The Contribution of FDI, *Technology and* R&D *to Spillovers in Industrial Development: A South African Firm-Level Investigation*

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This article studies the contribution of technological and knowledge spillovers towards the competitiveness of South African manufacturing firms. Literature often emphasizes the role of foreign direct investment (FDI), technology, and research and development (R&D) in spillovers, but seldom consider their effect simultaneously. This study focuses on the micro-economic production level and on the interaction of these factors. It determines their influence on the competitiveness, profits and eventual industrial development. The empirical study utilised data from the World Bank's firm-level survey on South African manufacturers. The study reveals that direct foreign investments and ownership contribute little towards secondary spillovers, which probably depends on absorptive capacity. Technological advancement is not very significant, while research and development are dependent on absorptive capacity to enhance competitiveness, especially with regard to the investment in human capital. International quality certification, foreign licensing and capacity utilisation all contribute positively towards the ability to enhance productivity growth and the competitiveness of firms.

Key Words: production, spillovers, FDI, technology, R&D, industrial development, competitiveness
JEL *Classification:* D24, D83, L11, L30, L60, O30

Introduction

This study investigates the contribution of technological and knowledge spillovers towards the competitiveness of South African manufacturing firms. The assumption is that spillovers have a positive effect on industrial development. Literature on the competitiveness of firms, for instance the Porter Diamond (Porter 1998) or agglomeration

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economics (Krugman, Obstfeld, and Melitz 2012, 172), often mentions spillovers without giving much attention to it, nor defining it. Even though spillovers are regarded as important, they are difficult to conceptualise and measure, and are often ignored. This paper wishes to investigate spillovers and find more clarity on these aspects.

The research question is to what extend technological and knowledge spillovers contribute to more efficient micro-economic production and competitiveness. Efficiency leads to higher profits and eventually to industrial development. Literature shows that technology, direct foreign investments (FDI), and research and development (R&D) cause most spillovers on the micro-economic production level and this study focuses on the contribution of these factors.

The available literature often investigate the role of some of these factors, but seldom acknowledge that FDI, R&D and technology might lead to spillovers simultaneously, and that there might be interaction between these factors that may affect competitiveness and the efficiency of production. This study wishes to investigate the interaction of these factors working together generating spillovers. Literature assumes that spillovers may contribute in a positive way, but neglect the fact that it might also be harmful to firms in some instances. This merits some attention and was also considered in this study. 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 article made a literature study, followed by an econometric study on firm-level data of South African manufacturing companies, mainly using panel data and regression analysis. This article is structured as follows: firstly, the literature study will report on the role of FDI, R&D, and technology causing spillovers during production of firms, as described by the existing literature and theory. Secondly, the findings of an empirical investigation are reported.

In the empirical section, the contributions of spillovers towards the competitiveness on firm-level were evaluated first, followed by an investigation of spillovers in relation to human capital. Here the focus is primarily on the level of experience and education of management and labour. Finally, the findings on the possible harmful effects of spillovers in production and competitiveness are reported. The final section summarised and concludes the article. Firstly, attention will now be paid to literature of existing research on this subject.

Literature Review on Spillover Effects

Firms learn from each other. According to Guiliani and Bell (2005, 47), spillovers occur especially in industrial districts or clusters, which they define as 'geographic agglomerations of economic activity that operate in the same sector.' Cassiman and Veugelers (2002, 13) 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 others and the information that the firm keeps to itself in order to reap the benefits of their innovativeness. The information sources for incoming spillovers are usually in the public domain for any firm to use. Whether this is useful to a particular firm depends on the firm's ability and absorptive capacity to create information flows from this public pool of knowledge.

The assumption is that economic growth in a country can be attributed to the openness of its trade and capital flows (Du Plessis and 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 be encouraged as they motivate growth, knowledge and technological spillovers, including absorptive capacity and capabilities.

There is a link between economic growth and spillovers. The spillover effects of investment start with capital (Keynes 1970, 136). According to Berthelemy (1995, 153), investments not only improve the productive capacity of a particular business and individual workers within that firm, but they also improve the productive capacity of other businesses or workers that come into contact with those directly affected by the investments. The knowledge and experience is then transferred between various parties, and spillovers stretch even beyond the confines of a single industry.

