

## The Impact of Trade-Embodied R&D on Employment

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### Abstract

The main objective of this paper is to examine the relationship between technology spillovers, through import from and export to OECD countries, and employment in 60 developing countries over the period from 2000 to 2010. Most of the literature was concerned with the impact of technology on employment but this paper is concerned with technology spillovers through two different channels, exports and imports. A panel vector autoregressive (PVAR) model has been employed. It has been found that technology spillovers through imports increases job creation while technology spillovers through exports decreases employment.

### أثر التجارة التي تشتمل على البحوث والتطوير على التوظيف

إنجي رؤوف

#### ملخص

الهدف الرئيسي من هذه الدراسة هو دراسة العلاقة بين الآثار غير المباشرة للتكنولوجيا، والتي انتقلت من خلال الاستيراد من والتصدير إلى دول منظمة التعاون الاقتصادي، والتوظيف في 60 دولة نامية خلال الفترة من عام 2000 إلى عام 2010. ووضحت معظم الدراسات السابقة تأثير التكنولوجيا على التوظيف لكنها لم تتناول الآثار غير المباشرة للتكنولوجيا. وقد استخدمت الدراسة Panel Vector Autoregressive model. وقد أكدت الدراسة ان اثر الآثار غير المباشرة للتكنولوجيا من خلال الواردات تؤدي الي خلق فرص عمل جديدة في الدولة حيث انها تساعد على تنفيذ الابتكارات وبالتالي تقوم الدول النامية باستخدام البضائع المستوردة لتطوير منتجات جديدة. بينما يكون اثر الآثار غير المباشرة للتكنولوجيا من خلال صادرات سلبيا على خلق فرص العمل حيث انها تؤدي الى تقليل فرص العمل في الدولة حيث انها تزيد من فرص الابتكار لمواكبه السوق العالمية.

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## 1. Introduction

One of the key drivers of economic growth and hereafter employment level in a country is technology. Improvement in technology, or in other words innovation, increases productivity and hence enhances economic growth. Improvement in technology is defined by Schumpeter as producing products or services or utilizing methods or inputs that are new for firms. There are two different forms of innovation, namely- product innovation and process innovation.

Product innovation means using new knowledge, new industrial design, management, R&D, production and economic activities. While process innovation is concerned with introducing new and more effective operations (Cohen and Levin, 1989). It includes also using new tools, devices, and knowledge which will help to increase factor productivity, and hence reduce costs of production. (Li, et.al, 2007, Gong, 2007).

During expansion, there is excess demand, as a result, entrepreneur has to carry out process innovation in order to increase production of existing products, as these products are well marketed. On the other hand, during recession, entrepreneur has to carry out production innovation in order to produce new products and hence encourage people to demand and hence increase economic growth. (Gong, 2007).

There are some doubts about the impact of improvement in technology in total employment. Most of the empirical studies were concerned with the impact of technology on employment. This study focuses on the impact of technology spillovers on employment. Branstetter (2000) identified that "technology spillovers occurs when "firm "a" is able to derive economic benefit from R&D activity undertaken by firm "b" without sharing in the cost firm "b" incurred in undertaking its R&D".

Technology spillovers is the involuntary and uncompensated transfer or movement of knowledge (ideas and techniques) resulted when investments in knowledge undertaken by one firm positively affect other firms in the same industry and/or in other industries. Technology can be transmitted through four channels, namely- imports, exports, inward FDI and outward FDI. This study is going to be concerned only with exports and imports.

It can be noticed that technology spillovers is another form of technology transfer without payments and it is one of the most important factors that can contribute to the economic growth of any country and hence employment.

The rest of this paper is organized as follows. Section 2 includes a literature review. Section 3 includes a description of how to measure technology spillovers. Section 4 presents the dataset, the variables used in the regression and the specification of the model. Section 5 discusses the econometric procedures employed in the analysis. Section 6 includes a discussion of the results of the estimation.

## 2. Literature review

There are two different points of view regarding the impact of technology on employment. A number of studies- Feenstra and Hong (2007), Hollandars and Weel (2002), Marabet and Lanova (2012), fung (2006), Lachenmaier and Rottmann (2011), Piva and Vivaralli (2005), and Chang and Hong (2006) - believed that technology has a positive impact on employment.

