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MULTINATIONAL CORPORATIONS AS CHANNELS FOR INTERNATIONAL TECHNOLOGY TRANSFER: EVIDENCE FROM THE SOUTH AFRICAN INNOVATION SURVEY

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ABSTRACT

In this article, we present evidence consistent with South African subsidiaries of foreign multinationals being channels for the introduction of foreign innovations in theSouth African market. We use firm-level data from the second wave of the South African Innovation Survey, which covers the 2005-07 period. We find that subsidiaries of foreign multinationals are significantly more likely to introduce product and process innovations, as well as foreign new products and processes than domestic firms that do not belong to a foreign multinational corporation.

Keywords: R&D; Innovation; Multinational Corporations; Technology Transfer.

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1. Introduction

The introduction of new products and processes is an important source of welfare gains. New products bring about increases in consumer surplus through greater product variety, as argued theoretically in Dixit and Stiglitz (1977). Similarly, new processes imply access to superior technology, which is an engine for productivity growth. Indeed, Jones (1995) finds that cross-country differences in per capita incomes may be largely explained by differences in total factor productivity. In this line, Coe and Helpman (1995) link the international diffusion of technology with international trade, and Mendi (2007) finds evidenceof trade in disembodied technology positively affecting the importing country's total factor productivity. Thus, the process of technological diffusion has very relevant consequences for economic growth. In the particular case of less developed countries (LDCs), the effect may be one of abandoning a situation of underdevelopment and catching-up with more advanced economies.

In view of the positive effects of technological diffusion on growth, a recurrent question in the literature in Economics and Business is the study of the channels and the nature by which international technology diffusion takes place. Among these, transfers of knowledge within multinationals stand out as a potentially relevant candidate.In fact, in a similar way as trade in goods, most trade in disembodied technology takes place within multinational corporations (see BEA, 2013 for US data). Internal transfer of technology are considered to be less problematic than arm's-length transactions, since it is assumed that within a MNC the scope for opportunistic behavior is smaller, especially when knowledge has an important tacit component (Arora, 1996).This paper precisely takes this point andfocuses on the role of multinationals in the process of international technology transfer. Many contributions to the literature have regarded subsidiaries of foreign multinationals as key players in this process of technological diffusion, and for this reason there has been a constant search for evidence consistent with this claim. In a pioneering empirical study, Mansfield and Romeo (1980) analyze the transfer of

technology from US-based MNCs to their overseas subsidiaries, focusing on the nature of the technology being transferred and the evaluation of the benefits to the host country.

Later studies use survey-level data, typically from OECD countries, to analyze thedeterminants and consequences of firms' innovation activities. For instance, Veugelers (1997), and Veugelers and Cassiman (1999) study the determinants of firms' decisions whether to make or buy technology. In this line, Cassiman and Veugelers (2006) find evidence that there are complementarities between external and internally-developed knowledge.In a contribution closely related with ours, Veugelers and Cassiman (2004) analyze the role of subsidiaries of foreign MNCs as effective channels for the acquisition of foreign technology. They use survey data from the Belgian Community Innovation Survey, to test whether Belgian subsidiaries of foreign MNCs are more likely than domestic firms to transfer technology locally. The authors control for the fact that subsidiaries of foreign MNCs could more easily source technology from other countries, and they find that subsidiaries of foreign MNCs have an easier access to foreign sources of technology but, controlling for access to foreign technology, they are less likely to transfer it locally. Un and Cuervo-Cazurra (2008) compare the performance of Spanish firms and subsidiaries of foreign multinationals in terms of R&D expenditures to find that the latter invest less on R&D than Spanish firms, a result that is driven by lower expenditures on external R&D, not internal R&D.

