Economics Working Paper Series

2020/006

The Impact of Foreign Technology & Embodied R&D On Productivity in Internationally-Oriented & High-Technology Industries in Egypt, 2006-2009

S. Elkomy, H. Ingham and R. Read

The Department of Economics
Lancaster University Management School
Lancaster LA1 4YX
UK

© Authors
All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission, provided that full acknowledgement is given.

LUMS home page: http://www.lancaster.ac.uk/lums/

The Impact of Foreign Technology & Embodied R&D On Productivity in Internationally-Oriented & High-Technology Industries in Egypt, 2006-2009

S. Elkomy*, H. Ingham** & R. Read**

*School of Economics, University of Surrey, Guilford, GU2 7XH. s.elkomy@surrey.ac.uk.
**Department of Economics, Lancaster University, Lancaster LA1 4YX.
h.ingham@lancaster.ac.uk.
***Department of Economics, Lancaster University, Lancaster LA1 4YX.
r.read@lancaster.ac.uk.

Abstract

This paper investigates the domestic productivity and spillover effects of foreign technology and embodied R&D on Egyptian manufacturing industries, 2003 to 2009. It also analyses the heterogeneous sectoral effects of technology transfer by focusing specifically on the productivity effects on highly internationalised and technology intensive industries. These are expected to have greater absorptive capacity with respect to foreign technology and therefore greater productivity effects because of their greater exposure to foreign competition and greater technological capacity respectively. The study is the first to analyse the efficiency effects of foreign technology by classifying industries in this manner. The study finds that foreign technology and embodied R&D have positive and significant industry-specific effects on domestic productivity and TFP in technology intensive industries but these are weaker in internationally-oriented industries. The findings suggest that only the technological intensive industries in Egypt have sufficient absorptive capacity to assimilate foreign technology effectively. The paper's findings highlight the key role of foreign technology in domestic productivity growth, subject to the absorptive capacity of the domestic labour force, and the need for improved policies to promote the domestic benefits of technology transfer through the accumulation of local technological competences.

1. INTRODUCTION

The transfer of foreign technology is a critically important conduit for developing countries to acquire advanced techniques and innovations in order to improve productivity and increase economic growth. The effectiveness of such transfers through learning and their efficient utilisation however, is highly dependent upon the absorptive capacity of a host country's human capital stock and the magnitude of the technology gap with the source country. Industrialised economies have invested heavily in R&D and human capital to develop innovative production methods and proprietary technology resulting in both technological progress and the accumulation of substantial stocks of knowledge. Many developing countries have acquired foreign technology embodied in inflows of foreign direct investment (FDI) and/or imports of capital equipment but these transfers have generally been less successful in that they have not stimulated the anticipated improvements in productivity. The economic growth effects of technological progress in developing countries are argued to be subject to critical constraints that are not present in most industrialised economies. In particular, persistent and unresolved structural and institutional constraints and impediments to innovation and technical advancement, including a lack of appropriate policies to foster the accumulation of relevant knowledge necessary for the successful adoption of new technologies.

This paper analyses the effects of the transfer of foreign technology and its embodied R&D on domestic industrial productivity in developing countries with respect to Egypt, 2006 to 2009. The paper follows Reggiani and Shevtsova (2018) in testing the importance of existing technological capacity and whether foreign technology and its embodied foreign R&D generate heterogeneous domestic productivity effects and technology spillovers between industries. This is accomplished by classifying industries according to their openness to trade and technological intensity. Those sectors that are more internationally-oriented and have a greater degree of technological intensity can be expected to possess a greater capacity to adapt more advanced foreign technologies – i.e., greater absorptive capacity – and therefore generate larger beneficial learning and efficiency spillover effects. By grouping Egyptian manufacturing industries in this manner, this study is the first to capture the effect of industry-level stocks of international R&D using the unbiased weighting approach suggested by Lichtenberg and de la Potterie (1998).

The next section presents an overview of the relevant literature on channels through which advanced foreign technologies are transferred to developing countries and the determinants of

their productivity effects. This is followed by a discussion of the estimation methods utilised in the paper and a description of the data. The empirical results and their implications are discussed in Section 5. Some conclusions and policy implications are presented in the final section.

2. THEORETICAL FOUNDATION AND REVIEW OF THE LITERATURE

Endogenous growth theory regards the international transfer of innovation and advanced technology as a critically important determinant of long-run economic growth, particularly for those countries lacking in indigenous R&D – i.e., developing countries. Analogous to the 'catch-up' theory of growth (Gerschenkron, 1962), the rate of technology diffusion will be more rapid the greater the extent of the technological gap with advanced economies. The primary determinant of variations in growth rates across countries is differences in total factor productivity (e.g., Easterly and Levine, 2001; Caselli, 2005) which are attributable, in great part, to national policies (Beck *et al*., 2000), including international trade and foreign direct investment (FDI). Trade and FDI are the principal channels for the diffusion of technological progress between countries, with foreign innovations and technologies being embodied in inflows of capital goods, intermediate products and final goods and services (see, for example, Coe and Helpman, 1995; Keller, 1998; Hejazi and Safarian, 1999; de la Potterie and Lichtenberg, 2001). These inflows may also generate positive technology spillovers through learning by doing and demonstration effects (Javorcik, 2004). The magnitude of such spillovers however, depends upon the extent to which such tacit knowledge can be assimilated; i.e., domestic absorptive capacity.

Although many developing countries have acquired foreign technology through trade and FDI, the empirical evidence indicates that this has not necessarily led to the anticipated improvements in domestic productivity. (e.g., Khan and Reinhart, 1990; Lee, 1995; Mazumdar, 2001; Caselli and Wilson, 2004; Ajakaiye and Page, 2012; Nwaogu and Ryan, 2015; Koo and Perkins, 2016). The principal explanation for this shortfall in performance is the poor quality of policy design and implementation to promote knowledge accumulation necessary for the adoption of more advanced technologies (Lall and Wangwe, 1998; Lall and Pietrobelli, 2002; Hanushek, 2013; Koo and Perkins, 2016). Nevertheless, the main driver of technological change in developing countries has been imports of capital goods and technology spillovers (Lall and Wangwe, 1998). The notable success of many high growth economies in Southeast Asia in recent decades is the outcome of explicit policies to fundamentally transform their

levels of technological sophistication and the magnitude and quality of their human capital stocks.

Technological progress and growth in developing countries are partly dependent upon their openness to both international trade and FDI, which are themselves correlated. Bhagwati (1978) argues that greater openness to trade attracts increased inflows of FDI while the growth effects of FDI increase with trade openness. Several studies find support for this latter relationship for developing countries (Balasubramanyam *et al*., 1996; de Mello, 1999; Read, 2008) although Borensztein *et al*. (1998) also suggest that this growth is a non-linear function of domestic absorptive capacity; i.e., it is dependent upon a minimum threshold stock of human capital. Further, Lichtenberg and de la Potterie (1998) demonstrate that the growth effects of foreign R&D are greater the more open to trade is the host economy.

The effects of technology transfer and spillovers on domestic productivity are analysed in an extensive empirical literature. The accumulation of imported capital contributes significantly to technological progress in developing countries (Brada and Hoffman, 1985), including the generation of significant technology spillovers (Coe *et al*., 1995). Imported technologies and new varieties of intermediate goods are also associated with higher manufacturing productivity resulting from increased specialisation in production (Grossman and Helpman, 1991). Most cross-country studies investigating the effects on recipient countries, both industrialised and developing, find significant support for positive domestic productivity effects of foreign technology, both directly as a result of technology transfers but also as a result of spillovers (e.g., Coe and Helpman, 1995; Lee, 1995; Lichtenberg and de la Potterie, 1998; Hejazi and Safarian, 1999; Keller, 2000, 2004; Mazumdar, 2001; Caselli and Wilson, 2004; Cecchini and Lai-Tong, 2008). The findings at the individual country level are broadly similar, although the effects tend to be heterogeneous, with larger productivity growth in those sectors with greater technological intensity. Evidence for India shows that foreign technology in chemicals, pharmaceuticals, electronics and machinery generate significant positive productivity effects (Hasan, 2002). Lower technology sectors however, derive larger productivity effects from additional domestic capital. Further, more productive firms experience significantly positive efficiency effects arising from foreign technologies (Bas and Berthou, 2017). In China, only those industries close to the technological frontier are found to generate significant productivity spillovers from foreign technology (Chuang and Hsu, 2004). Evidence from Hungary offers support for Grossman and Helpman (1991) and the availability of additional varieties of intermediate inputs (Halpern *et al*., 2006).

