Technological and Knowledge Spillovers Enhancing Industrial Competitiveness on Micro-Economic Firm-level

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Abstract

The paper studies the interaction of foreign direct investment (FDI), technology, sales, and research and development (R&D) spillovers enhancing production and competitiveness of firms on a micro-economic level. An empirical investigation on firm-level of South African companies was conducts. It starts by assuming that spillovers are good and should be encouraged. Industrial development seems to escalate when firms are growing individually and this growth is extended to other firms. Other firms learn from growing firms and then grow too. This is what is meant by spillover effects of industrial development. It is usually assumed that a rise in FDI, technology and R&D will have great returns for any firm and even greater returns for the industry as a whole. The motivation for this study was to test whether this is the case. Spillovers, however, have the ability to not only enhance, but also diminish productivity growth.

The study mainly utilised data from the World Bank's firm-level survey, applying regression analysis. The results showed a significant interconnectedness between firm growth and knowledge sharing on regional, national and international level. The importance of a productive human capital base was also confirmed. It found that direct foreign investments and foreign ownership contribute little to spillovers and probably depend on absorptive capacity. Technological advancement did not show up as a significant factor. Likewise, research and development are dependent on absorptive capacity to enhance competitiveness, especially with regard to investment on human capital. International quality certification, foreign licensing and capacity utilisation all contribute towards the competitive position of firms.

Keywords: Production, Spillovers, FDI, Technology, R&D, Industrial development, Information, Clusters, Competitiveness, Agglomeration, South Africa
JEL: D24, D83, L11, L30, L60, O30

WORK IN PROGRESS

1. INTRODUCTION

As globalisation integrates technologies and processes across borders, knowledge spillover effects between economic agents, increase. This study therefore aims to quantitatively and qualitatively analyse the effect of such spillovers on firm competitiveness and growth, as well as human capital improvement which will translate into regional, national and international improvement of production processes and ultimately, economic growth and development. This study investigates the interaction of technology, sales, foreign direct investment (FDI) and research and development (R&D) spillovers leading to industrial development. A literature study is followed by an econometric study using firm-level data of South African companies.

In an effort to increase productivity, competitiveness and maximise profits, firms need to enhance their technological and knowledge bases and gain competitive advantages, which may be facilitated with the help of spillovers from other firms, industries, regions or countries. The purpose of the knowledge creation and sharing lies in the determination of firms to achieve individual goals, which cannot be procured efficiently without new knowledge gains (Ding & Huang, 2010:949). This knowledge creation and sharing might eventually also improve the productivity of industrial, regional, national and worldwide processes. Initial focus should therefore be on the individual firm and how knowledge flows finds its way to the rest of the region and nation. New knowledge can lead to new or improved products or services, as well as new skills to improve income per capita and address poverty alleviation directly. Overall, technological progress and innovation are seen as imperative determinants for economic growth and development domestically (Cabrer-Borrás & Serrano-Domingo, 2007:1357).

The hypothesis is that spillovers have a positive effect on industrial development. Studies on innovation have revealed that for firms to be successful in their innovation processes there has to be

interaction between agents that are involved in innovation (Park, Lee & Park, 2009). Much literature on spillovers proves that spillovers are good for development. Spillovers do have a positive effect on industrial development; without them development would slow down, so they should be enhanced as far as possible. This paper, using the findings of previous studies and new empirical research, aims to prove this point. When an entrepreneur starts a new business, it is often close to his previous employer. In that way clusters are formed and they keep in touch, working together and thus spillovers are generated. Industrial clusters, according to Guiliani and Bell (2005), are "geographic agglomerations of economic activity that operate in the same sector".

This study focuses on foreign direct investment (FDI) spillovers, research and development (R&D) and knowledge spillovers, as well as technology spillovers and the interaction between these factors. Most literature found that FDI has no spillovers that are large enough to improve industrial development, and at times, FDI is harmful to other domestic firms. The existence of R&D spillovers means that the research done by one firm can be used by other firms without other firms purchasing the rights to do so (Steurs, 1995). Cassiman and Veugelers (2002) found that firms with higher incoming spillovers and better appropriation are most likely to cooperate in R&D agreements. Appropriation means the ability of firms to determine the part of its innovation that gets to be revealed to the public and the information that the firm keeps to itself in order to reap the benefits of innovativeness. The information sources for incoming spillovers are usually in the public domain for every firm to use, but its usefulness to the firm depends on the firm's ability to create information flows from this public pool of knowledge-absorptive capacity (Cassiman *et al*., 2002). The assumption is that economic growth in the country can be attributed to the openness of its trade and capital flows (Du Plessis & Smith; 2007).

The service sector also contributes to growth due to factors such as education and training, R&D and human capital accumulation. According to Clemes, Arifa and Gani (2003), the expansion in the services sector contributes greatly to the expansion in the manufacturing sector. This then shows that services and manufacturing influence each other, and inter-industry as well as intra-industry linkages are of great importance and investments in both these sectors should then be encouraged as they motivate growth, knowledge and technological spillovers, including foreign direct investment spillovers, which are beneficial.

This article will firstly study the role of FDI, research and development, and knowledge and technological spillovers in industrial development described by existing literature and theory, and will then conduct an empirical investigation. In the first section, attention will be paid to globalisation, the flow of information between firms and the flow of information between different firms and spillover effects of industrial development and then foreign direct investment spillovers, technology spillovers, and finally, attention is paid to spillovers that may become harmful to a firm. Then, in the second half of the article, the results on the empirical investigation, which studied the interaction between the various factors, will be reported. Firstly, attention will now be paid to globalisation and spillovers

2. LITERATURE REVIEW ON SPILLOVER EFFECTS

2.1 Globalisation and Spillovers

According to Holod and Reed (2004:289) linkages between suppliers and consumers within similar industries have intensified as a result of technology improvements world - wide. Attention should therefore be directed towards the competitive implications of such a revolution, as well as how it will affect the region, nation and ultimately the world, because, according to Giuliani and Bell (2004:48), knowledge spillover effects are interrelated across borders. There exists no reason why the process of learning should be limited to a specific location or territory.