Positive spillover effects of FDI are what would be expected in the "pipeline" model of technology diffusion most commonly used as a framework for understanding the process by which FDI has a positive effect on a host economy. This model posits that innovation capital and assets are produced at the headquarters of technologically advanced MNCs. The action of foreign subsidiaries of such MNCs is to take the knowledge capital and assets in a relatively unchanged form into the foreign environment. That environment is assumed to be sufficiently different to the more attractive technological culture of the MNC or its subsidiary to the extent

that local firms would seek to draw value from interactions with the subsidiary. Such engagement would be successful in generating enhanced economic growth provided the local firms are receptive enough to technology transfer and have the ability to incorporate the enhanced capabilities brought on through its interactions with the foreign subsidiary of the MNC. In this way the foreign subsidiary is seen as a conduit for the transference of innovative capability produced by the head of the MNC. Another mechanism through which the presence of a subsidiary of a foreign MNC could generate economic growth is through a perturbative effect on local firms who would find it necessary to compete harder with the more technologically developed foreign subsidiary thus promoting knowledge growth in local firms that are sufficiently technologically astute. However, under some circumstances, Marin and Bell (2006) argue that evidence for positive effects on the local economy by the presence of foreign subsidiaries of advanced MNCs has not been conclusive and in particular for LDCs such evidence has not been forthcoming at all. Furthermore, studies conducted in a developing economy context have suggested that absorptive capabilities of local firms were not an important constraint on the extent of spillovers. More recently, Marin and Sasidharan (2010) argued for the importance of distinguishing subsidiaries according to their orientation to carry out creative versus exploitation activities in the economy of developing countries. They used an unbalanced panel data approach on manufacturing firm-level data in India to support their view that subsidiaries that are oriented to technologically creative activities have a significantlypositive effect on technology transfer, whereas those engaged in exploitation activities have none and even generate negative effects under some circumstances. Generally for countries outside the OECD, lack of data has been an impediment to the conduction of similar studies. One exception is Oerlemans and Pretorius (2006), which analyzes 2001 South African firm-level data to study the determinants of innovation outcomes. The authors stress the importance of an educated workforce for innovation, although R&D intensity seems not to have a significant impact on innovation, although the effect varies across industries. They also

find evidence of foreign-owned firms generating better innovation outcomes. The characterization of innovation in South Africa is that of incremental innovators working in imitation mode. The South African economy has been described as mixed in that it has aspects of developed economies as well as those of less-developed economies, which creates an interesting backdrop for an investigation of the effect of FDI on the host economy.

The third edition of the Oslo manual considers not only technological product and process innovations as the means by which firms seek to gain economic success, but also marketing and organisational innovations. In this paper, we analyzesurvey data conducted according to the Oslo manual recommendations on such surveys from a sample of South African firms that includes local firms and subsidiaries of foreign multinational corporations (MNCs). We exploit the information in the questionnaire regarding the origin of innovations, whether domestic or foreign. We find that subsidiaries of foreign MNCs are indeed more likely than domestic firms not only to innovate but also to introduce innovations originally developed in foreign countries and to generate innovations that have a high novelty value.

In our case, the empirical findings suggest that, in the context of the South African economy, subsidiaries of foreign multinationals act as channels for the introduction of foreign innovations and hence the technologies associated with them. The domestic use of foreign technologies may bring about productivity gains to other domestic firms, as in Blalock and Gertler (2009). In any case, the potential gains from foreign spillovers will greatly depend on the level of absorptive capacity of domestic firms, i.e. their ability to acquire and make use of external knowledge (Zahra and George, 2002), and on their level of engagement with foreign subsidiaries in innovative activities (Marin and Sasidharan, 2010). However, given the available evidence, we cannot claim that our results may be interpreted as direct evidence of the existence of such external effects. Indeed, our results are suggestive of the potential existence of such effects, not a proof of their presence.

The remainder of the paper is organized as follows. Section 2 introduces the hypotheses to be tested using our data. Section 3 describes the data that will be analyzed in Section 4. Finally, section 5 presents some concluding comments.

2. Multinationals and the introduction of foreign innovations

This section presents the hypotheses that will be tested using data from the South African Innovation Survey. A question with relevant policy implications is whether subsidiaries of foreign MNCs add to the host country's technological base.In fact, that there are differences in innovativeness between indigenous firms and subsidiaries of foreign multinationals has been the object of study of a large strand of the literature. The fundamental questions are whether multinationals acquire the most efficient firms and what is the effect of foreign acquisitions on innovation performance. In this line, Stiebale and Reize (2011) using data from German firms find a negative effect of foreign acquisitions on the propensity to perform innovative activities and on R&D expenditures of innovative firms. Guadalupe and Kuzmina (2012), using a dataset of Spanish manufacturing firms, find that multinational firms acquire the most efficient firms, and that the effect of foreign acquisition on the introduction of new products and processes. This leads us to formulate the first hypothesis to be tested:

H1: South African subsidiaries of foreign MNCs are more likely to innovate than domestic firms.