The host country growth effects of technology transfer depend upon the extent of the technology 'gap' with the source country and, by implication, the absorptive capacity of domestic human capital to assimilate more advanced technology (Glass and Saggi, 1998). The 'relative backwardness' hypothesis, according to which technologically laggard countries exhibit faster growth via diffusion (Findlay, 1978; Wang and Blomström, 1992) however, receives only limited empirical support. In an analysis of manufacturing productivity in 27 industries across seven Asian economies, Chamarbagwala *et al.* (2000) find that the growth effects of foreign technology are greater for more technologically sophisticated countries; i.e., those with more abundant human capital and skilled labour. Malikane and Chitambara (2017) test the effects of the technology gap and growth for 45 African economies 1980-2012 but find no evidence to support more rapid catch-up. In Chile, only import-competing manufacturing sectors exhibited positive productivity gains from innovation and technical progress channelled by foreign trade in the late 1970s and early 1980s and gave rise to a reallocation of domestic resources (Pavcnik, 2002). Similarly, Bloom *et al.* (2016) find significant productivity gains through increased innovation and advanced technologies for European firms as a result of increased Chinese import competition.

Building on the work of De Long and Summers (1993), Temple and Voth (1998) and Hendricks (2000) suggest that the productivity effects of adopting superior technology in the presence of human capital are considerable. The critical issue is whether the absorptive capacity of the human capital stock is sufficient for the optimal adoption of foreign technologies. Further, inflows of foreign technology may significantly enhance the domestic skill base, particularly in more trade-oriented and import-competing sectors. Burstein *et al.* (2013) demonstrate that advanced foreign technology tends (unsurprisingly) to be skill-biased, with knock-on effects on labour demand and possible 'crowding out', as in the cases of Ireland (Barry and Bradley, 1997), Fiji and Samoa (Driffield and Read, 2004). Productivity gains arise from the shift of domestic factors into more skill-intensive sectors – as per Pavcnik above – along with a significant increase in the skill premium (Burstein and Vogel, 2017).

Technology spillovers via backward or upstream vertical linkages between foreign firms and local suppliers are regarded as an important additional means of generating beneficial domestic productivity effects (Javorcik, 2004). Again, the magnitude of such spillovers depends upon the technology gap, domestic absorptive capacity and the willingness of foreign affiliates to create such linkages (Glass and Saggi, 1998). Horizontal spillovers however, are far less likely owing to the risk of loss of proprietary technology (Javorcik, 2004; Kugler, 2006; Blalock and

Gertler, 2008). The empirical findings of studies of inter-industry spillovers of foreign technology on domestic productivity are mixed. The stock of foreign technology in India is found to generate positive domestic productivity spillovers in 13 out of 26 manufacturing sectors (Kathuria, 2000). Further, analyses of the impact of the 1991 Indian economic reforms on manufacturing find significant increases in productivity in import-competing manufacturing sectors (Topalova and Khandelwal, 2011) as well as for 'scientific' (i.e., technology-intensive) domestic firms but negative for 'non-scientific' ones (Kathuria, 2002). These findings contrast with those of Keller and Yeaple (2009) for the United States, where productivity spillovers from imports are insignificant. One explanation for these differential results is the magnitude of the gap between domestic and foreign technologies, which might be expected to be large for India but small or negative for many US industries.

The absorptive capacity of host economies to assimilate foreign technology is also determined by government policies as well as infrastructure and industry characteristics (Furman *et al.*, 2002). Investment in domestic human capital enhances countries' abilities to adapt new technologies and their innovative capacity (Furman and Hayes, 2004). Many industrialising economies are investing heavily in human capital formation, particularly in science and technology, to stimulate domestic R&D activity and reduce their technology gap through imitation and reverse engineering (Alvarez and Robertson, 2004; Almeida and Fernandes, 2008). The R&D embodied in foreign technology has significant indirect spillover effects on domestic innovation (Katrak, 1990; Lumenga-Neso *et al.*, 2005; Schiff and Wang, 2008) while for Chinese firms, the productivity effects of foreign technology depend, at least partly, upon interaction with in-house R&D (Hu *et al*., 2005; Liang and Zhang, 2012).

Technology spillovers are also argued to enhance the competitiveness of domestic firms although this depends upon a small technology gap (Cantwell, 1989; Kokko, 1994), a greater absorptive capacity of labour, competitive intensity (Sjöholm, 1999), level of internationalisation (Baily *et al*., 1995; Xu and Sheng, 2012) and the rate of adoption by competitors (Evenson and Westphal, 1995). Firms that are less trade-oriented however, are also shown to have greater scope to benefit from foreign technologies (Blomström and Sjöholm, 1999); i.e., to improve their efficiency. A major constraint for domestic firms may be the cost of acquisition along with the negative output effects of any initial learning period, even for standard technologies (Amiti and Khandelwal, 2013). It is important to note however, that competition spillovers may be negative if domestic firms are 'crowded out' by more efficient

foreign affiliates, particularly where the market is limited as in small and/or developing countries (see Driffield and Read, 2004; Read, 2018).

In an early study of Egypt, Karake (1988) finds that the domestic productivity impact of Western capital in the period 1952-85 was substantially greater than that of Eastern European and domestic capital. The contribution of total factor productivity to output growth was small relative to that of physical inputs, suggesting that foreign technology had little effect on the productivity of domestic labour. Massoud (2008) analyses the growth effects of FDI in three sectors in Egypt 1974-2007 and finds that these are positive only for manufacturing and then only when interacting with human capital. Hanafy (2015) finds similar results although without positive interaction effects with human capital in manufacturing. Elkomy *et al*. (2018) find that the FDI in Egypt 1990-2007 has positive growth effects in resource-based sectors but negative ones in services, suggesting possible crowding out of domestic investment and a lack of absorptive capacity.

The current paper empirically examines the effect of foreign technology and foreign innovative capital stock – measured by foreign R&D – on productivity in Egyptian manufacturing with reference to their differential sectoral and internationalisation characteristics. By incorporating these variables in a production function, this approach is intended to capture the efficiency effects and indirect knowledge spillovers of foreign technology not fully accounted for by physical capital accumulation. In so doing, it tests three specific research questions: to what extent are foreign technology and its embodied R&D in Egypt associated with productivity effects and efficiency spillovers as a result of knowledge transfers?; are more internationally-oriented domestic firms better able to transform foreign technological innovations into improved performance?; and do domestic firms in more technology-intensive sectors exhibit positive efficiency spillovers from foreign technology?

3. METHODOLOGY

This study follows Aslanoglu (2000), Liu *et al.* (2000) and Driffield and Love (2007) in estimating the following logarithmic regression equation:

$$\ln LP_{it} = \delta_0 + \delta_1 \ln KL_{it} + \delta_2 \ln ML_{it} + \delta_3 \ln WL_{it} + \delta_4 \ln WCL_{it} + \delta_5 \ln Firmsize_{it} + \delta_6 \ln Foreign\,Tech_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (1)$$

Where: *LP* is labour productivity, i.e., the ratio of gross value added by total labour employed in industry i; *Foreign Tech* is foreign capital imports per employee, measured as the annual

flow of investment in purchases of foreign machinery and equipment per worker. δ_6 is the main coefficient of interest since, if *Foreign Tech* has a positive and significant impact on labour productivity, domestic industries are able to assimilate advanced imported technologies efficiently.

ML is total materials per unit of labour and *KL* is the capital-labour ratio, measured as the share of fixed capital assets to labour. *Firmsize* is the average revenue per firm in each industry, reflecting market structure and some market characteristics (Liu *et al.*, 2000; Melitz, 2003; Luttmer, 2007). Melitz details the theoretical foundation of examining the effects of trade on industrial productivity as well as the linkages between aggregate productivity in each industry and specific industrial factors, including a proxy for firm size measured as revenues (or profits) according to the number of firms in each industry. Large firm size is expected to generate productivity gains owing to lower average costs arising from economies of scale.