Globalisation, modern technology and spillovers have influenced industrial development in South Africa and they continue to do so. Globalisation has increased competition for South African manufacturers, which may be positive, but may also put pressure on local producers and others forcing them to leave the industry because they are unable to compete with the low prices that foreign manufacturers offer. Modern technology has put firms in a position to achieve increasing returns to scale – increasing efficiency and delivering profits that are far higher than they had anticipated. The South African economy, and particularly its industrial sector, has become more service orientated and

that has increased investment in R&D as well as human capital. Some workers also became internationally competitive, which allows them to invest more in education in order to reach a stage where they can compete with other workers on an international level (Mostert, 2003). A link between growth and spillovers also exists, and that will be discussed in the next section.

2.2 The Link Between Growth and Spillovers

The spillover effects of investment start with capital. According to Berthelemy (1995), investment not only improves the productive capacity of a particular business and individual workers within that firm, but it also improves the productive capacity of other businesses or workers that come into contact with those directly affected by the investment. The knowledge and experience is then transferred between various parties, and spillovers stretch even beyond the confines of one industry.

Clemes *et al*. (2003) also show that investments in services and manufacturing are needed for the expansion of both these sectors, as growth in the services sector has an increasing effect on the demand for several manufactured goods. If growth in one sector can have an impact on growth in another sector, this should make it evident that growth between firms within the same sector can be facilitated by spillovers – firms in different sectors influence each other (Clemes *et al*., 2003), and so firms in the same sector should have a greater influence on each other. This can be made more realistic by the behaviour of investors. If an industry is progressing well, that will attract investors, as the term “growth in numbers” applies. If only a few firms are successful in the industry, it discourages investors because it leads to low expectations. The following section considers the flow of information between firms.

2.3 The Flow of Information Between Different Firms

When an employee is new to the firm, he shares general information with outsiders. The information becomes more specific the longer an employee remains with the firm (Dahl & Pederson, 2003). While conducting research for this paper, many other engineers have agreed that knowledge sharing is important for them as it helps make work easier and improves their productivity. The following sections investigate FDI spillovers.

Additionally, inherent regional levels of economic development, proxied by total factor productivity (TFP), were found to have an impact on knowledge sharing, as well as the formulation of policies regarding research and development efforts. Less developed regions specialise, for example, in low to medium level technology obtained from previous periods of knowledge creation and is not as active in new scientific research and development efforts (Cabrer-Borrás *et al*, 2007:1368). Nevertheless, a cluster of firms will be better able to benefit from knowledge spillovers, rather than undertaking it individually. A study by Giuliani and Bell (2004:48) using an analysis of social networking to identify the roles of cluster firms and the structure of the information system, found that new innovation ideas travel easily among firms in the same industrial cluster due to the favourable social and geographical proximity. This ultimately enhances collaborative and collective innovation efforts. Firms in a cluster will also benefit from the pool of skilled labour that is available (Marshall, 1890:272 & Krugman, 1991:484).

The role of absorptive capacity is just as important. It was found that knowledge will flow within a strategically core group of enterprises showing high levels of absorptive capacity (Giuliani et al, 2004:48). Eventually the whole country will benefit from increased absorptive capacity.

2.4 Spillover effects of industrial development

The main focus of this study is the effect of FDI, research and technology on industrial development and that will now receive attention, starting with FDI spillovers.

2.4.1 Foreign direct investment spillovers

Knowledge spillovers may also emanate from international sources such as multi-national enterprises. According to Alvarez (2007:377), becoming a permanent exporter depend on spillovers from multi-nationals and being situated close to where multi-ationals are concentrated. This increases productivity and experience with regards to exporting. The study however, found little evidence to

support the existence of a “learning by exporting”. Another study by Cabrer-Borrás and Serrano-Domingo (2007:1366) found that import suppliers can positively contribute to a region’s innovation efforts, but to a lesser extent than internal research and development efforts within the region itself. Local industries will also benefit from foreign direct investment (FDI), which may also increase exports and promote employment. Spillovers of research and development from FDIs in the form of imitation activities, relationships between business partners and training of the human capital base have become increasingly important in the literature and it has been included in the development processes of new growth models (Motohashi & Yuan, 2010:790). There are some underlying factors that influence the distribution of FDI though. It is also a means of reducing the technology gap between countries and may lead to greater international competitiveness and development.

Aitken and Harrison (1999) found no evidence proving that domestic firms benefit from FDI spillovers and there were no signs of the existence of technology spillovers from foreign firms to domestically owned firms in Venezuela, and this matter can be generalised to other developing countries. Positive effects of FDI for recipient firms do exist, but domestically owned firms tend to suffer. Konings (1999) found that spillovers that are associated with FDI are not helpful in terms of enhancing domestic firm performance, so the promotion of FDI may not be such a good idea, as it may lead to perverse effects in the short run.

There are, however, also positive findings. Blomstrom and Sjoholm (1999) found positive micro-spillovers from FDI in Indonesia and this is true for many other countries. Konings (1999), in his study on the effect of FDI on domestic firms, found that the output in foreign firms or firms within a country that have a large share of foreign investors is higher on average than that of domestic firms. According to Blomstrom and Sjoholm (1999), domestic firms benefit from spillovers from FDI. This means that labour productivity is higher in foreign firms than in domestic ones. This could be because of the higher income of workers in these firms and the higher sophistication of machinery and equipment as well as the modern technology of foreign firms.

The flow of knowledge between international actors is important as this is the best way to transfer international knowledge related to consumer needs and market trends (Kesidou & Romijn, 2008). Positive FDI spillovers to local firms are only spawned if the technology gap between the foreign firm and the domestic one is not too large and if the host country has the minimum human capital to provide absorptive capacity (Konings, 1999).

2.4.2 Research and development (R&D) and knowledge spillovers

According to Konings (1999), spillovers are achieved in industries that conduct high research and development (R&D) and /or by firms that have a sufficient amount of knowledge to start with. Cassiman and Veugelers (2002) found that there is a relationship between external flows and the decision to cooperate in R&D. Firms that think available external information sources are an important input to their innovative process, will be actively involved in R&D agreements (Cassiman *et al*., 2002). Firms that are able to appropriate the results from innovation processes are also likely to cooperate in R&D agreements. Innovative activities of firms are able to affect incoming spillovers and appropriation capabilities. However, in order for a firm to benefit from R&D spillovers, it has to undertake R&D projects itself (Bernstein & Nadiri, 1988). According to Steurs (1995), an increase in R&D should lead to a decrease in costs because equilibrium output and profits from production will be at their highest level given the lowest cost, and this will lead to consumer surplus as prices will be at their lowest. As development increases, technological spillovers also become important and this is considered next.