On the other hand, Diaz and Tomas (2002), Collard and Dellas (2007), Mandelman and Zanetti (2014), and Gali (1999) found a negative relationship between technology and employment.

Economists try to find reasons behind the contradictory results of how technology affects employment and. They realized that they have to differentiate between product innovation and process innovation.

Product innovation means that the new technology will help to introduce new product to the market. As a result, this product will have no substitutes. This will have a positive impact on employment as when demand increases, production will increase and hence job creation will increase as well.

Process innovation means using new technology that helps to improve the production process. This type of technology affects employment negatively. It helps to produce the same product using lower amount of resources or more efficiently. (Lachenmaier and Rottmann, 2011)

It can be concluded that relationship between technology and employment is not precise and this is due to differences in the forms of innovation tested in each study in addition to differences in the sample under consideration in each study.

### 3. Measurement of Technology Spillovers

The most important contributors to technology spillovers measurement are Coe and Helpman (1995). Their model is based on the economic growth theories which treat innovation efforts as a major engine of economic growth. Innovation depends on the accumulation of knowledge which results from the firm/ country cumulative R&D experience. They recognized that a country's productivity growth depends on both its own R&D capital stock and its trade partners R&D capital stock. In other words, a country will receive direct and indirect benefits of R&D. The direct benefits include learning about new technology, production techniques and organizational methods. The indirect benefits result from imports of goods and services, produced by country's trading partners.

Coe and Helpman used cumulative R&D expenditure as a proxy of stock of knowledge. A country's stock of knowledge is constructed as the weighted sum of R&D spending of the country. Coe and Helpman (1995) define the foreign R&D capital stock as "the import-share-weighted average of the domestic R&D capital stock of trade partners" (Coe and Helpman, 1995: 863). It is calculated as in (1).

$$S_{it}^f = \sum_j W_{ijt} S_{jt}^d \quad (1)$$

Where:

$j$  = a set of countries which transmit knowledge to country  $i$ , = domestic R&D capital stock, represents foreign R&D capital stock (trading partners' stock of knowledge), and  $t$  = time, and  $W_{ij}$  = the weight or the fraction of country  $j$ 's R&D that transmits to country  $i$ .

Coe and Helpman calculated this weight as the share of imports from country  $j$  to total imports.

$$W_{ijt} = \frac{m_{ijt}}{\sum_{j \neq i} m_{it}} \quad (2)$$

$$S_{it}^{f-CH} = \sum_{j \neq i} \frac{m_{ijt}}{m_{it}} S_{jt}^d \quad (3)$$

Equation (3.3) states that the more country  $i$  imports from high R&D expenditure countries, the more R&D spillovers country  $i$  will receive, keeping other things constant (Coe and Helpman, 1995: 859, 860, 862, 863; Xu and Wang, 2000: 4, 5).

Lichtenberg and de la Potterie (1996) modified Coe and Helpman model. Lichtenberg and de la Potterie believed that the weights formula used by Coe and Helpman model suffers from aggregation bias. Their weight formula does not reflect the level of imports – i.e. they noticed that  $m_i = \sum_j m_{ij}$ .

Lichtenberg and de la Potterie (LP) developed another formula to calculate the weights. This new formula proved to be more appropriate theoretically and empirically. It takes into account country's propensity to import. LP new formula takes the following form

$$W_{ijt} = \frac{m_{ijt}}{y_{it}} \quad (4)$$

Where

$y$  = country's GDP.

This formula allows the elasticity of imports to vary across countries.

$$S_{it}^{f-LP} = \sum_{j \neq i} \frac{m_{ijt}}{y_{it}} S_{jt}^d \quad (5)$$

This means that the higher the total imports, the more benefits domestic economy will receive from foreign R&D. Lichtenberg and de la Potterie believed that this formula seems to be more robust. It gives a higher explanatory power in the regression of total

factor productivity. The second important contribution made by Lichtenberg and de la Potterie is that they took into account another channels of technology spillovers. They took into account inward and outward FDI. (Lichtenberg and de la Potterie, 1996:1-3, 10-13; Lichtenberg and de la Potterie, 1998: 1484-1485).