The skill-intensity of labour is measured by two proxy variables: wages (WL), calculated as total remuneration per unit of labour; and the white-collar labour ratio (WCL), measured as the ratio of white-collar workers to total employment. White collar labour includes entrepreneurs, managers, technicians, specialists, administrators and secretaries. These two proxy variables control for an industry's capacity to adopt advanced foreign technologies (Buckley *et al.*, 2002; Sinani and Meyer, 2004, and Rosell-Martinez and Sanchez-Sellero, 2012). White collar labour identifies labour with certain educational levels and technical abilities, while the average wage rate reflects the mean skill level of labour (Globerman, 1979; Balasubramanyam *et al.*, 1999). Since all variables are in logs, the coefficient estimates denote elasticities while μ_i are industry-specific effects, ν_t are time-specific effects and ε_{it} is the random error term.

In addition, the model tests for the impact of foreign R&D stock embodied in imported capital on domestic labour productivity using the following empirical specification:

$$\ln LP_{it} = \delta_0 + \delta_1 \ln KL_{it} + \delta_2 \ln ML_{it} + \delta_3 \ln WL_{it} + \delta_4 \ln WCL_{it} + \delta_5 \ln Firmsize_{it} + \delta_6 \ln Foreign\ R\&D_{it} + \mu_i + \nu_t + \varepsilon_{it} \quad (2)$$

In Equation (2), *Foreign R&D* replaces *Foreign Tech* to test for the presence of productivity spillovers of foreign R&D arising from imports of foreign capital. This captures the indirect productivity spillovers from new foreign machinery and equipment that accrue from the transfer of new technologies, new intermediate products and the expansion of the variety of inputs. Although cross-country foreign R&D spillovers are examined in the literature (e.g., Lichtenberg and de la Potterie, 1998; Xu and Wang, 1999; Cecchini and Lai-Tong, 2008), the

productivity effects of *Foreign R&D* are examined here at the industry level. In order to do this, the unbiased weighting scheme suggested by Lichtenberg and de la Potterie (1998) is employed which provides a correction to the empirical framework, as proposed by Coe and Helpman (1995). *Foreign R&D* in industry *i* in year *t* is therefore calculated as:

$$Foreign\ R\&D_{it} = \frac{CM_{it}\, S^d_{it}}{Y_{it}} \quad (3)$$

Where: CM_{it} refers to total capital imports; S^d_{it} is the total R&D stock in all OECD countries in industry i in year t; and Y_{it} is the total output of that industry in all OECD countries[1]. This formula corrects for the bias in the weighting scheme by reflecting both the intensity and the direction of industry flows of R&D, hence multiplying foreign technology by the OECD R&D/output ratio in each industry.

Foreign R&D capital stock is computed from the annual R&D investment for each industry using the permanent inventory method:

$$S^d_{it} = \frac{I_{it}}{1-[(1-\lambda)/(1+r_t)]} \quad (4)$$

Where: I_{it} is the R&D investment in industry i in year t; r_t is the annual growth rate of annual R&D investment; and λ is the depreciation rate, which is assumed to be 10 percent per year (Cecchini and Lai-Tong, 2008). Imports of capital machinery and equipment from OECD countries constitute, on average, 76 percent of Egypt's total capital imports from 2000 to 2010 (UNCTAD, 2013). This suggests that foreign R&D stocks embodied in capital imports from the OECD may be an important channel for technology spillovers.

The analysis uses individual 2-digit industrial R&D and output data for the 25 OECD countries from the OECD's Analytical Business Enterprise Research & Development (ANBERD) and Structural Analysis (STAN). The aggregate variable for the *Foreign R&D* is constructed as explained above. While it would be desirable to have the data for Egyptian capital imports disaggregated by industry and country of origin to reflect the relative weight of foreign innovation by each country of origin, these are not available. Instead, the proxy measure discussed above is used, representing foreign technological intensity and the scale of international innovation in each industry channelled through capital imports.

---

[1]i.e., Australia, Austria, Belgium, Canada, Czech Republic, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, S., Mexico, Netherlands, Norway, Poland, Portugal, Slovenia, Spain, United Kingdom and United States.

The use of panel data enables a comparison of the results, both with and without controlling for unobserved heterogeneity by industry, using industry fixed effects. The reporting of the results proceeds sequentially. First, any fixed effects are excluded; second, they are included to control for average heterogeneity per industry. These effects control for any industry-specific, time-invariant, variation. In order to examine the validity of the fixed effects approach vis-à-vis the random effects model, the Hausman test is employed which, in essence, tests for correlation between the regressors and the fixed effects. Here, the null hypothesis of no correlation is rejected, suggesting that the fixed effects model is the preferred specification. All of the regressions reported below include standard errors clustered by industry; this controls for heteroskedasticity and correlation of the error terms within each industry.

There is a potential endogeneity problem in estimating equations (1) and (2). While the productivity of labour may depend on *Foreign Tech*, capital imports may also depend upon labour productivity. If such endogeneity exists, it would bias the results. In addition to conventional OLS and fixed effects estimates therefore, a Two-Stage Least Squares method (2SLS) instrumental variables approach is used to test for this simultaneity bias. The results from the endogeneity test are presented in Appendix Table A1. Following Wang (2010), a one-year lag, the square of the one-year lag and the two-year lag of capital imports are used as instruments. The Table shows the F-statistic of the excluded instruments in the first stage regression. This test validates the use of these instruments and shows a high degree of correlation with the instrumented variables. The Sargan Test for over-identification does not reject the null hypothesis of no correlation between the instruments and the error term, suggesting that the instruments are valid. A Durbin-Wu-Hausman Test is also performed to test statistically for the endogeneity problem. The results show that the null hypothesis of no significant difference between the two coefficient vectors of the 2SLS and FE procedures cannot be rejected. There is therefore little statistical evidence of the endogeneity problem in the dataset. A Generalised Methods of Moments (GMM) estimation is also conducted to deal with any potential simultaneity between labour productivity and the covariates, as discussed in Section 5.

4. DATA

The analysis here employs of a panel of 128 four-digit ISIC (International Standard Industrial Classification) industries comprising the whole manufacturing sector in Egypt, 2006 to 2009. The source for the data is Egypt's *Annual Census of Industrial Production in Private*

Establishments issued by the Central Agency for Public Mobilization & Statistics. The census includes data on the number of firms, classification of employment by job, total remuneration and wages, value added, costs of factors of production, domestic and foreign capital formation and fixed assets. On average, around 9,500 establishments are covered in each year. As stated earlier, the foreign R&D measure is obtained from the OECD's ANBERD and STAN databases. The R&D measure is available for 30 two-digit ISIC industries and it is assumed that all four-digit industries within each two-digit industry classification have the same level of R&D. The measure of R&D intensity is the ratio of R&D expenditure to total value added per industry in current PPP prices. All nominal values are converted into real terms using the wholesale price index from the *World Development Indicators* (World Bank, 2012) since producer price index data by industry is not available.

[TABLE 1 HERE]

In terms of industrial structure, Crude Petroleum & Natural Gas Extraction contributes 84 percent of the total value added in the manufacturing sector. Pharmaceuticals is the second largest industry in terms of value added, followed by Coke & Refined Petroleum Products, Basic Metals and Non-Metallic Mineral Products. As noted by Page (2012), the absence of manufacturing sector diversification and the lack of industrial sophistication are critical impediments to sustained economic growth in developing countries.

Data for labour productivity (*LP*), capital intensity (*KL*), *Foreign Tech* and value-added share (*VA*) for the two-digit industry classification based on ISIC Revision 4 are shown in Table 1. It should be noted that the sample includes all industrial activities being undertaken by private entities in the Egyptian economy. The Egyptian annual census of manufacturing also produces data for Mining & Quarrying and Agriculture (e.g., ISIC 06, 08 and 09), including Crop & Animal Production (ISIC 01) and Remediation Activities (ISIC 39) that falls under Water Supply. Crude Petroleum & Natural Gas extraction is the most productive industry, followed by the Printing & Media Products, Coke & Refined Petroleum Products and Non-Metallic Mineral Products. The most productive industries are therefore extractive industries. The table also shows a positive association between labour productivity and the capital-labour ratio (the correlation is 0.82; see also Table 3). Those industries with relatively high shares of capital imports however, are not necessarily characterised by high capital-labour ratios or high productivity. Remediation Activities, Paper, Computers, Electronic & Optical Products and Basic Metals exhibit the highest *Foreign Tech* share. Nevertheless, the Crude Petroleum &

Natural Gas Extraction, Basic Metals, Chemicals and Paper industries together constitute 67 percent of the total foreign imported capital in the manufacturing sector. This indicates both the large relative size of the crude petroleum industry and the high capital import shares of the other industries.