2.4.3 Human capital

Considering educational aspects, a sufficient pool of skilled labour and emanating technology spillover effects, as well as the co-location of customers and suppliers among firms within similar industries, generate increasing returns to scale and promote final production (Kleynhans & Drewes, 2008:2). On regional level, spatial spillovers, which may be defined as the interconnections that exist across geographical spaces, will be the result of increased investment in higher education (Cabrer-Borrás *et al*, 2007:1357). A sufficient human capital base is also important on an international level for effective export practices and participation, (Alvarez, 2007:377). It is clear then that promotion of the human capital base deserves extensive attention for future studies on this topic. The following section considers the theoretical foundation of the subject matter under investigation.

2.4.4 Technology spillovers

Modern technology processes are the reason there is so much flexibility within firms (Morrison Paul, 2002). Technology spillovers have positive effects on the productivity of domestic firms, but there may be a competition effect that may be harmful and put pressure on domestic firms (Konings, 1999). According to Blomstrom et al. (1999), technology spillovers are often the result of an increase in competition that follows FDI, while local participation with multinational corporations (MNCs) contributes very little to spillovers.

It is generally believed that local participation with multinationals reveals the MNC's knowledge base and that it will lead to spillovers of technology in the domestic industry. Blomstrom *et al*. (1999) found, however, that local participation with MNCs does not facilitate much technology spillovers in the host economy, but that spillovers are rather determined by something else.

Spillovers may also have adverse effects on firms and industries and that deserve serious attention. The following section pays attention to the possible harmful effects on firms and the protection of firms.

2.5 Harmful Effects of Spillovers and Protection of Firms

There is evidence suggesting that competitive firms and universities may form linkages with less productive firms because they can benefit somehow. Within the wine industry context, these benefits are through universities acquiring land and vineyards so they can carry out their experiments. The opposite is also true; firms may link with universities because they can get access to free advice from others because they do not have an adequate supply of skilled labour (Giuliani & Arza, 2009). The problem is in regulating who forms linkages with whom.

Firms try to protect and keep the benefits of their innovations to themselves by controlling the information flows from the firm into the pool of publicly available information (Cassiman *et al*., 2002). If appropriation of benefits is imperfect, this could increase benefits from cooperative R&D agreements. It is understandable that firms have to protect themselves, but they have to be careful that their forms of protection do not harm or inhibit the growth of the industry as a whole. If firms do not hide their information from other firms and appropriability is imperfect, this will increase the incentive of firms to take advantage of R&D investments of other firms and this encourages free riding on the R&D efforts of joint research ventures by those that are not part of the agreement (Cassiman et al. 2002).

This paper aims to determine the returns of FDI, technology and R&D. The aim is to see whether there are spillovers that arise from these and whether this will accelerate industrial development. The primary objective of this study is to investigate whether FDI, technology and R&D contribute positively to spillovers. Even if a direct link to spillovers cannot be found, this study still aims to obtain a better understanding of the interaction that exists between foreign direct investment, technology, knowledge and research and development in the production process.

This study also considers the factors that contribute to harmful spillovers, and advancements that have made it easier for information to diffuse between firms. In this paper, foreign direct investment, technology, research and development (R&D) and knowledge spillovers are investigated as well as how they can be enhanced without harming the firm. Many different firms in the manufacturing industry are analysed, and based on empirical evidence, the harmfulness of spillovers is determined. The aim of this paper is not to criticise linkages, but rather to ask: "where do we draw the line?".

The analysis of spillover effects for industrial development will be conducted for the manufacturing sector in South Africa and the scope of the study is for the period of between 2003 and 2009. This introductory section provided a brief summary of the reasons for the selection of the research topic and the need for the study; as well as literature review – the documented efforts of past researchers.

3. THEORIES OF INNOVATION SPILLOVERS UNDERLYING COMPETITIVENESS AND GROWTH

Spillover effects occur over time, space or industry. Temporal externalities imply that current production will be affected by previous collected stocks of physical and human capital (Morrison, 2002:292). Current investment decisions will therefore depend on previous capital accumulation decisions. Capital investments like machinery, training of employees and patents may have an influence on the flexibility of production processes, as enhanced flexibility benefit the production process, as it will become more adjustable to new techniques and production methods that can increase productivity growth. Capital investments on factors like machinery, training of employees and patents may have an influence on the flexibility of production processes, as it enhances flexibility and benefit the production process, because it becomes more adjustable to new techniques and production methods that can increase productivity growth.

The capital-output ratio and Harrod-Domar model may be used to determine the correct level of capital investment. In the basic growth model output is a function of capital (K) and labour (L), given as Y=F(K,L). The capital-output ratio will differ across countries, as different technologies are used to produce the same good and/or as a different mix of goods is produced (Perkins, Radelet & Lindauer, 2006:110). Together with spillover effects, capital investment may lead to increased ability for innovation as well as an increase in flexibility.

Spatial linkages imply interdependencies between regions and spaces as activities in one region may have an impact on the activities of neighbouring regions. In modern times however, it is increasingly easy to find and network with suppliers and other contacts globally, facilitated by the process of globalisation, which may reduce the importance of spatial spillovers (Morrison, 2002:295).

Sectorally bound or industrial spillovers also exist, implying that supply and demand side components are at work to influence the spillover process and all channels affect each other. Innovation at lower levels of the production process will be transferred to higher levels, while changes in demanded products with regards to quality and composition will have an impact on lower levels of the production chain. These linkages are becoming increasingly important because of expanded horizons of entities to promote production and the decision making process brought on by globalisation and enhanced information technology (Morrison, 2002:286).

Spillovers may also occur horizontally or vertically. Horizontal spillovers are intra-industry spillovers, meaning that they occur across firms in the same industry and that they are of equal origin, for example, domestic firms. Spillovers on horizontal level may be the result of human capital turnover or technology sharing. Vertical spillovers are inter-industry spillovers, meaning that firms gain knowledge from suppliers or international knowledge sources (Motohashi *et al*, 2010:796).