Clemes, Arifa, and Gani (2003, 29) also show that investments in both services and manufacturing are needed for the expansion of 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 also influence each other (Clemes, Arifa, and Gani 2003, 30), 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 progresses well, it will attract more investors, as the term 'growth in numbers' applies. If only a few firms are successful in an industry, it discourages investors because it leads to low expectations.

Studying South African manufacturers, Kleynhans and Swart (2012) found a positive correlation between sales figures and expenses on communication and the number of skilled workers and innovation, while the number of competitors and private ownership are detrimental to sales, emphasising the role of MNEs and FDI. Studies have revealed that in order for firms to be successful in their innovation processes, there has to be interaction between agents that are involved in a particular industry (Park, Lee, and Park 2009, 74). When entrepreneurs start new businesses, it is often close to previous employers. In that way, clusters are formed and they might keep in touch, working together and spillovers are thus generated.

Newly appointed employees at a firm generally share information more easily with outsiders. The longer an employee is employed, the more specific this information becomes (Dahl and Pederson 2003, 3). While conducting research for this paper, many engineers have agreed that knowledge sharing is important. It makes work easier and improves their productivity.

Literature on spillovers usually assumes that *foreign direct investment* (FDI) is a major contributor. Blomstrom and Sjoholm (1999, 6&7) found positive micro-spillovers from FDI in Indonesia and several other countries. Konings (2001, 626), 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 other domestic firms. Blomstrom and Sjoholm (1999, 8) found that labour productivity is also 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 con-

sumer needs and market trends (Kesidou and Romijn 2008, 2023). Positive FDI spillovers to local firms are, however, 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 2001, 26).

Most literature found that FDI has no secondary spillovers that are large enough to improve industrial development, and at times, FDI might even be 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, 250). Aitken and Harrison (1999, 617) also could not have found any 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 (2001, 632) found that spillovers that are associated with FDI do not enhance the performance of other domestic firms. In fact, the promotion of FDI may even lead to perverse effects in the short-run.

According to Konings (2001, 26), 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, 3) found that there is a relationship between external flows and the decision to cooperate in R&D. Firms that regard the available sources of external information as an important input to their innovative process, will be actively involved in R&D agreements (Cassiman and Veugelers 2002, 13). 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 also has to undertake R&D projects itself (Bernstein and Nadiri 1988, 6). According to Steurs (1995, 256) 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 its lowest.

As development increases, technological spillovers also become important. *Modern technology* provides much more flexibility within firms and their processes than there were before (Paul 2002, 302). Technology spillovers have positive effects on the productivity of domestic firms, but

there may be a competition effect that can be harmful, putting pressure on domestic firms (Konings 2001, 624). According to Blomstrom and Sjoholm (1999), technology spillovers are often a result of an increase in competition that follows FDI.

It is generally believed that local participation with multinational corporations (MNCs) reveals the MNC's knowledge base and that it will lead to spillovers of technology in the domestic industry. Blomstrom and Sjoholm (1999, 7), however, found that local participation with MNCs does not facilitate much technology spillovers in the host economy, but that spillovers are rather determined by other factors.

Spillovers may also have adverse effects on firms, although existing literature gives very little attention to this. Spillovers of information and technology that can benefit a firm's competition may also harm the firm if competitors obtain such knowledge and technology. In such cases, such spillovers should be limited. Firms attempt to protect and keep the benefits of their innovations to themselves by controlling the information flows from the firm to the pool of publicly available information (Cassiman and Vuegelers 2002, 1). 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 also have to be careful that their forms of protection do not harm or inhibit the growth of the industry. 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 such agreements (Cassiman and Vuegelers 2002, 2).

Evidence suggests that competitive firms and universities may form linkages with less productive firms because they can somehow benefit from it. Within the Brazilian wine industry context, these benefits are through universities acquiring land and vineyards to enable 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 and Arza 2009, 917). Synergies might also exist. The problem lies in regulating linkages of associates and competitors.