#### 4. Model Specification and Data Sources

This study examines the impact of R&D spillovers through trade on employment. It focuses on export and import embodied R&D and their impact on employment. This study depends on longitudinal data for 60 developing countries over the period from 2000 to 2010 and their bilateral trade with fifteen OECD countries. The selection of these countries was due to the availability of data.

A Panel Vector Autoregressive (PVAR) model will be used in this study. The VAR model shows the dynamic interaction between a number of time series variables. It helps to detect the statistical relationship among these variables. (Adenomon, et.al, 2013).

A PVAR system can be expressed as follows.

$$\log(Y)_{it} = A_1 \log(Y)_{1t-1} + \dots + A_p \log(Y)_{it-p} + \varepsilon_t \quad (6)$$

Where:

$Y_{it}$  is a vector of endogenous variables at time  $t$  and for country  $i$ .  $A_i$  is the coefficient vector;  $i = 1, 2, \dots, p$ .

The vector of endogenous variables is given by:

$$Y_{it} = [emp_{it}, ex_{it}, imp_{it}, exsp_{it}, impsp_{it}, GDP_{it}, GFCF_{it}] \quad (7)$$

Where:

$emp_{it}$  is the percentage of employed people to total population for country  $i$  at time  $t$ ;  $ex_{it}$  is the flow of exports of goods and services of country  $i$  to country  $j$  at time  $t$ ;  $imp_{it}$  is the flow of imports of goods and services of country  $i$  from country  $j$  at time  $t$ ;  $GDP_{it}$  is the gross domestic product of country  $i$  at time  $t$ ;  $GFCF_{it}$  denotes gross fixed capital

formation for country  $i$  at time  $t$ ;  $impsp_{it}$  denotes the import-share-weighted average of the domestic R&D capital stocks of trade partners;  $exsp_{it}$  denotes the export-share-weighted average of the domestic R&D capital stocks of trade partners.

Employment, inflation rate, GDP and gross fixed capital formation data have been collected from World Bank database. Bilateral sectoral imports and exports data have been collected from the Comtrade database.

In constructing the variables, following Schiff, et al (2002), imports embodied R&D spillovers is represented by:

$$IMP_{it} = \sum_{j=1}^{20} \left[ \frac{M_{ijt}}{VA_{it}} RD_{jt} \right] \quad (8)$$

Where:

$t$  denotes a time index,  $t = 2000, 2004, \dots, 2010$ ;  $i$  denotes a country index,  $i = 1, 2, 3, \dots, 20$ ;  $M_{ijt}$  denotes imports of country  $i$  from country  $j$ ;  $VA_{it}$  denotes the amount of value added of country  $i$ ; and  $RD_{jt}$  denotes the R&D stocks of country  $j$ 's in time  $t$ .

Schiff et al (2002) used value added in the denominator instead of the level of output used by Lichtenberg and de la Potteri (1998) and as the study aims to measure impact on employment level, which is one of the factors of production, then the value added will be more appropriate.

Exports is going to affect employment through learning by exporting as exporters try to close the gap between domestic production quality and foreign production. At the same time, foreign countries (importers) often provide technical assistance and product design to their suppliers (exporters) in order to increase the quality of imported goods, and they may transmit knowledge from other suppliers located to their foreign suppliers (Epifani, 2003). Moreover, Exports are considered as opportunities make more profit through the adoption of new technologies. This means that R&D are embodied in exports as well as imports and they can affect employment. Using the same methodology technology spillovers through exports are calculated as follows: (Raouf, 2013).

$$EXP_{it} = \sum_{i=1}^{20} \left[ \frac{X_{ijt}}{VA_{it}} RD_{jt} \right] \quad (9)$$

Where:

$X_{ijt}$  denotes exports of country  $i$  to country  $j$  at time  $t$ .

Now we are doing to turn the estimation of the econometric model described in section 4.

### 5. Estimation Results

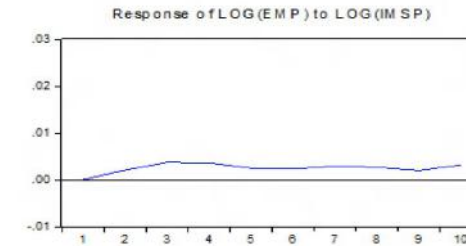
Stationarity problem should be considered before turning to econometric analysis. If the variables have unit roots, then the regression results will be spurious. Levin and Lin (1992, 1993) developed a specific procedure to test for panel data unit roots.