There exist a number of different spillover theories, but the most important and relevant for this study is the Porter spillover theory, stating that the close proximity of specialised industries that are competitive would have the greatest influence on enterprise growth and competitive advantages (see for e.g. Marshall, 1890; Anon, 2010:1; Portrer, 1998; Kleynhans & Drewes, 2008; and Krugman, 1991). It is relevant for South Africa in that the country's industrial sector is relatively highly concentrated and is characterised by specialisation (Fedderke & Simbanegavi, 2008:138).

There exists a positive relationship between knowledge spillovers and productivity, as knowledge spillovers may motivate innovation efforts to increase firm competitiveness and thus, raising productivity growth and ultimately, economic growth. The innovation process may be facilitated from in-house research and development efforts, from knowledge gained from external sources, as well as knowledge gained during collaboration efforts with other firms.

Ultimately, information components rely on human and physical resources, communication abilities and support of logistics to effectively attain, process, store and diffuse relevant knowledge. The costs in time and energy are also important aspects in the transferral and absorption of new knowledge (Ding *et al*, 2010:951).

With regards to competitiveness, there exists a positive relationship between competitiveness and productivity as increased competition in product and service markets have positive effects on growth in productivity in an effort by firms to gain market share and remain or become market leaders

(Fedderke *et al*, 2008:22). International competitiveness depends on the availability of needed factors of production, linkages to other industries like suppliers and government trade units, as well as effective strategies for international market share and business operations (ITRISA, 2008:17). Markup prices will also influence competitiveness. It is defined as the ratio of price (P) to marginal cost (MC) and may be represented by the formulation:

$$\mu=P/MC$$

where μ is markup. If μ=1, perfect competition in the market prevails (as P=MR=MC), and if μ>1, there exists monopoly or oligopoly conditions in the market with accompanying barriers to entry (Fedderke *et al*, 2008:16). Ultimately, knowledge will only lead to a competitive advantage if it is scarce, difficult to imitate and valuable (Ding *et al*, 2010:951).

Focusing on a regional base, spillovers are of utmost importance, as it will translate to greater innovation efforts locally and eventually promote regional and domestic economic growth, through an increase in competition by similar firms. On the other hand, the advantages from greater diversity of activities, brought on by complementary information exchange of complementary industries, will yield greater returns to new knowledge and innovation efforts, thus promoting growth (Cabrer-Borrás *et al.*, 2007:1359). The initial level of development has also been found to be of importance to facilitate future innovation efforts (Cabrer-Borrás *et al*, 2007:1369). Firms in the same region are more likely to undertake collaborative innovation efforts, however, firms should be careful not to expose information to other parties it did not intend to share, as it may reduce individual firm's competitive advantages (Ding *et al*, 2010:951). Unwanted externalities like the above may be protection from patents, keeping sacred the initial innovation ownership before collaboration started. Firms not engaged in collaboration efforts should also issue patents to protect intellectual property (Varian, 1992:435).

On national level, knowledge spillovers tend to be country- and firm specific. For example, low-income countries mainly specialise in low value added goods like commodities, limiting the need for innovation efforts (Alvarez, 2007:384). On the other hand, high-income countries, like Japan, produce high value-added goods like software and therefore, constantly need new ideas to remain competitive. Another important factor to take into account is absorptive capacity levels of firms, consisting of the level to which information may be absorbed by the enterprise. The higher it is, the more likely new information may lead to increased production of new inventions (Motohashi *et al*, 2010:791). Internal training may be presented to employees, or knowledge may be gained from external sources, although certain policies will then have to be adhered to. It was also indicated that the largest gains in growth originates from national economic integration, rather than global coordination (Holod *et al*, 2004:35).

International knowledge diffusion may be enhanced through globalisation activities and foreign direct investment initiatives. There remain many questions surrounding the role of multi-national enterprises (MNEs) and knowledge gains through export activities on the diffusion of knowledge domestically (see for e.g. Cypher & Dietz, 2009:469). Channels of international knowledge diffusion to the local economy include: Trade across borders, foreign investment in research and development capacities and imported inputs of technology (Cabrer-Borràs *et al*, 2007:1359).

On the positive side for domestic firms, MNE investment could improve growth and competition prospects of especially less developed countries through the transferral of information and technology or the improvement of domestic understanding of international markets (Alvarez, 2007:387). Traditional beneficial characteristics of MNEs like superior technology and managerial skills, may also not be fully protected, presenting local firms with the opportunity to internalise the leakage of information emanating from foreign investment (Franco *et al.,* 2010:272).

On the negative side, a loss of independency may be experienced by domestic firms and a significant portion of profits and market share may have to remain with the multi-national firm who made the initial investment (Motohashi *et al.*, 2010:795). The spillover effect of MNEs is mediated through three channels, namely:

1) The demonstration effect as a result of the MNEs' superior expertise emanating from their operations in foreign markets.
2) The imitation effect or research and development effect, and
3) The competition effect forcing firms to promote their productivity and export performance (Franco *et al.*, 2010:271).

With regards to the role of human capital in this process, the importance thereof has been frequently emphasised. It is therefore an imperative that a skilled domestic labour force be trained and made available. Local and international firms can assist the enhancement of the knowledge base by providing bursaries to prospective students, thereby committing the knowledge and innovation possibility to the firm.

The next section details the research design and the data and considers the methodology and econometric analysis that were used in this study. The results and discussion are presented in the last section.

4. THE EMPIRICAL FINDINGS

4.1 South African Manufacturing Data

This study investigated South African manufacturing firms that produce durable, as well as non-durable products. The data was collected by the World Bank surveys on manufacturing firms. The data from this source is easily accessible; however, its accuracy cannot be guaranteed. Some of the firms export, while others only produce for the domestic market. The oldest firm began its operations in 1890, whereas the youngest firm is four years old. The sample includes 1057 observations. The Augmented Dickey-Fuller unit root test was performed to test for shocks in the data. The 2008 financial crisis, which had a great impact on the manufacturing sector, does affect the data, but the results remain reliable. The White heteroscedasticity test was used to test for consistency in the variation of the error terms in the estimates.