The industries in Table 1 are also classified into two categories based upon their trade share relative to real value added and technological orientation. Industries are classified as internationally-oriented if they have a minimum of a 40 percent trade share of value added, which is the 50th percentile. High-tech industries are those with a relatively high technological endowment, based upon the OECD classification. Medium-tech and high-tech industries are grouped together in line with Carroll *et al*. (2000), with low-tech industries defined as having a R&D intensity in production lower than 0.34 percent (Hatzichronoglou, 1997).

Table 2 presents the descriptive statistics for the variables used in the analysis. In most cases, the mean is much larger than the median, suggesting that the variables are right-skewed; hence estimating the model in natural logs gives better statistical properties. Mining Support Services showed no spending on total materials and zero revenue, since this industry is monopolised by one public firm, whereas the sample data is for private firms. In this industry as well as Water Supply & Treatment, there is no investment in foreign machinery and equipment.

[TABLE 2 HERE]

Table 3 reports the correlation coefficients between the variables used in the analysis. The dependent variable, labour productivity, is positively correlated with all of the explanatory variables and is especially highly correlated with the capital-labour ratio and *Foreign Tech*. In the report of the regression analysis in the next section, these positive correlations are explored to see whether they hold up in multivariate analysis. Most of the explanatory variables are only weakly correlated with each other, which reduces the likelihood of multicollinearity being a problem for the analysis.

[TABLE 3 HERE]

5. ESTIMATION RESULTS

This section summarises the estimation results and the principal findings of this study.

5.1 THE IMPACT OF FOREIGN TECHNOLOGY & R&D ON PRODUCTIVITY

The estimation results for the various model specifications testing the first hypothesis regarding the impact of foreign technology and embodied R&D on productivity in Egypt based upon Equations 1 and 2 are presented in Table 4. All standard errors reported are clustered by industry. The Ordinary Least Square (OLS) results are shown in Columns (1) and (2) while those in Columns (3) and (4) include industry Fixed Effects (FE) from the panel analysis.

[TABLE 4 HERE]

The results in Column (1) show that *Foreign Tech* has a positive and significant effect on domestic industrial productivity in Egypt. This implies that foreign technology induces significant indirect productivity gains and efficiency spillovers that exceed the effect on physical capital accumulation. When controlling for industry fixed effects in Column (3) however, *Foreign Tech* becomes statistically insignificant. This implies that a large part of the positive effects obtained in Column (1) reflects unobserved industry-specific productivity determinants (Lee, 1995). The *Foreign R&D* stock embodied in foreign technology is statistically insignificant in both OLS and FE estimations, shown in Columns (2) and (4) respectively. This suggests that Egyptian industries generally lack the human capital and in-house R&D capacity to capture the productivity effects embodied in foreign R&D, echoing the findings of Hanafy (2015). The capital-labour ratio (*KL*) has a robust significant positive effect on labour productivity across all specifications of the model and has the largest the coefficient estimate. A one percent increase in the *KL* ratio results in an average increase in labour productivity of approximately 0.6 percent. Physical capital accumulation is therefore an important contributor to industrial productivity in Egypt and industries characterised by relatively high productivity are those with the highest capital-labour ratios. This finding is similar to that of Karake (1988) for the period 1952-85. The results for the materials-labour ratio *ML* show a consistently negative coefficient although it in the specifications of the model without industry fixed effects. The average wage bill *WL* has a positive and significant effect on labour productivity; a one percent increase in the average wage bill increases labour productivity by an average of 0.15 to 0.17 percent. This suggests that more highly skilled labour, reflected in higher wages, is more productive. The ratio of white collar to total employment *WCL* has a consistently positive, but insignificant, effect on labour productivity. This finding refutes the general view in the literature that higher concentrations of white-collar workers enhance labour productivity. The correlation between *WL* and *WCL* (Table 2) is 0.33 such that these two variables are not highly correlated. Significant labour productivity gains are also found for larger average firm size (*Firmsize*), indicating the positive effect of scale

economies on firm performance. Controlling for industry fixed effects however, reduces the significance of this variable; again suggesting that this result is partly driven by industry-specific characteristics.

5.2 THE IMPACT ON THE PRODUCTIVITY OF INTERNATIONALLY-ORIENTED & TECHNOLOGY INTENSIVE FIRMS

The estimation results for the second hypothesis testing the impact of foreign technology and R&D on the productivity of Egyptian firms according to their international and technological orientation are shown in Table 5. Industries are classified as internationally-oriented (HI) if their trade share of value added is at least 40 percent and as high technology (HT) if their technological intensity accords with the OECD classification.

[TABLE 5 HERE]

Internationally-oriented Egyptian industries are found to be more competitive (i.e., more productive) and have a greater capacity to assimilate foreign technologies and their embodied R&D stock relative to domestic-oriented ones. *ML* has a positive and significant impact on productivity for the internationalised industries and a weaker significant negative impact for the technology intensive ones. The coefficients of *WL* generally increase in magnitude, suggesting that higher wages have a greater impact on labour productivity in these industries. The significances of these coefficients for the HT group are consistently very strong but weaker for the HI group relative to those in Table 4. The firm size effects are strongly significant in the OLS estimation but disappear in fixed effects, again suggesting that substantial labour productivity gains for larger firms are driven by industry-specific characteristics.

The results in Columns (1), (2), (5) (6) and (7) of the table reveal evidence of significant productivity spillovers of foreign technology and foreign embodied R&D, averaging 0.04 to 0.05 percent. The findings presented in Table 5 therefore provide further support for the view that more internationalised and technology intensive industries exhibit significantly greater productivity gains and efficiency spillovers from imported technology and foreign R&D.

5.3 PRODUCTIVITY SPILLOVERS & TFP EFFECTS ON TECHNOLOGY INTENSIVE FIRMS

The results presented in Table 5 also provide support for the third hypothesis that technology intensive firms, in particular, in Egypt possess the capacity to benefit from productivity

spillovers from foreign technology. This suggests therefore that these industries possess engineers and technologists with the requisite expertise and absorptive capacity to understand, assimilate and utilise the knowledge embodied in imports from industrialised economies (Hatzichronoglou, 1997; Boothby *et al.*, 2010). This finding highlights the issue of domestic absorptive capacity, which is likely to affect the magnitude and significance of foreign technology spillovers (Liu and Buck, 2007; Vogel and Wagner, 2010). R&D embodied in foreign technology however, appears not to drive significant productivity gains in the technology intensive industries, as revealed in columns (4) and (8) of the table.

The third hypothesis is also tested by estimating the effects of foreign technology and embodied R&D on total factor productivity (TFP) growth in Egypt, reflecting changes in efficiency and technical progress (Nishimizu and Page, 1982). These results are shown in Table 6. The estimation assumes perfect competition in factor markets along with a neo-classical production function (Caselli and Coleman, 2006). The production inputs here are represented by labour, capital and total materials, with TFP growth measured by the Solow residual (Wang, 2010). In the second-stage, the estimated TFP is regressed against the variables of interest; foreign technology, embodied foreign R&D and the other control variables. In line with Wang, foreign technology demonstrates positive and significant growth effects on TFP for all manufacturing sectors. This reveals the relevance of the diffusion of new technological products and services as a channel for technical progress, so creating a new domestic production frontier driving long run economic growth (Andersson *et al*., 2016).

[TABLE 6 HERE]

The results presented in Table 7 show that technology intensive industries in Egypt have experienced significant productivity gains from foreign imported technology. No significant results however, are found for either the effect of foreign technology or embodied R&D for highly internationalised industries. This implies that the technological change required to drive the industrial frontier outwards may require a certain knowledge threshold that might only be present in technology intensive industries.

[TABLE 7 HERE]

Following Driffield and Love (2007), and as a robustness check for the results, Generalised Methods of Moments (GMM) is used to control for potential simultaneity between labour productivity and foreign technology and foreign R&D. These results are reported in Table 8. Owing to the short nature of the panel, the depth of the lags is restricted to two periods and a

collapsed instrument set is used. The findings in Column (1) reveal positive productivity effects of the order of 0.07 percentage points arising from foreign technology. Those industries with relatively greater technological potential however, experience larger productivity spillovers from foreign technology of the order of 0.10 percentage points. Caution should be exercised here however, owing to the relatively high value of the Hansen statistic (0.681) when GMM estimation is used on the reduced sample containing only the technology intensive industries. The results for the highly internationalised industries are not statistically significant, which implies that, in this context, trade openness at the industry level is not necessarily associated with a better capacity to adopt foreign technological progress. Finally, foreign embodied R&D does not achieve statistical significance in any specification of the model.