From another perspective, the nature of transnational corporations is precisely the transfer of knowledge across national borders. In fact, Kogut and Zander (1993) argue that multinationals arise because of their greater efficiency in transferring knowledge internationally, especially know-how. From this perspective, subsidiaries of foreign MNCs are expected to be more likely to introduce innovations that have been developed elsewhere within the multinational.

H2: South African subsidiaries of foreign MNCs are more likely to introduce innovations developed outside South Africa than domestic firms.

One concern is the fact that the subsidiaries of foreign MNCs are good at transferring innovations developed within the enterprise group, but not other foreign innovations. However, the very presence of other parts of the multinational in other countries implies a greater exposure to innovations developed outside of the multinational. We hypothesize that this will be translated into a greater propensity to introduce innovations developed in foreign countries, but outside the group of firms.

H3: South African subsidiaries of foreign MNCs are more likely to introduce innovations developed by third parties outside South Africa than domestic firms.

The impact of MNCs on the local economy is considered beneficial when local companies are spawned from interactions or collaborations in joint ventures or public-private partnerships with subsidiaries of technology- and knowledge-rich corporations. Collaborations of SA companies with high-tech foreign subsidiaries would mostly be necessary if it entails the creation of innovations that would be beneficial to both groups. The third edition of the Oslo manual (OECD, 2005) discusses varying degrees of novelty from firm-only innovation, which occurs when a firm implements an innovation which is novel for the unit concerned but that is already implemented in other firmsand industries, to worldwide innovation which occurs when an innovation is delivered to the market for the very first time. We hypothesize that the type of innovations done in collaboration with subsidiaries of MNCs is likely to be of greater novelty to the SA market or the world than those innovations that occur in domestic companies.

H4: South African subsidiaries of foreign MNCs are more likely to contribute to novel innovations than indigenous South African companies.

In order to test these hypotheses, we will use data from the 2008 South African Innovation Survey, which refers to innovation activities in the 2005-07 reference period. This

survey was conducted following the recommendations of Eurostat for the Community Innovation Survey, which should allow for a cross-country comparison of innovation activities.

3. The Data: The South African Innovation Survey

The 2008 South African Innovation Survey was conducted by the Centre for Science Technology and Innovation Indicators (CeSTII) of the Human Sciences Research Council, on behalf of the Department of Science and Technology (DST) of South Africa. This is the second wave of innovation surveys conducted in South Africa following the same guidelines as the Community Innovation Survey, the first one being in 2005. This second wave successfully collected information from 757 firms on their innovation activities from 2005 to 2007. The main results from the analysis of the survey data, reported in CeSTII (2011), suggest that the population of South African firms sampled have a high rate of innovationat 65%, comparable with that of firms in OECD countries, although the rate of innovation is observed to be very much sensitive to firm size. We assess here the role of subsidiaries of foreign MNCs as channels for local diffusion of foreign technologies.

Table 1 lists the main variables used in the present study. Among these variables, FORINN is an indicator variable that takes value one if the firm introduced an innovation – whether product of process- that was originated abroad during 2005-07, zero otherwise. The indicator for innovation that has been measured prior to the third edition of the Oslo manual is INNOV, which takes value one if the firm introduced either a product or a process innovation during 2005-07, regardless of the origin of that innovation, zero otherwise. The latter variable has been used in many studies of the determinants of innovation activities. However, this is, to the best of our knowledge, the first time the FORINN variable has been used in an analysis of the determinants of innovation. The rest of the variables are similar to those used in related studies. FORSUB is a binary variable that takes value one if the firm is a subsidiary of a foreign