The next section details the research design and the data, and considers the methodology and econometric analysis that were used in this study. This is followed by a report on the findings of the empirical re-

search that was conducted during this study and the paper concludes with a discussion in the last section.

The Research Design

This section will first describe the database used, followed by an explanation of the model and procedures that was followed during this research. Then the results obtained will be given. Firstly, reporting on the findings about spillovers on firm-level in general, secondly, the role of human capital in spillover effects are investigated, and finally, the possible harmful effects of spillovers are studied and reported.

SOUTH AFRICAN MANUFACTURING DATA

This study investigated South African manufacturing firms that produce durable, as well as non-durable products. Data from the World Bank's surveys on manufacturing firms was used. The database is known as the World Bank Enterprise Surveys (see http://www.enterprisesurveys.org/). It provides comprehensive firm-level data of emerging markets and developing economies. The World Bank uses standard survey instruments to collect firm-level data on the business environment from business owners and top managers. The surveys cover a broad range of topics including access to finance, corruption, infrastructure, crime, competition, labour, obstacles to growth, and performance measures.

This World Bank database offers business data of 130,000 firms in 135 countries. 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 that was utilised for this study included 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 heteroskedasticity test was used to test for consistency in the variation of the error terms in the estimates. The inclusion of variables for FDI, exports and in some regressions a time lag, also addressed the problem of endogeneity to some extent.

THE EMPIRICAL MODEL AND PROCEDURE FOLLOWED

This study assumes that spillovers are dependent on foreign direct investment (FDI), technology, research, and development (R&D), as it was

indicated by the existing literature (Bielik, Pokrivčák, Qineti, and Pokrivcakova 2006; Konings 2001; Cassiman and Veugelers 2002; Leahy and Neary 2004), thus:

Spillovers = FDI + technology + R&D.

In other words, the more a firm invests in technology and R&D, and/or receives FDI funds, the more it will contribute to spillovers in the industry. This will also assist other firms, as other firms learn from it. 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 may be shared with workers from other firms, which may in turn also decrease spillovers.

The research question can specifically be phrased as, to what extend foreign direct investment (FDI), technology, research, and development (R&D) contribute towards spillovers between firms and through that, towards higher production output, productivity and international competitiveness. A direct measure for spillovers cannot be found easily. The number of competitors was used as a proxy for spillovers in this study. Firms in any industry are usually dependent on each other; if one firm improves on its production, it invites an equally competitive response from other firms (Hitt, Ireland, and Hoskisson 2009, 53). 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 remain in business. The existence of many competitors forces it to invest in new technology and R&D and to attract FDI. Firms have to be more innovative than others to stay competitive. The more competitive a firm is, the higher the possibility of spillovers. Konings (2001, 623) found that for firms to benefit from FDI, they have to possess absorptive capacity and their technology has to be at least partially advanced. To increase its technological capacity, a firm has to be competitive. Firms have to stay ahead of their competitors, and should therefore always strive to be competitive.

The fact that a firm exists over time is 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 is, and firms that are competitive are the ones that contribute most to spillovers because they invest in research and development (R&D) and technology, and are the main attractors of foreign direct investment (FDI).

The number of competitors and hence competitiveness was said to be used as a proxy of spillovers, while 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 and Dietz 2009, 459) and cannot be measured with just a single variable. Capacity utilisation, the cost of training workers, foreign licensing and international quality certification were used as measures of R&D – dummy variables were used in this case. The use of these variables is justified because capacity utilisation indicates how well a firm has invested in research and development and in return it is able to utilise its capacity. If a firm trains its workers, it spends funds, investing in human capital, which is a 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 impact of factors such as the experience of managers, the education of workers and the number of employees on competitiveness was also tested. Competitiveness and spillovers were measured in relation to managerial experience (manexp), the level of education among workers (workeduc) and the number of employees (employ). This was estimated using panel data and regression analysis, which can be represented as:

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

Finally, the possible negative effects of spillovers on firm-level were estimated. Spillovers may 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, employment source of information and the number of employees in the business were tested.

The empirical findings of what was thus far explained above are reported in the following sections.

Empirical Results on Spillover Effects

The model was then tested and general estimations were made. 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 the following section. The results are as follows.