The research question in this study is whether foreign direct investment (FDI), technology and research and development (R&D) partaken in by firms will increase spillovers of industry, and thus production output, productivity and international competitiveness, or not. A direct measure for spillovers cannot easily be found. In this study, the number of competitors was used as a proxy for spillovers. Firms in industry are usually dependent on each other; if one firm improves on its production, this invites an equally competitive response from other firms (Hitt, Ireland & Hoskisson, 2009). It can further be explained that the more competitors a firm has, the more firms will respond to the activities of one firm and so the firm is forced to stay competitive in order to stay in business. Firms have to be more innovative to stay competitive. The more competitive a firm is, the more spillovers there will be. Konings (1999) found that for firms to benefit from FDI, they have to have absorptive capacity and their technology has to be at least partially advanced. To increase its technological capacity, a firm has to be competitive. What pushes it to be competitive are its competitors, because it has to stay ahead of the competition.

4.2 The Empirical Model

The model used in this study assumes that spillovers are dependent on foreign direct investment (FDI), technology and research and development (R&D), as was indicated by the existing literature, thus:

$$Spill = FDI + technology + R\&D$$

In other words, if spillovers are present, they will arise from the presence of FDI, technology and investment in R&D. The more a firm invests in technology, the more it will contribute to spillovers in the industry. This will also help other firms, as other firms may learn from it. Informal contacts make the transfer of information occur faster and simpler between firms. If a firm receives FDI, this should help it make more contributions to spillovers in the industry. As a firm invests more in R&D and its workers become more educated, this will also increase its contributions to spillovers, although it has a dual effect. An increase in human capital will also make workers more conscious of what can be shared with workers from other firms and this may also decrease spillovers.

The number of competitors and hence competitiveness was said to be used as a proxy of spillovers and foreign ownership was used as a measure of foreign direct investment. Information technology expenditure by firms was used as a measure of technology. R&D is taken as a proxy for investment in human capital (Cypher & Dietz, 2009), and it therefore cannot be measured with just one variable. Capacity utilisation, cost of training workers, foreign licenses and international quality certification were used as measures of R&D.

The impact of factors such as managers' experience, the education of workers and the number of employees on competitiveness was also tested. It was found that managers' experience and workers' education increase competitiveness of firms, but may decrease spillovers because there is more appropriation and workers are better able and willing to protect the information and activities of firms. The number of employees may have a negative impact on competitiveness. More employees in manufacturing usually means that the firm still uses much manual labour and could be less competitive than those who are more technologically oriented.

Spillovers can also be harmful to competitiveness and this is largely determined by how the information is transferred. The impact of crime, corruption, Internet communication, how much the firm spends on security, number of years with supplier, temporal employment source of information and the number of employees in the business on the competitiveness of the firm was tested.

The findings show that spillovers from FDI are relatively small and the firm that benefits more is the direct receiving firm. The other firms in industry do not enjoy many benefits, but this can be because of their lack of absorptive capacity. Spillovers from technology are not as large as was anticipated; however, the reason for this could be slow technological development in South Africa. Spillovers from R&D are high, but the more educated workers are, the less spillovers there will be; unless these spillovers are through improper channels.

Spillovers through crime and corruption harm the competitiveness of firms as spillovers occur through improper channels. The firm is usually not aware of the information that is leaking to external parties and this could be confidential information. What was thus far explained above is tested in the following section.

4.3 Empirical Results on Spillover Effects

The fact that a firm exists over time is taken as an indication that it has the capacity to sustain its operations and compete with other firms. The longer a firm has been in existence, the more competitive it will be and firms that are competitive are the ones that contribute more to spillovers because they invest in research and development (R&D) and technology, and are the main attractors of foreign direct investment (FDI). There is no direct measure for spillovers, therefore, in this study, competitiveness will be used as the measure for spillovers. The number of competitors was used as a measure of competitiveness in this study, because the more competitors a firm has, the more competitive it has to be. The existence of many competitors forces it to invest in new technology and R&D and to attract FDI.

Foreign ownership was used as a proxy for FDI; information technology expense represented technology. Three variables were employed to indicate research and development (R&D), as it cannot be reduced to just one activity. Capacity utilisation, international quality certification, foreign licenses and cost of training were used to indicate R&D – dummy variables were used in this case. The reason for the use of all these variables is because capacity utilisation indicates just how well a firm has invested in research and development and is then able to utilise its capacity. If a firm trains its workers, it spends money, it invests in human capital, which is part of R&D. This increases the absorptive capacity of the firm and the ability to benefit from the spillovers as workers know more, are better skilled and are able to take advantage of new technologies that are introduced all the time. If a firm has international quality certification, that means its products are good enough to be exported to other countries and are accepted in those countries and the firm is competitive. The estimated model can be represented as:

$$Spill = \beta_0 + \beta_1 FDI + \beta_2 + technology + \beta_2 R\&D + u$$

Spillovers are determined by foreign direct investment (FDI), the level of technology and research and development (R&D). The aim was to show that when FDI increases, spillovers also increase. As the level of technology increases within an industry, technology spillovers also increase and as R&D in the manufacturing industry increases, the R&D spillovers will also increase.

The model was then tested and general estimations made. Attention will now be paid to the results. The competitiveness of firms and factors strengthening it will also be discussed, as well as factors that give firms a competitive advantage. These are then related to spillovers. Spillovers can be

harmful depending on how they occur and how they are managed; the results of this hypothesis are also given in this section.

4.3.1 Spillovers in general

The model implies that the number of competitors (*compnum*) hence competitiveness and therefore spillovers are determined by the following: foreign ownership (*forown*), IT expense (*itexpense*), capacity utilisation (*capacity*), international quality certification (*intqual*), foreign license (*forlic*) and cost of training workers (*costtrain*). The aim of this equation is to test spillovers given all the relevant variables (mentioned throughout the text as FDI, technology and R&D).

The aim is to test spillovers, given the relevant variables. The final estimated model is:

$$\begin{aligned} Compnum = \; & -0.132 - 0.0017\,forown - 7.44E\text{-}10\,itexpense + 0.0148\,capacity + \\ & \quad (0.11) \qquad (0.002) \qquad\quad (8.11E\text{-}09) \qquad\quad (0.0023) \\ & + 0.149\,intqual + 0.9212\,forlic - 0.0048\,costtrain \\ & \quad (0.065) \qquad\quad (0.102) \qquad\quad (0.0098) \end{aligned}$$

$n = 1056 \quad R^2 = 52.9\% \quad \bar{R}^2 = 52.6\% \quad \text{Prob(F-statistic)} = 0.000000$

The R^2 of 52.8% indicates the part of the variation where the independent variables explain a significant part of the variation of the dependent variable (number of competitors). The R^2 higher than 50 per cent implies that the model is quite a good fit. The Prob (F-stat) is zero, indicating a significant relationship between the independent variables.