[TABLE 8 HERE]

6. CONCLUSIONS & POLICY IMPLICATIONS

This paper investigates the domestic productivity and spillover effects of foreign technology and its embodied R&D on Egyptian industries, 2003 to 2009. In so doing, it also analyses the heterogeneous impacts of technology transfer across sectors, focusing specifically on internationally-oriented and technology intensive industries. This facilitates an exploration of differences in the importance and magnitude of productivity spillovers in industries with greater exposure to foreign competition and a higher technological capacity. These industries are anticipated to possess greater absorptive capacity and therefore expected to generate greater learning and efficiency spillover effects, reflected in higher productivity. As such, this study is the first to analyse the effect of international R&D stocks at the industrial level by classifying industries according to their degree of both internationalisation and technological intensity using the unbiased weighting scheme suggested by Lichtenberg and de la Potterie (1998). The principal findings of this study are as follows.

Foreign technology and embodied R&D is found to have generally positive and significant effects on domestic productivity in Egyptian manufacturing, suggesting that there significant efficiency spillovers in addition to physical capital accumulation. A large part of these productivity effects however, are revealed to be industry-specific when controlling for fixed effects such that Egyptian manufacturing as a whole lacks sufficient absorptive capacity to capture such productivity spillovers. Internationally-oriented (HI) and technology intensive (HT) Egyptian industries are found to have a greater absorptive capacity for foreign technology

– and HT industries in particular – with significant productivity spillovers of between 0.4 and 0.5 per cent. Foreign technology exhibits positive and significant growth effects on total factor productivity (TFP) for all manufacturing sectors, suggesting that the diffusion of foreign technology is contributing to the country's long-run economic growth. TFP effects are found to be positive and significant for HT industries but not for HI ones, suggesting that only the former have attained a possible threshold level of knowledge. GMM estimation confirms the earlier OLS and Panel Data findings, with overall productivity effects of foreign technology of around 0.07 per cent, rising to 0.10 per cent for HT industries. The insignificant results for HI industries suggest that openness to trade has not enhanced their capacity to absorb foreign technological progress.

The findings of this paper for Egypt generate several important policy implications for developing countries generally regarding the domestic growth effects of foreign technology. A key benefit of inflows of FDI for developing countries is that they enhance the domestic technology stock without incurring the high cost of innovation, leasing to potential improvements in the productivity of domestic labour. The findings in this paper however, highlight the heterogeneous sectoral productivity effects of foreign technology according to industry-specific factors, including the absorptive capacity of their labour force and the existence of possible knowledge thresholds. These effects are found to be greatest for technology intensive industries in this paper with less significant impacts on internationalised industries. The general consensus among existing empirical studies is that the spillover effects of foreign technology are also important because they enhance the domestic stocks of technology and knowledge (e.g., Madsen, 2007; Cassiman and Golovko, 2011). The findings here for internationally-oriented industries in Egypt however, suggest that the productivity effects of trade openness may be limited if there is insufficient domestic absorptive capacity. Policy-makers should therefore promote the accumulation of local technological competences by prioritising technical assistance and knowledge transfers from foreign firms (Bozeman, 2000).

REFERENCES

Ajakaiye, O. and Page, J.(2012) Industrialisation and economic transformation in Africa: Introduction and overview. Journal of African Economies, 21(2), ii3-ii18.

Almeida, R. and Fernandes, A.M. (2008) Openness and technological innovations in developing countries: Evidence from firm-level surveys. Journal of Development Studies, 44(5), 701-27.

Alvarez, R. and Robertson, R. (2004) Exposure to foreign markets and plant-level innovation: Evidence from Chile and Mexico. Journal of International Trade & Economic Development, 13, 57–87.

Amiti, M. and Khandelwal, A.K. (2013) Import competition and quality upgrading. Review of Economics & Statistics, 95(2), 476-90.

Andersson, U., Dasí, Á., Mudambi, R. and Pedersen, T. (2016) Technology, innovation and knowledge: The importance of ideas and international connectivity. Journal of World Business, 51(1), 153-62.

Aslanoglu, E. (2000) Spillover effects of foreign direct investments on Turkish manufacturing industry. Journal of International Development, 12(8), 1111-30.

Baily, M.N., Gersbach, H., Scherer, F.M. and Lichtenberg, F.R. (1995) Efficiency in manufacturing and the need for global competition. Brookings Papers on Economic Activity: Microeconomics, 307-58.

Balasubramanyam, V.N., Salisu, M.A. and Sapsford, D.R. (1996) Foreign direct investment and growth in EP and IS countries. Economic Journal, 106 (434), 92-105.

Balasubramanyam, V.N., Salisu, M.A. and Sapsford, D.R. (1999) Foreign direct investment as an engine of growth. Journal of International Trade & Economic Development, 8(1), 27-40.

Barry, F. and Bradley, J. (1997) FDI and trade: The Irish host-country experience. *The* Economic Journal, 107(445), 1798-1811.

Bas, M. and Berthou, A. (2017) Does input-trade liberalization affect firms' foreign technology choice? World Bank Policy Research Working Paper No. 7883, Washington D.C.: The World Bank

Beck, T., Levine, R. and Loayza, N. (2000) Finance and the sources of growth. Journal of Financial Economics, 58(1-2), 1072-85.

Bhagwati, J.N. (1978) Anatomy and Consequences of Exchange Control Regimes, Vol. 1, Studies in International Economic Relations No. 10: New York: NBER.

Blalock, G. and Gertler, P. (2008) Welfare gains from foreign direct investment through technology transfer to local suppliers. Journal of International Economics, 74(2), 402-21.

Blomström, M. and Sjöholm, F. (1999) Foreign direct investment, technology transfer and spillovers: Does local participation with multinationals matter? European Economic Review, 43(4), 915-23.

Bloom, N., Draca, M. and Van Reenen, J. (2016) Trade induced technical change? The impact of Chinese imports on innovation, IT and productivity. The Review of Economic Studies, 83(1), 87-117.

Boothby, D., Dufour, A. and Tang, J. (2010) Technology adoption, training and productivity performance. Research Policy, 39(5), 650-61.

Borensztein, E., De Gregorio, J. and Lee, J-W. (1998) How does foreign investment affect economic growth? Journal of International Economics 45(2), 115-35.

Bozeman, B. (2000). Technology transfer and public policy: A review of research and theory. Research Policy, 29(4-5), 627-55.

Brada, J. and Hoffman, D. (1985) The productivity differential between Soviet and Western capital and the benefits of technology imports to the Soviet economy. Quarterly Review of Economics & Business, 25(1), 6-18.

Buckley, P., Clegg, J. and Wang, C. (2002) The impact of inward FDI on the performance of Chinese manufacturing firms. Journal of International Business Studies, 33(4), 637-55.

Burstein, A., Cravino, J. and Vogel, J. (2013) Importing skill-biased technology. American Economic Journal: Macroeconomics, 5(2), 32-71.

Burstein, A. and Vogel, J. (2017) International trade, technology and the skill premium. Journal of Political Economy, 125(5), 1356-1412.

Cantwell, J.A. (1989) Technological Innovation & Multinational Corporations. Oxford: Basil Blackwell.

Carroll, P., Pol, E. and Robertson, P.L. (2000) Classification of industries by level of technology: An appraisal and some implications. Prometheus: Critical Studies in Innovation, 18 (4), 417-36.

Caselli, F. (2005) Accounting for cross-country income differences. In: Aghion, P., and Durlauf, S.N. (Eds.), Handbook of Economic Growth, Vol. 1A. Rotterdam: Elsevier, 679-741.

Caselli, F., and Coleman, J. (2006) The World Technology Frontier. American Economic Review, 96(3), 499-522.

Caselli, F. and Wilson, D. (2004) Importing technology. Journal of Monetary Economics, 51(1), 1-32.

Cassiman, B. and Golovko, E. (2011) Innovation and internationalization through exports. Journal of International Business Studies, 42(1), 56-75.