SPILLOVERS IN GENERAL

The model implies that the number of competitors (*compnum*), hence competitiveness and therefore spillovers are determined by: foreign ownership (*forown*), IT expense (*itexpense*), capacity utilisation (*capacity*), international quality certification (*intqual*), foreign license (*forlic*), and the 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 final estimated model is:

$$\begin{aligned} Compnum = {} & -0.132 && -0.0017\ forown && -7.44^{e-10}\ itexpense \\ & (0.11) && (0.002) && (8.11^{e-9}) \\ & +0.0148\ capacity && +0.149\ intqual \\ & (0.0023) && (0.065) \\ & +0.9212\ forlic && -0.0048\ costtrain \\ & (0.102) && (0.0098) \end{aligned}$$

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

The R^2 of 52.8% indicates that a part of the variation in the independent variables explains 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 probability (F-stat) is zero, indicating a significant regression.

The model has 1056 observations and the Durbin-Watson is less than 2, implying that some negative autocorrelation exists, which implies that some relationships between the variables in the equation are not as significant as it was initially considered, but 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 confirm the findings of other researchers on this topic (e. g., Konings, 2001). 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 even 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.

Spillovers from technology are not as large as it was anticipated; however, the reason for this might be slow technological development in South Africa. Spillovers from R&D are high, but the more educated workers there are, the less these spillovers are; unless these spillovers flow through improper channels.

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. Technological 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 were more investments in technology as well as R&D, the results might be slightly different.

The components that were utilised to measure research and development were the cost of training workers (which means that the firm invests in human capital), international quality certification, foreign license and capacity utilisation. All of these factors increase 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 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. 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 information can be shared with other firms and to protect the interests of the firm, therefore, decreasing spillovers. They have enough knowledge to know what can be transferred to other firms and what should not be disclosed within

the firm. Their knowledge gathered from R&D allows them to protect the firm and its innovations and knowledge. The following section focuses on the role of human capital in spillovers.

SPILLOVERS IN RELATION TO HUMAN CAPITAL

Considering the influence that spillovers may have on human capital, existing literature suggests that the experience and education of managers and workers increase competitiveness of firms (Leahy and Neary 2004). This study found that experiences of managers, education of the workforce, and the number of employees also contribute to competitiveness. It may, however, also decrease spillovers because there is more appropriation and workers are better able and willing to protect the information and activities of firms when they are more experienced and better trained. 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 competing firms.

It was found that when the experience of a manager increases by one per cent, the competitiveness of the firm increases by 1.7 per cent. It was also found that if the manager has more experience, the chances of the firm contributing to spillovers are less; as was shown above, when human capital increases, spillovers decrease. If the firm has an educated workforce, it does not rely as much on spillovers, hence spillovers on firm level decrease. When the education of workers in a firm increases by one per cent, the competitiveness of the firm increases by 24.97 per cent. The more skilled the workers of a firm are, 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 one per cent increase in the number of employees leads to a 0.04 per cent decrease in competitiveness. A firm using more human labour than technological capital, experiences lower production levels. More employees in a manufacturing firm often implies that the firm still uses much manual labour and could be less competitive than those who are more technologically oriented. Firms with many workers may be slower in their production output, as humans work slower than machines. Another factor could be that the more employees the firm has, the larger the chances of information on its operations leaking to its competitors, declining its competitive advantage.

HARMFUL EFFECTS OF SPILLOVERS

Spillovers may occur in ways that are harmful to firms. This implies that there is a point where spillovers may start being harmful or occur in a manner that may decrease the firms' profitability and its competitive position. This phenomenon was measured with the inclusion of variables on corruption (*corrupt*), the Internet communication (*intercom*), percentage cost of security (*costsec*), years known supplier (*yrsuppl*), employees (*tempemploy*), supplier as a new source of information (*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 information leaking to competitors. Much information is exchanged via the Internet; employees get comfortable and share information with their informal contacts. Firms reveal much of their practices on the Internet, on firm websites, or in other forms. The more the firm pays for security, the more serious it seems to be about protecting its property and innovations; therefore, this variable shows to what extend the firm protects itself against spillovers and its effects on competitiveness.