The model has 1056 observations and the Durbin-Watson is less than two, implying that negative autocorrelation exists, meaning that there is a poor relationship between the variables in the equation. The reason for this negative autocorrelation is because some variables affect spillovers negatively. For instance, as some aspects of R&D, such as cost of training increase, spillovers decrease as the firm now has more information and wants to protect the information it has in order for the firm itself to profit from it. This gives the firm more competitive advantage in its industry.

The findings of the study are not far from what previous researchers on this topic have found. FDI still contributes very little to spillovers. The increase in the FDI in one firm does very little in benefiting the other firms; the benefit of the FDI is mainly enjoyed by the firm receiving it. The contribution would be better if domestic firms had absorptive capacity and the technology levels were higher. There is also a negative relationship between FDI and spillovers. The receiving firm enjoys the benefits derived from FDI, all other firms can only benefit if they have absorptive capacity. Therefore, FDI does not increase spillovers in the manufacturing industry.

As technological knowledge increases in a firm, the firm acquires new ways to protect its resources from outside exposure, which may decrease spillovers. Industrial espionage has become common in industry today and firms constantly try to protect themselves. Technology advancement should contribute more to spillovers; however, the results do not show this. The reason the results prove otherwise could be because technological advancement in South Africa is not at the level where it should – or could – be and hence does not contribute as much. If there could be more invested in technology as well as R&D, then the results could be slightly different.

Research and development has many aspects or factors that define it and cannot be limited to just one variable. In this study, the variables that are taken into consideration are the cost of training workers, which means that the firm invests in human capital, international quality certification, foreign license and capacity utilisation. All but one of these factors increase spillovers and that is cost of training. Exporting firms have the ability to contribute positively to spillovers. They have exposure to other countries that have acquired the necessary skills to meet the import requirements of that country; their production is effective and can aid other firms in achieving this. Firms with capacity utilisation increase competitiveness and therefore spillovers in the sense that these firms invest in R&D, they have the absorptive capacity and can utilise the skills and knowledge acquired through R&D, and instead of all that knowledge spilling over to other firms, they become more competitive and

have appropriation capabilities. Firms that invest in human capital have the advantage of employees who can discern what can be shared with other firms and protect the interests of the firm, therefore decreasing spillovers. They have enough knowledge to know what should be transferred to other firms and what should remain within the firm. Their knowledge gathered from R&D allows them to protect the firm and its innovations and knowledge.

4.4 Competitiveness of Firms

Managers' experience, workforce education and number of employees also contribute to competitiveness. The number of competitors was used as the dependent variable. The more competitive a firm is, the lower the number of competitors as new competitors do not stay in the industry for long and it empowers the other competitors. The following equation includes these three variables and shows how they contribute to spillovers. Managers' experience (*manexp*), level of education among workers (*workeduc*) and the number of employees (*employ*) determine the competitiveness of a firm. This is represented as:

$$compnum = \beta_0 + \beta_1 manexp + \beta_2 workeduc + \beta_3 employ$$

As the experience of the manager increases by one per cent, the competitiveness of the firm increases by 1.7 per cent. However, if the manager has more experience, the chances of the firm contributing to spillovers are decreased, as shown above; as human capital increases, spillovers decrease. If the firm has educated workers, it does not rely on spillovers in the industry as much, hence spillovers on firm level decrease.

As the education of workers in the firm increase by one per cent, the competitiveness of the firm increases by 24.97 per cent. The more skilled the workers of a firm the more productive and competitive the firm will be.

There is a negative relationship between the number of employees and competitiveness, which is in line with the law of diminishing returns on labour. A firm using more human labour than technological capital experiences lower production levels. Firms with many workers, not considering size, may be slower in its production output, as humans work slower than machines. Another factor could be that the more employees a firm has, the larger the chances of information on its operations leaking to its competitors and its competitive advantage declining. A one per cent increase in the number of employees leads to a 0.04 per cent decrease in competitiveness.

4.5 Sales and spillovers

When sales are taken as the independent variable the most important findings of the empirical research were as follows: Firm-level cross-sectional data was used to conduct an empirical regression model consisting of 276 observations. The large size of the sample lead to a more effective and significant model.

The equation of a simple regression model may be given as: $\ln y = \ln \beta 0 + \ln \beta 1x + u$, where β will be the coefficient of the variables, x represents the variable itself and u is the error term. The log of sales was used as the dependent variable as it represents firm growth, productivity and competitiveness. The independent variables included direct exports (direx), the log of the number of competitors (comp), the log of cost of communication (com), which will be the proxy for spillover effects in knowledge creation efforts, the log of cost of machinery and equipment (mac), the log of the number of skilled production workers (skill), which will be the proxy for education and a dummy variable representing the undertaking of new projects by the firm (newproj), which will be the proxy for innovation and the percentage of private domestic ownership (priv).

Referring to the final estimated output regression model reflected a positive relationship to direct exports, cost of communication, cost of machinery, skilled production workers and new projects undertaken – as expected. A negative relationship to competitors and privately owned firms was also expected and concluded. Variables significant on the 5% level include direct exports, cost of communication, cost of machinery and equipment and skilled production workers. Significant variables on the 10% level include new projects and private domestic ownership.

The coefficient on competitors was not found as significant but according to the strong theory surrounding competitors in the market place, it has been included in the model. Therefore, best estimation of the regression equation is as follows:

$$\ln(sales) = 6.038 + 0.022\,direx + 0.536\ln(com) - 0.133\ln(comp) + 0.29\ln(mac)$$
$$(6.038)\quad (0.008)\quad (0.536)\quad (0.105)\quad (0.290)$$
$$+ 0.241\ln(skill) + 0.246newproj - 0.003priv$$
$$(0.241)\quad (0.246)\quad (0.002)$$

The R^2 is equal to 0.81 which means that 81% of the variation in the variables that are declared by the model and the overall fit is very good. The adjusted R^2 is also very close to the R^2, indicating that there is enough variables in the model and the specification is correct. The F-statistics indicated a model, which are statistically significant as a whole.