MNC, zero otherwise. Firm size has log(EMPLOYEES) as a proxy, where EMPLOYEES is the number of employees in 2005. KNOWLEDGE is the percentage of the firm's employees with higher education. RDINTENSITY is expenditures on R&D per employee. INDUSTRIES takes value one if the firm belongs to an industry with a one-digit SIC[1] code in {6, 7, 8} (that is wholesale and retail trade; transport, storage and communication; financial intermediation, computer and related activities, research and development, architectural, engineering and other technical activities); zero if SIC in {2,3,4}(that is mining and quarrying; manufacturing; electricity, gas and water supply). Obstacles to innovation activities are represented by the COSTFACTOR, KNOWLEDGEFACTOR, MARKETFACTOR, and REASONSFACTOR variables.

Table 1. Description of the variables

Variable	Specification
ALLINNOVATIVE	Takes value one if the firm introduces either a product or a process innovation, regardless of its origin, or has some ongoing innovation activities, between 2005 and 2007; zero otherwise
COOP	Takes value one if the firm cooperated with other firms in 2005-07; zero otherwise
COSTFACTOR	A measure of the extent of how cost factors inhibit innovation that ranges from zero to one. Constructed as (importance of lack of funds within the enterprise or group + importance of lack of finance from sources outside the enterprise + importance of innovation costs too high)/9
EMPLOYEES	Number of employees in 2005
EXTRD	Takes value one if the firm has positive expenditures on external R&D in 2007; zero otherwise
EXTRDEXP	Amount of expenditure in 2007 spent on acquisition of R&D in units of thousands of Rands
FORINN	Takes value one if the firm introduces either a product or a process innovation originated abroad; zero otherwise
FORINNEXT	Takes value one if the firm introduces either a product or a process innovation originated abroad and if the innovation was developed in collaboration with or mainly by other enterprises or institutions; zero otherwise
FORSUB	Takes value one if the firm belongs to a foreign

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[1] The South African SIC is based on ISIC Rev. 3.

	multinational; zero otherwise
ind1	SIC=2: mining and quarrying
ind2	SIC=3: manufacturing
ind3	SIC=4: electricity, gas and water supply
ind4	SIC=6: wholesale and retail trade
ind5	SIC=7: transport, storage and communication
ind6	SIC=8: financial intermediation, computer and related activities, research and development, architectural, engineering and other technical activities
INDUSTRIES	Takes value one if SIC ={6,7,8}; zero if SIC={2,3,4}
INNOV	Takes value one if the firm introduces either a product or a process innovation, regardless of its origin, between 2005 and 2007; zero otherwise
INNOVMODE	Takes value one if the firm has introduced an innovation that was either new to South Africa or new to the world during 2005-2007; zero if neither was done or if the firm did not introduce an innovation; zero otherwise
INTERACTION	FORSUB*RDINTENSITY
INTMKT	Takes value one if the firm exported to at least one foreign market; zero otherwise
INTRD	Takes value one if the firm has intramural R&D activity or positive expenditures on internal R&D in 2007; zero otherwise
INTRDEXP	Amount of expenditure in 2007 on in-house R&D in units of thousands of Rands
KNOWLEDGE	Number of employees with higher education
KNOWLEDGEFACTOR	A measure of the extent of how knowledge factors inhibit innovation that ranges from zero to one. Constructed as (importance of lack of qualified personnel + importance of lack of information on technology + importance of lack of information on markets + importance of difficulty in finding co-operation partners for innovation)/12
LICENCE	Takes value one if the firm has been granted a license; zero otherwise
LogEMPLOYEES	Log(EMPLOYEES)
LogTURNOVER	Log(TURNOVER)
MARKETFACTOR	A measure of the extent of how market factors inhibit innovation that ranges from zero to one. Constructed as (importance of market dominated by established enterprises + importance of uncertain demand for innovative goods or services)/6
ONGOINGINNOVATORS	Takes value one if the firm had abandoned innovation activities between 2005 and 2007 or had ongoing innovation activities at the end of 2007; zero otherwise
PROCESSINNOVATORS	Takes value one if the firm introduced new or improved methods of manufacturing or producing products; logistics, delivery or distribution methods; or ssupporting activities between 2005 and 2007. Zero

