "A panel data analysis: research and development spillover", *Economics Letter*, Vol. 64 No. 1, pp. 39-41.

Sunkwark, N. and Young, S. (2006), "International R&D spillovers revisited: human capital as an absorptive capacity for foreign technology", *International Economics Journal,* Vol. 20 No. 2, pp.179-196.

Wolf, E. and Ishraq, N. (1993), "Spillover effects, linkage structure, and research and Development", *Structural Change and Economic Dynamics*, Vol. 4 No. 2, pp. 315-331.

Zhu, L. and Bang, J. (2007), "International R&D spillovers: trade, FDI and information technology as spillover channels", *Review of International Economics*, Vol. 15 No. 5, pp. 955-976.

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