The results of the empirical analysis revealed a positive relationship between firm growth and direct exports, communication investments and investments in machinery and equipment as well as, investment in the skills of production workers and new projects undertaken. The growth of firms is, however, impeded by new competitors in the market and private domestic ownership of a firm, confirming the benefits of multi-national investments.

The findings of this study is in line with previous studies suggesting the same relationships of firm growth and competitiveness with communication capabilities, the presence of competition in the market, new project undertaking which serves as a proxy for innovation, skilled workers, the role of MNEs in domestic firm growth because of their knowledge spillovers and the acquisition of new, modern technology and machinery.

4.6 The harmfulness of spillovers

Spillovers can occur in a way that is harmful to firms. Industrial espionage has become common in industry, which means that there is a point when spillovers start being harmful or they occur in a manner that is harmful to the firm. These also affect competitiveness and a model showing the harmfulness of spillovers to competitiveness is estimated. This phenomenon was measured with the inclusion of following variables: corruption (*corrupt*), Internet communication (*intercom*), percentage cost of security (*costsec*), years known supplier (*yrsuppl*), temporal employees (*tempemploy*), source of information new supplier (*sourceinfo*), number of employees (employ), as well as crime, theft and disorder (crime).

The higher the levels of corruption in a firm, the more it is exposed to its information leaking to its competitors. Much information is exchanged via the Internet; employees get very comfortable and share information with their informal contacts. Firms reveal much of their practices on the Internet, on the firm's websites or in other forms. The more a firm pays for security, the more serious it seems about protecting its property and innovations, therefore this variable will show how protecting the firm decreases or increases spillovers and affects competitiveness. Temporal employees within a firm can share information with anyone as they interact with various firms. This may threaten firms. Information can be transferred through suppliers. It is important that firms use suppliers they can trust. The longer a firm has been with one supplier, the more trustworthy they are. However, suppliers will get to know more about the firm and can share that knowledge with competitors. The more crime, theft and disorder within industries, the more spillovers can take place in a way that can harm the competitiveness of firms.

The estimation of the final regression in this case is:

$$compnum = 1.8199 + 0.163\,corrupt + 0.425\,intercom + 0.0248\,costsec +$$
$$(0.142)\quad (0.056)\quad (0.051)\quad (0.016129)$$
$$+ 0.009\,yrsuppl + 4.84E\text{-}05\,tempemploy + + 0.0544\,sourceinfo -$$

(0.005971) *(0.000553)* *(0.0163)*

- 0.0004 employ - 0.0726 crime

(0.0002) *(0.0527)*

n = 1055 R^2 = 9.02% $\bar{R}^2$ = 8.32% Prob (F-statistic) = 0.000000

The model is a reasonable fit. The adjusted $\bar{R}^2$ is at 8.3 % per cent indicating that the independent variables do have some significance. Although the variation of the independent variables explains only about eight per cent of the variation of the dependent variable, the correlation is still positive. The Durbin-Watson shows some positive autocorrelation at 1.01.

As corruption increases, the number of competitors of the firm also increases. Information leaks out to potential entrepreneurs. New firms know about the operations of the existing firm and this may harm its competitiveness. Corruption, including bribes, decreases the benefits of spillovers because spillovers do not happen in a way that benefits the firm. The party that benefits is the one involved in the corruption and the other one suffers. A one per cent increase in Internet communication by employees increases the number of competitors by 42.5 per cent. Information spreads much faster over the Internet, even confidential information about the firm and its operations that can harm its competitiveness. An increase in the cost of security for the firm also increases the number of competitors to some extent. The amount is very small and its significance is questionable. As the years with the same business supplier increase, the number of competitors of a firm also increases. This is, however, small because relationships have been built with suppliers and suppliers may be reluctant to share information about a firm with irrelevant parties. When a firm is exposed to one supplier, it is not exposed to other suppliers, backward and forward linkages are minimised and the possibility of learning something new is minimised, leading to a decrease in spillovers . Staying with one supplier has disadvantages as well; there is an opportunity cost when it comes to staying with one supplier. The supplier could give discounts to its loyal customer and the firm trusts the supplier. On the other hand, suppliers may have enough information about a firm to hurt the firm. A new supplier might also give discounts in order to lure firms away from competitors; however, these firms might be sceptical, because they do not know a supplier well enough to trust it with their information and they lack experience of the quality of goods and services it suppliers.

A one per cent increase in the number of temporal employees, increases the number of competitors by 0.04 per cent. This is because temporal employees learn new skills and knowledge while working with one firm and then apply them when they move to another firm. However, the percentage here is small, because in South Africa many temporal employees do not leave a firm to start their own firm, so they do not increase the number of competitors. An increase in new suppliers giving the firm information increases its number of competitors to some extent. The new supplier provides the firm with new information about the industry, the firm's competitive advantage increases, and it can be better than its competitors. This will force some competitors out of business, thereby increasing its market share and being more competitive. As the number of employees increases, it reduces the number of competitors. This is because potential entrepreneurs that could be a firm's competitors are part of the firm. An increase in crime leads to a significant decrease in the number of competitors. Crime does not contribute positively to industrial development and will not increase the number of firms that emerge therein.

5. Some Policy Implications and Recommendations

The results of this research lead to several policy implications and recommendations. It is important to formulate and adjust development strategies for different industries and a laissez-faire trade approach (with no or little government interference) regarding the import of key elements in the production process. Eventually, these key elements might be produced locally as well. Another recommendation is to involve universities and other research institutions in the effort to improve innovation and competitiveness on regional level initially. This will result in industrial development which is the ultimate goal of innovation policy (Motohashi *et al*, 2010:797).

It is assumed that multi-national enterprises (MNEs) can contribute to knowledge flows from external markets and as such, there is a role for government, especially in developing countries, to be more active in the process of knowledge diffusion to particularly industries in which MNEs are scarce, as

well as to support domestic firms with low levels of absorptive capacity. Therefore also, firm characteristics, as well as knowledge and technology spillovers form MNEs and exporting firms are important for market participation (Alvarez, 2007: 390).

It is also important that firms themselves engage in knowledge creation efforts in order to benefit from knowledge spillovers as their absorptive capacities will be enhanced with greater internal research and development efforts. This also necessitates sufficient human capital endowments to carry out these developments. Therefore, enhancement in terms of training and education should be encouraged by suitable policies. This will also lead to poverty alleviation, and an increase in foreign direct investment and infrastructure promotion.