Cecchini, L. and Lai-Tong, C. (2008) The links between openness and productivity in Mediterranean countries. Applied Economics, 40(6), 685-97.

Chamarbagwala, R., Ramaswamy, S. and Wunnava, P.V. (2000) The role of foreign capital in domestic manufacturing productivity: Empirical evidence from Asian economies. Applied Economics, 32(4), 393-98.

Chuang, Y. and Hsu, P. (2004) FDI, trade and spillover efficiency: Evidence from China's manufacturing sector. Applied Economics, 36(10), 1103-15.

Coe, D. and Helpman, E. (1995) International R&D spillovers. European Economic Review, 39(5), 859-87.

Coe, D., Helpman, E. and Hoffmaister, A. (1995) North-south R&D spillovers. National Bureau of Economic Research, Working Paper No.5048. Washington DC: NBER.

de la Potterie, B. and Lichtenberg, F. (2001) Does foreign investment transfer technology across borders? Review of Economic Studies, 83(3), 490-7.

De Long, B. and Summers, L. (1993) How strongly do developing economies benefit from equipment investment? Journal of Monetary Economics, 32(3), 395-415.

de Mello, L.R. (1999) Foreign direct investment-led growth: Evidence from time series and panel data, Oxford Economic Papers 51(2), 133-51.

Driffield, N. and Love, J. (2007) Linking FDI and host economy productivity effects: Conceptual and empirical analysis. Journal of International Business Studies, 38(3), 460-73.

Driffield, N. and Read, R. (2004) Linkages & Flow-On Impacts of Foreign Investment in Pacific Island Economies, Final Report. Sydney: FIAS (World Bank)/Pacific Islands Forum.

Easterly, W. and Levine, R. (2001) Its not factor accumulation: Stylized facts and growth models. World Bank Economic Review, 15(2), 177-219.

Elkomy, S., Ingham, H., and Read, R. (2018) FDI and growth in Egypt: Aggregate and heterogeneous sectoral effects. Lancaster University Management School, Economics Working Paper Series 2018/009.

Evenson, R. and Westphal, L. (1995) Technological change and technology strategy. In Behrman, J. and Srinivasan, T.N. (Eds.). Handbook of Development Economics, Vol.3, Part A, 2209-99.

Findlay, R. (1978) Relative backwardness, direct foreign investment and the transfer of technology: A simple dynamic model. Quarterly Journal of Economics, 92(1), 1-16.

Furman, J.L. and Hayes, R. (2004) Catching up or standing still? National innovative productivity among 'follower' countries, 1978–1999. Research Policy, 33(9), 1329-54.

Furman, J.L., Porter, M.E. and Stern, S. (2002) The determinants of national innovative capacity. Research Policy, 31(6), 899-933.

Gerschenkron, A. (1962) Economic Backwardness in Historical Perspective. Cambridge MA: Belknap Press.

Glass, A. and Saggi, K. (1998) International technology transfer and the technology gap. Journal of Development Economics, 55 (2), 369-98.

Globerman, S. (1979) Foreign direct investment and 'spillover' efficiency benefits in Canadian manufacturing industries. Canadian Journal of Economics, 12(1), 42-56.

Grossman, G., and Helpman, E. (1991) Comparative advantage and long-run growth. American Economic Review, 80(4), 796-815.

Halpern, L., Koren, M. and Szeidl, A. (2006) Imports and productivity. New York: Federal Reserve Bank of New York (mimeo).

Hanafy, S. (2015) Sectoral FDI and economic growth: Evidence from Egyptian governorates. MAGKS Joint Discussion Paper in Economics no. 37-2015, Universität Marburg.

Hanushek, E.A. (2013) Economic growth in developing countries: The role of human capital. Economics of Education Review, 37, 204-12.

Hasan, R. (2002) The impact of imported and domestic technologies on the productivity of firms: Panel data evidence from Indian manufacturing firms. Journal of Development Economics, 69(1), 23-49.

Hatzichronoglou, T. (1997) Revision of the high-technology sector and product classification. Technology & Industry Working Papers No.2. Paris: OECD.

Hejazi, W. and Safarian, E. (1999) Trade, foreign direct investment and R&D spillovers. Journal of International Business Studies, 30(3), 491-511.

Hendricks, L. (2000) Equipment investment and growth in developing countries. Journal of Development Economics, 61(2), 335-64.

Hu, A,G.Z., Jefferson, G.H., Guan, X. and Qian, J. (2005) R&D and technology transfer: Firm-level evidence from Chinese industry. Review of Economics & Statistics, 87(4), 780-86.

Javorcik, B.S. (2004) Does foreign investment increase the productivity of domestic firms? In search of spillovers through backward linkages. American Economic Review, 94(3), 603-27.

Karake, Z.A. (1988) Effects of Eastern European and Western technologies on LDCs: A macroeconometric analysis. Applied Economics, 20(8): 1099-1114.

Kathuria, V. (2000) Productivity spillovers from technology transfers to Indian manufacturing firms. Journal of International Development, 12(3), 343-69.

Kathuria, V. (2002) Liberalisation, FDI, and productivity spillovers – an analysis of Indian manufacturing firms. Oxford Economic Papers, 54(4), 688-718.

Katrak, H. (1990) Imports of technology and the technological effort of Indian enterprises. World Development, 18(3), 371-81.

Keller, W. (1998) Are international R&D spillovers trade-related? Analysing spillovers among randomly matched trade partners. European Economic Review, 42(8), 1469-81.

Keller, W. (2000) Do trade patterns and technology flows affect productivity growth? World Bank Economic Review, 14(1), 17-47.

Keller, W. and Yeaple, S. (2009) Multinational enterprises, international trade and productivity growth: Firm-level evidence from the United States. Review of Economics and Statistics, 91(4), 821-31.

Khan, M.S. and Reinhart, C.M. (1990) Private investment and economic growth in developing countries. World Development, 18(1), 19-27.

Kokko, A. (1994) Technology market characteristics and spillovers. Journal of Development Economics, 43(2), 279-93.

Koo, B.H. and Perkins, D.H. (Eds.) (2016) Social Capability & Long-Term Economic Growth. London: Springer.

Kugler, M. (2006) Spillovers from foreign direct investment: Within or between industries? Journal of Development Economics, 80(2), 444-77.

Lall, S. and Pietrobelli, C. (Eds.) (2002) Failing to Compete: Technology Development & Technology Systems in Africa. Cheltenham: Edward Elgar.

Lall, S. and Wangwe, S. (1998) Industrial policy and industrialisation in sub-Saharan Africa. Journal of African Economies, 7(1), 70-107.

Lee, J. (1995) Capital goods imports and long-run growth. Journal of Development Economics, 48(1), 91-110.

Liang, H. and Zhang, Z. (2012) The effects of industry characteristics on the sources of technological product and process innovation. Journal of Technology Transfer, 37, 867-84.

Lichtenberg, F. and de la Potterie, B. (1998) International R&D spillovers: A comment. European Economic Review, 42(8), 1483-91.

Liu, X. and Buck, T. (2007) Innovation performance and channels for international technology spillovers: Evidence from Chinese high-tech industries. Research Policy, 36(3), 355-66.

Liu, X, Siler, P., Wang, C. and Wei, Y. (2000) Productivity spillovers from foreign direct investment: Evidence from UK industry level panel data. Journal of International Business Studies, 31(3), 407-25.

Lumenga-Neso, O., Olarreaga, M. and Schiff, M. (2005) On 'indirect' trade-related R&D spillovers. European Economic Review, 49, 1785–98.

Luttmer, E.G. (2007) Selection, growth and the size distribution of firms. The Quarterly Journal of Economics, 122(3), 1103-44.

Madsen, J.B. (2007). Technology spillover through trade and TFP convergence: 135 years of evidence for the OECD countries. Journal of International Economics, 72(2), 464-80.

Malikane, C. and Chitambara, P. (2018) Foreign direct investment, productivity and the technology gap in African economies. Journal of African Trade, 4, 61-74.

Massoud, N. (2008) FDI and growth in emerging markets: does sectoral distribution matter – the case of Egypt. WP-EMG-05-2008, Cass Business School, London.

Mazumdar, J. (2001) Imported machinery and growth in LDCs. Journal of Development Economics, 65(1), 209-24.

Melitz, M.J. (2003) The impact of trade on intra-industry reallocations and aggregate industry productivity. Econometrica, 71(6), 1695-1725.