Table 1 : Unit root test

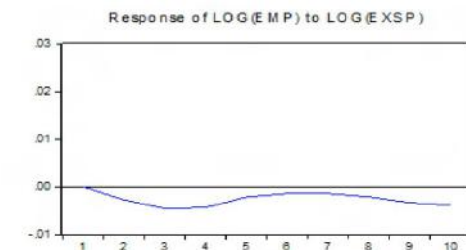
Variable	Levin, Lin , Chu t*	Prob
Log(emp)	-6.0578	0.0000
Log(imp)	-7.58513	0.0186
Log(ex)	-6.96644	0.0000
Log(impssp)	-5.62453	0.0000
Log(expsp)	-7.82025	0.0000
Log(GFCF)	-12.6241	0.0000
Log(GDP)	-3.51448	0.0002

From table 1, it can be concluded that the null hypothesis that there is unit root is rejected and the alternative is accepted. In other word, all variables are stationary.

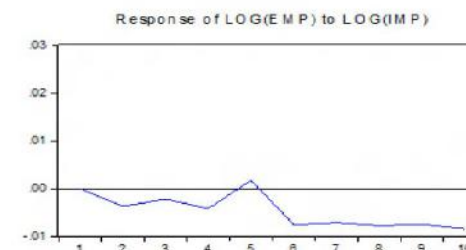
A VAR model has been constructed with six lags and unrestricted constant.



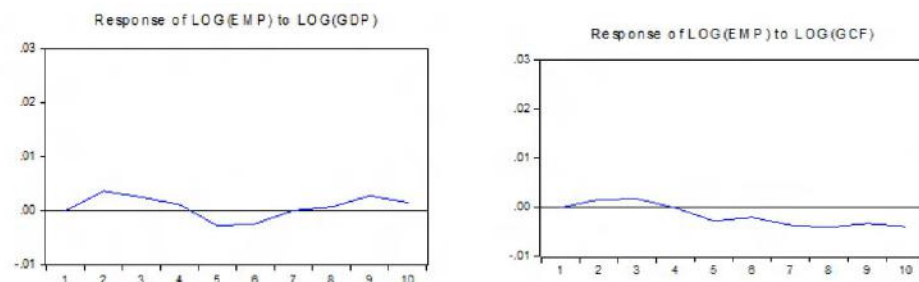
Panel 1 characterizes the response of the economy to 1% increase in the technology that spills through imports. As import embodied R&D increases, new jobs will be created which means that technology spillovers through imports has positive impact on employment. This means that technology spillovers through imports is a kind of product innovation as new product is going to be introduced to the market.



Panel 2 shows the response of the economy to 1% increase in the technology that spills through exports. Technology spillovers through exports will have negative impact on job creation as old jobs will be more obsolete. This form of spillovers is considered to be process innovation.



Panel 3 indicates that a 1% increase in imports will have negative impact on employment in the importing countries. Panel 4 indicates that a 1% shock in exports will have positive impact on job creation.



A 1% shock in GDP in general has a positive impact on job creation expect over the 5<sup>th</sup> and 6<sup>th</sup> year and it can be noticed that during the same period imports is going to increase and exports is going to decrease. Finally, a 1% increase in capital stock is going to have positive impact on the short run but this impact is going to deteriorate and then become negative in the long run.

## 6. Conclusion

The main objective of this paper is to investigate the linkage between technology spillovers and employment in 60 developing countries over the period from 2000 to 2010. I focused mainly on two channels of technology spillovers, namely– import and exports. It has been found that technology spillovers through imports help to carry out product innovation which means that developing countries use the imported goods to develop new products. With respect to technology spillovers through exports, it has been found that it encourages process innovation which means it affects employment negatively.

It has been found that exports have positive impact on employment; while imports have negative impact which means if the country has a trade deficit, employment will be affected negatively. With respect to capital, it has positive impact on the short–run but one the long run it is going to affect employment negatively.

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