	otherwise
PROCESSORIGIN	Takes value one if a process innovation originated in South Africa; missing if origin is unknown; zero otherwise
PRODUCTINNOVATORS	Takes value one if the firm introduced new or improved goods or services between 2005 and 2007; zero otherwise
PRODUCTORIGIN	Takes value one if a product innovation originated in South Africa; missing if origin is unknown; zero otherwise
RDINTENSITY	Expenditures on R&D per employee in 2007
REASONSFACTOR	A measure of the extent of how reasons not to innovate inhibit innovation that ranges from zero to one. Constructed as (importance of no need due to prior innovations+ importance of no need because of no demand for innovations)/6
SIZE	Takes values {1,2,3,4} corresponding to {large, medium-large, medium, small} enterprises, respectively
TURNOVER	Total enterprise turnover in 2005 in units of thousands of Rands

Table 2 displays descriptive statistics of the variables used in the present study.The 2008 South African Innovation Survey made use of a sample stratified by industrial sector and size of a population of 22 456 enterprises. Isolating the variables for the present study to test the hypotheses stated above results in the inclusion of enterprises with weights which introduce too much error into the population estimates for clear determinations to be made. As a result, a case study approach was taken that utilisedthe raw data arising from the 757 firms collected. Out of these 757 firms in the sample, 420 introduced at least one product and/or one process innovation in 2005-07. This represents 55% of the total of firms in the sample. 95 of these introduced either a product or a process innovation that was originated abroad (FORINN=1). This is 13% of the firms in the sample, and 23% of innovative firms. Regarding foreign ownership, 115 of the firms in the sample are subsidiaries of foreign MNCs, and only 5% of the total are exporters. The ALLINNOVATIVE variable takes the value one if the firm was innovative or when it had ongoing innovations in 2007, even if it was not a successful innovator in 2005-07. The ONGOINGINNOV, PRODUCTINNOV, and PROCESSINNOV variables

are indicators of the firm having ongoing innovation activities in 2007, and having introduced

product innovations and process innovation in 2005-07, respectively. Notice that, since these

are non-exclusive categories, the total adds up to more than 100%.

Table 2. Descriptive statistics

Variable	N	NMiss	Min	Mean	Median	Max	StdErr
ALLINNOVATIVE	757	0	0	0.6	1	1	0.02
COOP	757	0	0	0.26	0	1	0.02
COSTFACTOR	757	0	0	0.36	0.33	1	0.01
EMPLOYEES	713	44	1	778.93	55	63 993	155.25
EXTRD	757	0	0	0.22	0	1	0.02
EXTRDEXP	161	596	4	4873.55	273	398 770	2596.12
FORINN	757	0	0	0.2	0	1	0.01
FORINNEXT	757	0	0	0.13	0	1	0.01
FORSUB	757	0	0	0.15	0	1	0.01
ind1	757	0	0	0.05	0	1	0.01
ind2	757	0	0	0.4	0	1	0.02
ind3	757	0	0	0.03	0	1	0.01
ind4	757	0	0	0.34	0	1	0.02
ind5	757	0	0	0.09	0	1	0.01
ind6	757	0	0	0.09	0	1	0.01
INDUSTRIES	757	0	0	0.52	1	1	0.02
INNOV	757	0	0	0.55	1	1	0.02
INNOVMODE	757	0	0	0.18	0	1	0.01
INTERACTION	247	510	0	10.48	0	1 299	5.67
INTMKT	757	0	0	0.05	0	1	0.01
INTRD	757	0	0	0.35	0	1	0.02
INTRDEXP	251	506	2	10856.55	500	835 879	4297.24
KNOWLEDGE	582	175	0	18.95	10	100	0.91
KNOWLEDGEFACTOR	757	0	0	0.3	0.33	1	0.01
LICENCE	757	0	0	0.05	0	1	0.01
LogEMPLOYEES	713	44	0	4.15	4.01	11	0.07
LogTURNOVER	699	58	2	10.82	11.25	18	0.09
MARKETFACTOR	694	63	0	0.35	0.33	1	0.01
ONGOINGINNOVATORS	757	0	0	0.43	0	1	0.02
PROCESSINNOVATORS	757	0	0	0.46	0	1	0.02
PROCESSORIGIN	350	407	0	0.74	1	1	0.02
PRODUCTINNOVATORS	757	0	0	0.45	0	1	0.02
PRODUCTORIGIN	340	417	0	0.67	1	1	0.03
RDINTENSITY	247	510	0	22.87	2.94	1 299	6.17
REASONSFACTOR	757	0	0	0.25	0.17	1	0.01
SIZE	724	33	1	1.25	1	2	0.02
TURNOVER	700	57	0	834252.6	75924.5	80 585 000	181770.1