When engaging in joint knowledge creation efforts with other firms, an optimal ratio between prior and current knowledge attained through joint ventures should be achieved and maintained for the joint venture to be successful (Ding *et al*, 2010:957).

In essence, policies that will enhance regional development and education are crucial as this will eventually spill over to the local market and also across national borders. Trade liberalisation and investment in local markets by MNEs should also be encouraged.

6. SUMMARY AND CONCLUSION

Knowledge spillovers may have important effects on firm growth and competition. It is thus important to identify the elements that affect the transferral of knowledge between firms such as clustering. This study focused on the knowledge spillover effects and competition in the manufacturing sector on regional, national and international level occurring as a result of increased market integration with the surge of globalisation. The interaction between foreign direct investment (FDI), sales, technology, and research and development (R&D) spillovers were investigated. The study starts by assuming that spillovers are good and should be encouraged. Industrial development seems to escalate when firms are growing individually and this growth is extended to other firms. Other firms learn from growing firms and then grow too – this is what is meant by the spillover effects of industrial development. It is usually assumed that a rise in FDI, technology and R&D will have increasing returns for any firm and even greater returns for the industry as a whole. Testing this hypothesis was the motivation of this study – spillovers then have the ability to enhance but, to the other extreme, also diminish productivity growth.

The findings of this study confirm the results of previous researchers on this topic. FDI contributes very little to spillovers. An increase of FDI in one firm does very little in benefiting the other firms; the benefit of the FDI is mainly enjoyed by the firm receiving it. The contribution occurs when domestic firms have the absorptive capacity and the technology levels of a high stage. Different types of spillover effects exist and the type most relevant to this study was Porter spillovers that state that a country is able to create the necessary factor endowments, like skilled labour and a strong technology base.

Technological advancement contributes more to spillovers; however, this did not show very strongly in the results. The reason could be that technological advancement levels in South Africa are too low and hence does not contribute much. If there could be more invested in technology as well as R&D, the results might be slightly different.

Research and development (R&D) has many aspects or factors that define it and cannot be limited to a single variable. In this study, the variables that are taken into consideration are the cost of training workers – which means that the firm invests in human capital – international quality certification, foreign license and capacity utilisation. All but one of these factors increases spillovers, except the cost of training. Exporting firms have the ability to contribute positively to spillovers. They have exposure to other countries that have acquired the necessary skills to meet import requirements of that country; their production is effective and can aid other firms in achieving this. Firms with high capacity utilisation increase competitiveness and therefore spillovers in the sense that these firms invest in R&D, they have the absorptive capacity and can utilise the skills and knowledge acquired through R&D and instead of all that knowledge spilling over to other firms, they become more

competitive and have appropriation capabilities. Firms that invest in human capital have the advantage of employees who can discern what can be shared with other firms and protect the interests of the firm and this decreases spillovers. They have enough knowledge to know what should be transferred to other firms and what should remain within the firm. Their knowledge gathered from R&D allows them to protect the firm, its innovations and knowledge.

Spillovers can be harmful to the competitiveness of firms and this phenomenon is shown by the results. Crime and corruption, among other factors, contribute to the incorrect spillover of knowledge and technology and this can be harmful. A firm can also be a victim of industrial espionage. Information is also transferred over the Internet; this information can be the kind that the firm would like to keep within the firm and this negatively affects the firm if it leaks to competitors.

The conclusion was that spillovers are good for industrial development and should be promoted; however, the process should be well managed, or else it may hurt the competitiveness of firms. The limitations to this study are that spillovers are not easily measurable. It is difficult to determine just how much a firm contributes to its industry in terms of foreign direct investment, how much technological knowledge it shares with other firms or how much R&D benefits it shares with other firms. Basically, it is difficult to determine just how much is spilled over from one firm to the rest of the industry or a knowledge sharing system.

Spillovers are good for industrial development, but if they are to occur in wrong ways they may hurt the competitiveness of firms. Spillovers can be harmful to the competitiveness of firms and this phenomenon was highlighted by the results. Crime and corruption, among other factors, contribute to the incorrect spillover of knowledge and technology and this can be harmful. A firm can be a victim of industrial espionage due to crime and corruption. Information is also transferred over the Internet; this information can be the kind that the firm would like to keep within the firm and this negatively affects the firm if it leaks to the wrong people. There are however ways to encourage and participate in knowledge and technology spillover systems without jeopardising the firm's competitiveness and how to protect it.

The government needs to encourage firms to gain knowledge. It should give firms incentives to invest in research and development (R&D) and in human capital. The government could subsidise firms that embark on such activities. The government is in a better position to attract foreign direct investments (FDI) to the country and towards industries. It can better negotiate with international capital and if a private firm intends to go into business with a foreign firm, it may be easier to get investors if they are backed by the government. Large, resourceful organisations, trans-national corporations, large domestic firms and universities should invest in the accumulation and the creation of local knowledge and policy-making boards to encourage FDI.

The promotion of relationships between firms should be promoted as it is good for industrial development. Firms with the same knowledge base should work closely together. They can grow much faster and contribute much more to the industry. Firms should, however, find the best way to protect themselves from corruption, crime and theft, as these could harm the competitiveness of the firm. The government should make the patent application process shorter and less costly, so that producers can protect their ideas and innovations and profit from them. This will all accelerate industrial development.

Previous literature studies emphasised the importance of prior knowledge protection through patents as well as the importance of internal research and development efforts to encourage investment from MNEs, as well as FDI. The importance of an educated human capital base was also researched and found to be of utmost importance for industrial development. Joint knowledge creation efforts may also be undertaken to encourage industrial development. Specifically the study using data from manufacturing firms in South Africa, found that significant connections between firm growth (where sales acted as a proxy for growth), exports, communication investment, machinery and equipment investment, skilled production workers, private firm ownership and the undertaking of new projects and the number of competitors in the market. These findings are in line with existing literature studies.

Policies that encourage cooperation between firms as well as cooperation with research institutions should be formulated to improve industrial development. Competition policy will have to address

issues, which limit internal research and development efforts. The role for government, especially developing in countries, is important to protect key industries and stimulate knowledge creation and innovation efforts, as well as to stimulate investment from MNEs. This however, necessitates a certain level of development already, emphasising the need for internal research and development. Education should be a primary goal to facilitate the knowledge creation and innovation process of a country.

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