Temporary employees within a firm may share information indiscriminately with anyone as they interact with various firms. This may threaten firms. Information can also be transferred through suppliers. It is important that firms use suppliers that are trustworthy. The longer the firm uses a certain supplier, the more trustworthy such supplier becomes. Sensitive information of a firm is safer with suppliers that have a long relationship with that firm. An increase in crime, theft, and disorder within industries also promote spillovers, which may be harmful to the competitiveness of firms.

The final regression estimated in this case was:

$$
\begin{aligned}
compnum = \; & 1.8199 && + 0.163\ corrupt && + 0.425\ intercom \\
& (0.142) && (0.056) && (0.051) \\
& + 0.0248\ costsec && + 0.009\ yrsuppl && + 4.84^{e-5}\ tempemploy \\
& (0.016129) && (0.005971) && (0.000553) \\
& + 0.0544\ \text{sourceinfo} && - 0.0004\ employ && - 0.0726\ crime \\
& (0.0163) && (0.0002) && (0.0527)
\end{aligned}
$$

$n = 1055$, $R^2 = 9.02\%$, $\bar{R}^2 = 8.32\%$, 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, though

not much. 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, competitiveness decreases. Information leak to potential entrepreneurs and often occurs through improper channels. New firms learn about the operations of an existing firm, which may harm its competitive position. Corruption, including bribes, decreases the benefits of spillovers, because spillovers do not happen in a way, which benefits firms in such cases. The firm is usually not aware of the piece of information, which is leaking to external parties and these could be some confidential information. The party that benefits is the one involved in the corruption while the other suffers.

One per cent increase in the Internet communication by employees increases the number of competitors by 42.5 per cent. Information spread much faster over the Internet, even confidential information about the firm and its operations 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 business with the same supplier increases through the years, 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 other parties. When a firm is only exposed to a single supplier, it limits its exposure, which minimises backward and forward linkages and the possibility of its competitors learning something new is minimised, leading to a decrease in spillovers. Staying with only one supplier may also have some disadvantages as well; there is an opportunity cost when it comes to staying loyal to a single supplier. The supplier could give discounts to its loyal customer and the firm trusts the supplier. On the other hand, suppliers may also have enough information about the 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 the supplier well enough to trust him with their information and they lack experience of the quality of goods and services he supplies.

One per cent increase in the number of employees increases the number of competitors by 0.04 per cent. This is because employees learn new skills and knowledge while working with one firm and then apply them when they move to another firm. An increase in new suppliers provides

increases of information on competitors to some extent. New suppliers provide firms with new information about the industry, which increases the competitive advantage of particular firms, in relation to its competitors. This will force some competitors out of business, thereby increasing its market share, making it even more competitive. As the number of employees increases, it reduces the number of competitors. This is because potential entrepreneurs that could become a firm's competitors remain 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.

Summary and Conclusion

This study considered the effect of technological and knowledge spillovers on the competitiveness and efficiency of micro-economic production of South African manufacturers. The focus was on the interaction between foreign direct investment (FDI), technology, and research and development (R&D) spillovers, as these factors are often emphasised in the existing literature. The article starts by assuming that spillovers advance industrial development 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 they 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 deliver increasing returns to firms and even greater returns for the industry as a whole.

The findings of this study confirm the results of previous researchers on this topic. FDI contributes little to secondary spillovers to other firms. An increase of FDI in one firm does very little in benefiting the other firms; the benefit of the FDI is mainly internalised by the firm receiving it. Benefits occur mostly when domestic firms have the absorptive capacity and a stage of technology, which is high enough to enable firms to take advantage thereof.

Technological advancement should contribute to spillovers; however, this did not show in the results of this specific study. The reason could be that technological advancement levels in South Africa are too low and hence do not contribute much. If more could be invested in the capacity and capability to utilise and internalise new technology, as well as R&D, the results might be slightly different.