4. Empirical Analysis

In this section, we describe the econometric analysis that is carried out to test the hypotheses laid out in Section 2, and presents the results obtained. Probit regression results are presented for all industries, as well as conditional on non-services industries (mining and quarrying;manufacturing; electricity, gas and water supply) and services industries (wholesale and retail trade; transport, storage and communication; financial intermediation, computer and related activities, research and development, architectural, engineering and other technical activities).

In order to test the first hypothesis, we estimate a probit model where the dependent variable is ALLINNOVATIVE, and FORSUB is the independent variable. Additionally, we control for industry fixed effects, size, and obstacles to innovation activities (COSTFACTOR, KNOWLEDGEFACTOR, MARKETFACTOR and REASONSFACTOR).

Table 3. Multinational corporations and innovativeness

Dependent variable: ALLINNOVATIVE

	(i)All industries		(ii)SIC={2,3,4}		(iii)SIC={6,7,8}	
FORSUB	0.13262**	(0.00171)	0.04614	(0.00108)	0.21275***	(0.00322)
KNOWLEDGE	0.00241**	(0.00003)	0.00102	(0.00002)	0.00299**	(0.00005)
Log(EMPLOYEES)	0.06402***	(0.00083)	0.07239***	(0.00169)	0.05880***	(0.00089)
COSTFACTOR	0.04507	(0.00058)	0.02369	(0.00055)	0.08894	(0.00135)
KNOWLEDGEFACTOR	0.47811***	(0.00617)	0.40377***	(0.00945)	0.52714***	(0.00799)
MARKETFACTOR	-0.04653	(0.00060)	0.00144	(0.00003)	-0.08481	(0.00129)
REASONSFACTOR	-0.33413***	(0.00431)	-0.44061***	(0.01031)	-0.25227**	(0.00382)
Industry dummies	Yes		Yes		Yes	
Observations	520		242		278	
Log likelihood	-264.63		-107.06		-153.60	

Standard errors in brackets and significance level (＊＊＊significant at 1%, ＊＊significant at 5%,＊significant at 10%). Coefficients and standard errors of the six industry dummies are not explicitly reported to save on space.

Table 3 presents results from the probit model. Indeed, the effect of FORSUB is positive and significant, suggesting a higher propensity to innovate by subsidiaries of foreign MNCs. This confirms our first hypothesis. In the case of the services industries the effect of FORSUB is also positive and significant suggesting a higher propensity to innovate by subsidiaries of foreign MNCs in these industries. Other results are obtained in Table 3. Firstly, the often-stated assertion that the probability of a firm being innovative is strongly and positively associated with firm size is borne out by the large and significant coefficient of Log(EMPLOYEES) across all industries and when subset by non-services and services industries. Secondly, the presence of a large number of employees that have a high level of education is positively associated with innovative firms as can be seen from the positive and significant coefficient for KNOWLEDGE. The factors hampering innovation or influencing the decision not innovate recorded in the survey were cost factors, knowledge factors, market factors and other reasons not to innovate. For all three cases in Table 3, when the reasons for unsuccessful innovations were reported to be knowledge-related factors such as lack of qualified personnel, lack of information on technology or markets, and difficulty in finding cooperation partners, this was associated with firms that were likely to be innovative. Also, an absence of a need to innovate as a reason for unsuccessful innovations was reported to be negatively associated with innovative firms, as evidenced by the coefficient of REASONSFACTOR in all three cases.