Nishimizu, M. and Page, J.M. (1982) Total factor productivity growth, technological progress and technical efficiency change: Dimensions of productivity change in Yugoslavia, 1965-78. The Economic Journal, 92(368), 920-36.

Nwaogu, U.G. and Ryan, M.J. (2015) FDI, foreign aid, remittance and economic growth in developing countries. Review of Development Economics, 19(1), 100-15.

Page, J. (2012) Can Africa industrialise? Journal of African Economies, 21(2), ii86-ii124.

Pavcnik, N. (2002) Trade liberalization, exit and productivity improvements: Evidence from Chilean plants. The Review of Economic Studies, 69(1), 245-76.

Read, R. (2008) Foreign direct investment in small island developing states. Journal of International Development, 20(5), 502-25.

Read, R. (2018) The determinants and growth effects of foreign direct investment in small economies. In Briguglio, L. (Ed.). Handbook of Small States. London: Routledge, 386-402.

Reggiani, C. and Shevtsova, Y. (2018) Trade and productivity in a transition economy: The role of industry and export destination. Journal of Industry, Competition & Trade, 18(3), 395-428.

Rosell-Martinez, J. and Sanchez-Sellero, P. (2012) Foreign direct investment and technical progress in Spanish manufacturing. Applied Economics, 44(19), 2473-89.

Schiff, M. and Wang, Y. (2008) North-south and south-south trade-related technology diffusion: How important are they in improving TFP growth? Journal of Development Studies, 44(1), 49-59.

Sinani, E. and Meyer K. (2004) Spillovers of technology transfer from FDI: the case of Estonia. Journal of Comparative Economics, 32(3), 445-66.

Sjöholm, F. (1999) Technology gap, competition and spillovers from direct foreign investment: Evidence from establishment data. Journal of Development Studies, 36(1), 53-73.

Temple, J. and Voth, H. (1998) Human capital, equipment investment and industrialization. European Economic Review, 42(7), 1343-62.

Topalova, P. and Khandelwal, A. (2011) Trade liberalization and firm productivity: The case of India. Review of Economics & Statistics, 93(3), 995-1009.

UNCTAD (2013) Balance of Payment Statistics: Bilateral Trade Data. UNCTAD: Geneva.

Vogel, A. and Wagner, J. (2010) Higher productivity in importing German manufacturing firms: Self-selection, learning from importing or both? Review of World Economics, 145(4), 641-65.

Wang, Y. (2010) FDI and productivity growth: The role of inter-industry linkages. Canadian Journal of Economics, 43(4),1243-72.

Wang, Y. and Blomström, M. (1992) Foreign investment and technology transfer. European Economic Review, 36(1), 137-55

World Bank (2012). World Development Indicators (WDI). Washington DC: The World Bank.

Xu, X. and Sheng, Y. (2012) Productivity spillovers from foreign direct investment: Firm-level evidence from China. World Development, 40(1), 62-74.

Table 1: Sectoral Productivity, Capital Intensity, Foreign Technology, Value Added, Trade Share & Technological Classification

ISIC	Sector	LP	KL	FT	VA	TS	Tech
06	Petroleum/Natural Gas Extraction	58.91	12.93	25.36	84.20	0.00	Med
18	Printing/Media Products	13.84	171.63	0.05	0.22	0.22	Low
19	Coke/Refined Petroleum Products	10.34	25.81	5.72	2.74	2.32	Med
23	Other Non-Metallic Mineral Products	5.59	55.35	7.09	1.58	0.23	Med
11	Beverages	3.78	33.21	16.42	0.55	0.28	Low
13	Textiles	3.76	33.83	18.64	0.48	0.64	Low
28	Machinery & Equipment nec.	3.71	33.13	16.52	0.10	0.29	High
20	Chemical Products	2.68	11.54	32.78	0.97	1.02	High
33	Machinery/Equipment Report	2.19	0.27	1.25	0.01	0.04	Med
09	Mining Support Services	1.68	0.22	0.00	0.01	0.00	Med
25	Fabricated Metal Products	1.58	18.08	8.73	0.27	0.52	Med
24	Basic Metals	1.37	2.00	36.49	2.74	2.85	Med
21	Pharmaceuticals	1.31	1.41	16.23	2.76	0.56	High
16	Wood/Cork Products	1.10	14.74	9.35	0.03	0.46	Low
17	Paper Products	1.05	6.17	40.31	0.60	1.12	Low
22	Rubber/Plastic Products	1.02	3.36	22.10	0.48	2.03	Med
10	Food Products	1.01	4.72	8.37	0.67	0.84	Low
12	Tobacco Products	0.83	0.09	18.55	0.35	2.90	Low
27	Electrical Equipment	0.81	5.39	16.22	0.42	0.83	High
36	Water Supply/Treatment	0.75	0.05	0.00	0.00	0.01	Med
26	Computer/Electronic Products	0.70	0.64	36.54	0.11	1.30	High
29	Motor Vehicles	0.60	0.68	16.38	0.52	1.08	High
32	Other Manufacturing	0.53	1.80	12.71	0.06	0.63	Med
08	Other Mining/Quarrying	0.51	1.00	14.46	0.05	0.20	Med
30	Other Transport Equipment	0.48	1.24	29.87	0.27	0.96	High
15	Leather/Related Products	0.29	0.53	17.01	0.05	0.62	Low
31	Furniture	0.20	0.36	10.46	0.25	0.46	Low
14	Wearing Apparel	0.16	0.21	20.83	0.99	1.02	Low
01	Crop/Animal Production	0.15	2.41	3.48	0.02	0.04	Low
39	Remediation Activities	0.08	0.07	98.50	0.00	0.26	Low

Notes: The reported figures are the mean of the real values of the variables in the four-digit industry from 2006 to 2009.
LP is the real value added per unit of labour and the reported figures are in 100,000LE.
KL is the real fixed assets per labour and the reported values are in 100,000 LE.

Table 2: Descriptive Statistics

Variables	Mean	Median	St. Dev	Min.	Max.
Labour productivity (*LP*)	4.03	1.03	10.80	0.08	58.91
Capital-labour ratio (*KL*)	14.76	2.20	32.67	0.05	171.6
Materials per labour (*ML*)	2.44	0.70	8.50	0.00	47.19
Wages per labour (*WL*)	0.16	0.11	0.16	0.03	0.72
White collar ratio (*WCL*)	0.29	0.26	0.12	0.12	0.65
Firm size (*Firmsize*)	1900.5	206.9	6597.5	0.00	34587
Foreign Technology (*Foreign Tech*)	0.07	0.01	0.29	0.00	1.58
Foreign R&D (*Foreign R&D*)	0.002	0.0004	0.003	0.00	0.018

Notes: The reported figures are the mean of the real values of the variables in the four-digit industry from 2006 to 2009. White collar ratio is a percentage; firm size is measured in 100,000LE per firm; all other variables are measured in 100,000LE per labour.

Table 3: Correlation Matrix

	1-	2-	3-	4-	5-	6-	7-	8-
1-Ln *LP*	1.00							
2-Ln *KL*	0.82	1.00						
3-Ln *ML*	0.16	0.04	1.00					
4.Ln *WL*	0.28	0.03	0.28	1.00				
5-Ln *WCL*	0.28	0.16	0.14	0.33	1.00			
6-Ln *Firmsize*	0.26	-0.06	0.60	0.51	0.29	1.00		
7-Ln *Foreign Tech*	0.63	0.69	0.07	0.03	0.21	0.00	1.00	
8-Ln *Foreign R&D*	0.35	0.28	0.05	0.21	0.14	0.18	0.62	1.00

Table 4: Productivity Effects of Foreign Technology & Foreign R&D in Egypt, All Manufacturing Sectors, 2006-09

Dep. Variable: Ln *LP*	(1) OLS	(2) OLS	(3) FE	(4) FE
Ln *KL*	0.54***	0.58***	0.58***	0.61***
	(0.03)	(0.02)	(0.06)	(0.06)
Ln *ML*	-0.10*	-0.09*	-0.05	-0.05
	(0.06)	(0.06)	(0.08)	(0.08)
Ln *WL*	0.18***	0.17***	0.15**	0.15*
	(0.06)	(0.06)	(0.08)	(0.08)
Ln *WCL*	0.05	0.07	0.01	0.02
	(0.10)	(0.10)	(0.12)	(0.12)
Ln *Firmsize*	0.22***	0.21***	0.16*	0.15*
	(0.04)	(0.04)	(0.09)	(0.09)
Ln *Foreign Tech*	0.05**		0.03	
	(0.02)		(0.02)	
Ln *Foreign R&D*		0.01		0.01
		(0.02)		(0.02)
R^2	0.80	0.79	0.55	0.54
Root Mean Sq. Error	0.60	0.61	0.35	0.35
No. of obs.	363	363	363	363
No. of groups	-	-	119	119
F-statistic	147.90	140.59	19.80	18.30
p-value	0.00	0.00	0.00	0.00