Considering spillovers in general, this study found a positive relationship between competitiveness and R&D, especially with regards to capacity utilisation, foreign licensing and international quality certification, while the cost of training was detrimental, probably due to limited absorptive capacity. On the other hand, the relationship between competitiveness and foreign ownership was negative. The same applied to the contribution of FDI and technology; although more expenses on IT, especially the Internet, leads to more spillovers.

With regards to spillovers in relation to human capital, it was found that the degree of managerial experience and educational level of labour contributed positively to competitiveness, but to a decline in spillovers, probably because workers learn to protect the concerns of their firms better. On the other hand, spillovers increase with the number of employees, leading to a decline in competitiveness. Firms that invest in human capital have the advantage of employees that are capable of discerning what can be shared with other firms, protecting the interests of their firms, which decreases spillovers. They have enough knowledge to know what information may 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 have the ability to enhance but, to the other extreme, it can also diminish productivity growth. Spillovers are generally to the advantage of firms and should be promoted, but if they occur in the wrong places, it may be detrimental to the competitiveness of firms. This phenomenon was highlighted by the results of this study. Crime and corruption, among other factors, contribute to the incorrect spillover of knowledge and technology, and this may be harmful. Firms can also fall victim to industrial espionage. Information which a firm would prefer to keep restricted within the firm can also be transferred over the Internet; having a negative effect if it is leaked to its competitors.

Investigating the possible negative and harmful effects of spillovers, this study revealed that spillovers are positively associated with the volume of internet communication, the number of temporary workers, corruption, crime, theft, and disorder, which also curbs competitiveness and industrial development in general. New suppliers can serve as a source of information due to more spillovers, while this decline as suppliers are known longer to a particular firm as loyalty is build up with time. As could be expected, the level of spillovers decline as expenditure on security increases, which then also enhances firm's competitiveness.

Much information about the interaction of technology, FDI and R&D, and their contribution towards knowledge and technological spillovers and competitiveness was revealed by this study. Several studies reported in the existing literature consider the contribution of one of these factors towards spillovers that may affect competitiveness. The unique contribution of this study is that it also acknowledges that there are interactions between these factors of technology, FDI and R&D that influence the spillover effects together. Therefore, it also studied the spillover effects that these factors have when considered simultaneously when estimating regressions. Very little is also known about the negative effects of spillovers in the existing literature and in that regard this study makes a particular contribution.

Determining and measuring spillovers still remains a difficult endeavour and much research still needs to be done. In further research, the time factors and causality should also be taken in regard, although data restrictions make it difficult. More attention might be given to such techniques as investment and other actions during the production and management processes probably take some time to take effect, which cannot be indicated using cross sectional data and regressions. This study already utilised panel data to build in some time lag into the model.

Spillovers are good for industrial development and should be promoted; however, the process should be well managed, or else it may harm the competitiveness of firms. The limitations of studies like this one 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 into a knowledge sharing system.

Following this study, some recommendations are in order. Governments need to encourage firms to gain knowledge. It should give incentives to firms to invest in research and development (R&D), as well as in human capital. The government could subsidise firms that embark on such activities. Governments are in a better position to attract foreign direct investments (FDI) towards countries and industries. It can better negotiate with international capital and when private firms intend to go into business with foreign firms, it may be easier to attract investors if there is backing from government. Large, resourceful organisations, transnational corporations, large domestic firms and universities should

be encouraged to invest in the accumulation and the creation of local knowledge and technology.

The promotion of professional contact between firms should be promoted, as this contributes towards industrial development. Firms with the same knowledge base can cooperate. Firms can grow much faster and contribute more to industry in this way. Firms should, however, discover the best ways to protect themselves from corruption, crime and theft, as these could harm the competitiveness of the firm. The governments should make patent application processes shorter so that producers can protect their ideas and innovations and profit from them. This will all accelerate industrial development. This study highlighted the positive effects, which technological and knowledge spillovers have on the efficiency and competitiveness of firms.

References

Aitken, B. J., and A. E. Harrison. 1999. 'Do Domestic Firms Benefit From Direct Foreign Investment: Evidence from Venezuela.' *The American Economic Review* 89(3): 605–18.