We now turn our attention to the comparison between local firms and subsidiaries of foreign MNCs of the propensity to introduce innovation developed outside South Africa. In order to do so, we estimate a probit model where the dependent variable is FORINN, an indicator of the innovation being developed outside South Africa. In addition to FORSUB, we include RDINTENSITY, KNOWLEDGE, INDUSTRIES, and the product of FORSUB and RDINTENSITY. This variable is included to allow for the possibility of a differential effect of

R&D intensity within subsidiaries of foreign MNCs. H2 predicts a positive estimated coefficient on FORSUB.

Since FORINN is observed only if the firm is innovative, a probit model of FORINN on the listed variables would only include innovative firms, which could bias the results. For this reason, we estimate a probit model with sample selection, as described in Maddala (1983). Sample selection is corrected for by including an inverse Mill's ratio, obtained from the selection equation, where the dependent variable is ALLINNOVATIVE and the independent variables are FORSUB, SIZE, COSTFACTOR, KNOWLEDGEFACTOR, MARKETFACTOR, REASONSFACTOR, INTMKT and industry dummies. This method is more computationally efficient than using maximum likelihood estimation, but it is known that the resulting estimates, although consistent, are not asymptotically efficient under normality assumption. Table 4 presents estimated coefficients from the two specifications, with and without a correction for sample selection.

Table 4. Multinational corporations and introduction of foreign innovations
Dependent variable: FORINN

	(i) Basic: all industries	(ii) Correction: all industries	(iii) Correction: SIC={2,3,4}	(iv)Correction: SIC={6,7,8}
FORSUB	0.326***	0.24245***	0.20693**	0.2294 *
	(0.0624)	(0.0724)	(0.09097)	(0.12727)
RDINTENSITY	-0.00078	-0.0007	0.00149	-0.0012
	(0.00096)	(0.0011)	(0.00288)	(0.0013)
INTERACTION	0.0039	0.00376	-0.00084	0.020384
	(0.00298)	(0.00296)	(0.00312)	(0.01789)
Industry dummies	Yes	Yes	Yes	Yes
Observations	435	507	237	270
Log likelihood	-253.0956	-458.5727	-209.762	-241.23
Heckman ρ		-0.5276 *	-0.44271	-0.66433 *
		(0.23381)	(0.34989)	(0.3098)

Standard errors in brackets and significance level (∗∗∗significant at 1%, ∗∗significant at 5%, ∗significant at 10%). Coefficients and standard errors of the six industry dummies are not explicitly reported to save on space.

As it may be observed, the coefficient on FORSUB is positive and significant in both cases, and it is corrected downward by around a fifth of the original estimate in the model estimated to account for selection bias. A significant Heckman correction is included. The insignificant value of the correlation estimate in other cases indicates that selection bias is not a

big problem for those cases. To see whether the presence of internal R&D activities has a different effect on firms that are foreign subsidiaries or not, the interaction term (INTERACTION) between the two variables RDINTENSITY and FORSUB was included in the model.

We turn our attention to the third hypothesis laid out. In order to do this, we replicate the previous analysis but using an indicator of the foreign technology being developed outside the multinational as dependent variable. Like in the previous case, the nature of the variable calls for correction for sample selection. We expect a positive relationship between a firm being a subsidiary of a foreign MNC and the probability that the firm introduces an innovation originated outside South Africa. This is because subsidiaries of multinationals are expected to be able to more easily tap on the global innovation pool, and thus transfer foreign technology, since their parent companies and other subsidiaries are located in different markets. The estimated coefficients are displayed on Table 5.

Table 5. Multinational corporations and introduction of foreign innovations developed outside the group

Dependent variable: FORINNEXT

	(i) Basic: all industries	(ii) Correction: all industries	(iii) Correction: SIC={2,3,4}	(iv) Correction: SIC={6,7,8}
FORSUB	-0.44319 ***	-0.1235716	-0.21525	0.0812016
	(0.11231)	(0.17594)	(0.505)	(0.12664)
RDINTENSITY	0.00855	0.0105307	0.0039012	0.0071151
	(0.0122)	(0.01245)	(0.00652)	(0.00865)
INTERACTION	-0.008383	-0.0102895	-0.0036	-0.00868
	(0.01226)	(0.01242)	(0.0056)	(0.00907)
Industry dummies	Yes	Yes	Yes	Yes
Observations	129	374	193	187
Log likelihood	-53.3953	-279.2404	-139.1608	-135.6655
Heckman ρ		0.929829	-0.67392	0.975441
		(0.1364909)	(0.87702)	(0.07731)

Standard errors in brackets and significance level (∗∗∗significant at 1%, ∗∗significant at 5%, ∗significant at 10%). Coefficients and standard errors of the six industry dummies are not explicitly reported to save on space.