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 5: Productivity Effects of Foreign Technology & Foreign R&D for Internationally-Oriented & High Technology Industries in Egypt

Dep. Variable: Ln *LP*	(1) OLS HI	(2) OLS HI	(3) OLS HT	(4) OLS HT	(5) FE HI	(6) FE HI	(7) FE HT	(8) FE HT
Ln *KL*	0.35***	0.36***	0.56***	0.59***	0.26***	0.27***	0.60***	0.63***
	(0.02)	(0.03)	(0.04)	(0.03)	(0.08)	(0.08)	(0.08)	(0.09)
Ln *ML*	0.15***	0.17***	-0.12**	-0.12**	0.07	0.07	-0.03	-0.02
	(0.04)	(0.04)	(0.06)	(0.06)	(0.17)	(0.17)	(0.10)	(0.10)
Ln *WL*	0.15**	0.14*	0.25***	0.24***	0.14*	0.15*	0.22***	0.22***
	(0.07)	(0.07)	(0.07)	(0.07)	(0.08)	(0.09)	(0.08)	(0.08)
Ln *WCL*	0.14	0.14	0.05	0.07	0.05	0.06	0.03	0.05
	(0.08)	(0.08)	(0.12)	(0.12)	(0.13)	(0.14)	(0.15)	(0.15)
Ln *Firmsize*	0.22***	0.19***	0.24***	0.24***	0.12	0.10	0.15	0.13
	(0.03)	(0.03)	(0.04)	(0.05)	(0.12)	(0.12)	(0.11)	(0.11)
Ln *Foreign Tech*	0.04**		0.04		0.05**		0.05**	
	(0.02)		(0.02)		(0.02)		(0.02)	
Ln *Foreign R&D*		0.03**		0.01		0.04*		0.02
		(0.01)		(0.02)		(0.02)		(0.03)
R^2	0.84	0.84	0.79	0.78	0.23	0.22	0.58	0.57
Root Mean Sq. Err	0.39	0.39	0.63	0.63	0.28	0.28	0.37	0.37
No. of Obs.	200	200	230	230	200	200	230	230
No. of Groups	-	-	-	-	82	82	77	77
F-statistic	174.34	171.96	79.99	79.59	4.80	4.53	14.39	12.36
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 6: Effects of Foreign Technology & Foreign R&D On TFP in Egypt, All Manufacturing Sectors, 2006-2009

Dep. Variable: Ln *TFP*	(1) OLS-All	(2) OLS-All	(3) FE-All	(4) FE-All
Ln *WL*	0.10***	0.10***	0.13**	0.13**
	(0.04)	(0.04)	(0.05)	(0.05)
Ln *WCL*	-0.07	-0.05	-0.04	-0.03
	(0.06)	(0.06)	(0.08)	(0.08)
Ln *Firmsize*	0.01	0.01	0.24***	0.23***
	(0.01)	(0.01)	(0.03)	(0.04)
Ln *Foreign Tech*	0.02*		0.04**	
	(0.01)		(0.02)	
Ln *Foreign R&D*		0.00		0.00
	(0.01)		(0.02)	
R^2	0.07	0.06	0.27	0.25
Root Mean Sq. Error	0.34	0.34	0.27	0.27
No. of Obs.	363	363	363	363
No. of Groups	-	-	117	117
F- statistic	3.85	3.56	19.63	13.76
p-value	0.00	0.01	0.00	0.00

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 7: Effects of Foreign Technology & Foreign R&D for Internationally-Oriented & High Technology Industries On TFP in Egypt

Dep. Variable: Ln *TFP*	(1) OLS HI	(2) OLS HI	(3) OLS HT	(4) OLS HT	(5) FE HI	(6) FE HI	(7) FE HT	(8) FE HT
Ln *WL*	0.08*	0.08*	0.13***	0.13***	0.11	0.11	0.17***	0.17***
	(0.04)	(0.04)	(0.04)	(0.04)	(0.07)	(0.07)	(0.06)	(0.06)
Ln *WCL*	0.02	0.04	-0.11	-0.10	0.09	0.09	-0.07	-0.05
	(0.07)	(0.06)	(0.07)	(0.07)	(0.10)	(0.10)	(0.10)	(0.10)
Ln *Firmsize*	0.00	0.01	0.02	0.01	0.28***	0.27***	0.23***	0.21***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.09)	(0.09)	(0.04)	(0.05)
Ln *Foreign Tech*	0.01		0.03**		0.01		0.05**	
	(0.01)		(0.01)		(0.02)		(0.03)	
Ln *Foreign R&D*		-0.01		0.02		0.01		0.02
		(0.01)		(0.01)		(0.02)		(0.02)
R^2	0.06	0.06	0.11	0.10	0.21	0.21	0.31	0.27
Root Mean Sq. Err	0.30	0.30	0.37	0.37	0.22	0.22	0.29	0.30
No. of Obs.	200	200	230	230	200	200	230	230
No. of Groups	-	-	-	-	82	82	77	77
F-statistic	2.22	2.24	4.57	4.47	5.46	5.54	13.71	9.20
p-value	0.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Table 8: GMM Estimation of Productivity Effects of Foreign Technology & R&D On TFP in the Egyptian Manufacturing Sector

Dep. Variable: Ln *LP*	(1) GMM All	(2) GMM All	(3) GMM HI	(4) GMM HI	(5) GMM HT	(6) GMM HT
Ln *KL*	0.5414***	0.6067***	0.3432***	0.4205***	0.5267***	0.6048***
	(0.05)	(0.03)	(0.04)	(0.04)	(0.05)	(0.04)
Ln *ML*	-0.1308*	-0.1077	0.1335**	0.1091**	-0.1293*	-0.1070
	(0.08)	(0.07)	(2.36)	(0.06)	(0.07)	(0.09)
Ln *WL*	0.1388*	0.1845**	0.0501	0.1847**	0.2376***	0.2628***
	(0.08)	(0.08)	(0.37)	(0.08)	(0.08)	(0.08)
Ln *WCL*	0.0276	0.0377	0.1639	0.0649	-0.0148	0.0085
	(0.22)	(0.11)	(1.10)	(0.61)	(0.14)	(0.14)
Ln *Firmsize*	0.2447***	0.2392***	0.2210***	0.2056**	0.2615***	0.2409***
	(0.06)	(0.05)	(0.06)	(0.05)	(0.06)	(0.07)
Ln *Foreign Tec*h	0.0746**		0.0718		0.1070***	
	(0.04)		(0.05)		(0.04)	
Ln *Foreign R&D*		-0.0117		-0.0080		-0.0003
		(0.02)		(0.04)		(0.03)
No. of Obs.	363	363	200	200	230	230
No. of Groups	117	117	82	82	77	77
No. of Instrum.	12	12	12	12	12	12
Arellano-Bond (1)	0.003	0.007	0.015	0.032	0.013	0.007
Arellano-Bond (2)	0.892	0.991	0.931	0.297	0.681	0.439
Hansen Statistic	0.294	0.737	0.015	0.083	0.785	0.395

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.

Appendix Table A1: IV & Endogeneity Testing: F-Statistic, Sargan Test & Durbin-Wu-Hausman Statistics

Dep. Variable *Ln LP* Test	Ln *Foreign Tech*	Ln *Foreign R&D*
First-Stage Regressions		
F statistic for under-identification	10.40	21.13
F test *p*-value	(0.00)***	(0.00)***
Second-stage regressions		
Sargan statistic for over-identification	4.31	2.61
Chi square *p*-value	(0.11)	(0.10)
Endogeneity Test		
Durbin-Wu-Hausman test for endogeneity	12.04	12.22
Chi square p-value	(0.10)	(0.10)

Notes: Standard errors clustered by industry in parentheses. * p<0.10; ** p<0.05; *** p<0.01.