Bernstein, J. I., and M. I. Nadiri. 1988. 'Interindustry R&D Spillovers, Rates of Return, and Production in High-Tech Industries.' *American Economic Review – AEA Papers and Proceedings* 78(2): 429–34.

Berthelemy, J. 1995. *Whither African Economies?* Paris: Organisation for Economic Co-Operation and Development.

Bielik, P., J. Pokrivčák, A. Qineti, and N. Pokrivčáková. 2006. 'The Spillover Effect of Foreign Direct Investment: The Case of Slovak Beer and Malt Production Sector.' *Agricultural Economics* 52 (8): 347–52.

Blomstrom, M., and F. Sjoholm. 1999. 'Technology Transfer and Spillovers: Does Local Participation with Multinationals Matter.' *European Economic Review* 43(4–6): 915–23.

Cassiman, B., and R. Veugelers. 2002. 'R&D Cooperation and Spillovers: Some Empirical Evidence from Belgium.' *American Economic Review* 92(4): 1169–84.

Clemes, M. D., A. Arifa, and A. Gani. 2003. 'An Empirical Investigation of the Spillover Effects of Services and Manufacturing Sectors in Asian Countries.' *Asia-Pacific Development Journal* 10 (2): 29–40.

Cypher, J. M., and J. L. Dietz. 2009. *The Process of Economic Development.* 3rd ed. Abingdon: Routledge.

Dahl, M. S., and O. R. Pedersen. 2003. 'Knowledge Flows Through Informal Contacts in Industrial Clusters.' DRUID Working Paper 03-0, Danish Research Unit for Industrial Dynamics.

Du Plessis, S., and B. Smit. 2007. 'South Africa's Growth Revival after 1994.' *Journal of African Economies* 16 (5): 668–704.

Giuliani, E., and V. Arza. 2009. 'What Drives the Formation of "Valuable" University-Industry Linkages? Insights from the Wine Industry.' *Research Policy* 38:906–21.

Giuliani, E., and M. Bell. 2005. 'The Micro-Determinants of Micro-level Learning and Innovation.' *Research Policy*: 34:47–68.

Hitt, M. A., D. R. Ireland., and R. E. Hoskisson. 2009. *Strategic Management: Competitiveness and Globalization, Concepts and Cases.* 8th ed. Mason, OH: South-Western.

Kesidou, E., and H. Romijn. 2008. 'Do Local Knowledge Spillovers Matter for Development? An Empirical Study of Uruguay's Software Cluster.' *World Development* 36 (10): 2004–2028.

Keynes, J. M. 1970. *The General Theory of Employment, Interest, and Money.* London: Macmillan.

Kleynhans, E. P. J., and A. Swart. 2012. 'Spillover Effects Enhancing Sales, Production and Competitiveness of South African Manufacturers.' *African Journal of Business Management* 6 (10): 3699–705.

Konings, J. 2001. 'The effect of Direct Foreign Investment on Domestic Firms: Evidence from Firm Level Panel Data in Emerging Economies.' *Economics of Transition* 9 (3): 619–33.

Krugman, P. R., M. Obstfeld, and M. J. Melitz. 2012. *International Economics: Theory and Policy.* Boston: Pearson.

Leahy, D., and J. P. Neary. 2004. 'Absorptive Capacity, R&D Spillovers and Public Policy.' Working Paper 200418, School Of Economics, University College Dublin.

Mostert, J. 2003. 'The Impact of Globalisation on Developing Countries.' Paper delivered at the ESSA conference, Somerset West, 17–19 September.

Park, J., H. Lee, and Y. Park. 2009. 'Disembodied Knowledge Flows among Industrial Clusters.' *Technology in Society* 31 (1): 73–84.

Paul, C. J. 2002. 'Supply and Demand-Driven Spillovers and Productivity Growth.' *Japan and the World Economy* 14 (3): 285–304.

Porter, M. E. 1998. *The Competitive Advantage of Nations.* New York: Palgrave.

Steurs, G. 1995. 'Inter-Industry R&D Spill-Overs.' *International Journal of Industrial Organisation* 13 (2): 249–76.

World Economic Forum. 2007. *The Global Competitiveness Report 2007/2008.* Geneva: World Economic Forum.