The coefficient of FORSUB is not significant in any of the cases. Interestingly, the results hint at foreign subsidiaries with internal R&D activity having a propensity not to introduce innovations originating outside South Africa, since the coefficient of the interaction term FORSUB*RDINTENSITY is negative and significant.

Finally, we consider the fourth hypothesis expressed. In order to do this, we repeat the previous analyses but use an indicator of the novelty value of the innovation as dependent variable. Like in the previous situations, the nature of the variable calls for correction for sample selection with ALLINNOVATIVE being the selection variable as before. Subsidiaries of multinationals are expected to be able to draw more easily on the innovative processes and practices of their parent companies, and thus transfer foreign technology of a nature that is new to the SA market at the very least. Therefore, we expect a positive relationship between a firm being a subsidiary of a foreign MNC and the probability that the firm introduces a product or process innovation that is of high novelty value, at least in South Africa. The estimated coefficients are displayed in Table 6.

Table 6. Multinational corporations and type of innovations developed
Dependent variable: INNOVMODE

	(i) Basic: all industries	(ii) Correction: all industries	(iii) Correction: SIC={2,3,4}	(iv)Correction: SIC={6,7,8}
FORSUB	0.0841	-0.0451	-0.1416	0.0901
	(0.06851)	(0.07074)	(0.0954)	(0.11923)
RDINTENSITY	0.0066 ***	0.004733 **	0.00182	0.00837 **
	(0.002048)	(0.00196)	(0.0028)	(0.00346)
INTERACTION	-0.0069***	-0.004891**	-0.0022	-0.008033 **
	(0.00211)	(0.002)	(0.0029)	(0.00357)
Industry dummies	Yes	Yes	Yes	Yes
Observations	366	452	210	242
Log likelihood	-219.07646	-391.7547	-184.1694	-199.6547
Heckman ρ		-0.8262***	-0.83501 ***	-0.77565***
		(0.0927249)	(0.12476)	(0 .1678)

Standard errors in brackets and significance level (∗∗∗significant at 1%, ∗∗significant at 5%, ∗significant at 10%). Coefficients and standard errors of the six industry dummies are not explicitly reported to save on space.

The significant and positive coefficient for RDINTENSITY indicates that R&D-intensive firms in the overall sample contribute positively to the propensity for innovation that

is new to the South African market or the world. Thus, the introduction of innovations that are new to the market seems to be mainly driven by the firms' internal capabilities. On the other hand, the coefficient on FORSUB is found to be statistically insignificant in all four specifications. Furthermore, the coefficient on the interaction term is negative and statistically significant in specifications (i), (ii) and (iv). This suggests that internal capabilities are not as important for subsidiaries of foreign multinationals, which implies that these firms are simply transferring already-developed technologies without much contribution from the local subsidiary. Therefore, we do not find evidence of subsidiaries of foreign multinationals being significantly more active than local firms in the introduction of technologies that are new to the South African market.

5. Conclusions

This paper has analyzed the innovative activities of South African subsidiaries of foreign multinationals, in comparison with indigenous firms. We found that subsidiaries of foreign multinationals are more likely to be innovative, and also more likely to introduce innovations that have a foreign origin. However, they are not more likely to introduce foreign innovations developed mostly by another firm outside its own multinational, or innovations that are new to the South African market. These results suggest that South African subsidiaries of foreign multinationals specialize in the transfer of technologies developed within its own multinational, and show no particular advantage in transferring foreign technologies developed by third parties. Furthermore, internal R&D capability has a positive effect on the novelty level of innovations mostly due to the activities of domestic firms, since the activities of subsidiaries of foreign multinationals that have R&D expenditure impact negatively on the propensity for novel innovations.

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