

Egbetokun, Abiodun A.

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Abiodun A. Egbetokun

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www.uni-jena.de

Max Planck Institute of Economics
Kahlaische Str. 10
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www.econ.mpg.de

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Cooperation behaviour and innovation performance in the Nigerian manufacturing industry

Abiodun A. Egbetokun

Friedrich-Schiller University, Graduate College 'Economics of Innovative Change' (DFG-GK-1411), Carl-Zeiss-Strasse 3, D-07743 Jena, Germany. Email: abiodun.egbetokun@uni-jena.de

National Centre for Technology Management (Federal Ministry of Science and Technology), Obafemi Awolowo University, Ile-Ife, Nigeria. Email: abiodun.egbetokun@nacetem.org

Abstract

Analysing the relationship between firms' openness to external knowledge and their innovation performance is nothing new. What is new is studying how this relationship fares in latecomer economic contexts such as Nigeria, and that is the focus of this paper. Using unique micro-level innovation data, it is shown, as the existing literature suggests, that firms are more likely to innovate when they access external knowledge either through formal or through informal interactions. However, innovative firms that exploit external knowledge do not necessarily enjoy greater innovation benefits than those that do not. Thus, while openness to external knowledge might help firms to become better at innovating, it does not assist them in reaping the benefits derivable from their innovation efforts. Moreover, different innovation types are essentially the same with respect to the effect that network resources have on them. Thus, it makes little sense to engage network partners selectively for certain innovation types at the expense of others.

Keywords: innovation, networking, openness, collaboration, external knowledge, Nigeria, manufacturing industry

JEL Classification: O31, L14, L60

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1. Introduction

Innovation is systemic (Lundvall, 1992) and requires firms to maintain in-house the capability to value, acquire and assimilate external knowledge (Cohen and Levinthal, 1990). Consequently, firms increasingly have to rely, to varying degrees, on several external sources of knowledge. This is beneficial for innovation in many ways: in disseminating information about innovations, lowering transaction costs, increasing the potential for the division of labour between enterprises and fostering collective action (Barr, 1998). In particular, cooperation is necessitated by the fact that no single firm can possibly possess all the knowledge and capabilities required to innovate. There will always be certain inputs into the innovation process, especially knowledge and capabilities, which the firm does not possess in-house. Such missing inputs are typically sought outside the boundaries of the firm. Therefore, as part of the innovation process, firms need to engage in a search for complementary knowledge and capabilities beyond their boundaries (Chesbrough, 2003). However, market failures make the market transactions of such knowledge and capabilities very difficult (Mowery et al., 1998; Pisano, 1990). Cooperative arrangements – either formal or informal – help firms to solve some of the problems and to improve their efficiency by pooling their resources and accessing complementarities (Belderbos and Lokshin, 2004; Cassiman and Veugelers, 2006).

There is nothing new about analysing the relationship between firms' innovation performance and their cooperation choices or openness to external knowledge. Previous studies (e.g. Freitas et al., 2011; Laursen and Salter, 2006; Leiponen and Helfat, 2010; von Hippel, 2005) present results from different industries suggesting that cooperation and the search for external knowledge indeed enhance firm-level innovativeness. However, this body of evidence is mostly restricted to developed countries. Therefore, the relationship in developing countries between firms' decision to open up to external knowledge and their propensity to innovate has been underexplored. There is also a heavy bias towards technological product and process innovation in the existing literature. Many studies measure innovation through patents or products that are new to the market. However, in latecomer contexts like Nigeria, innovation often consists of minor technological changes that are only new to the firm. Besides, marketing and organizational innovations are of major importance to firms in this context (OECD, 2005). Thus, in addition to product and process innovation, a study of firm-level innovation in the Nigerian context should also explicitly include marketing and organizational innovation in order to gain a proper understanding of the innovation landscape.

Moreover, the focus of many recent studies is on the issues that firms face when they seek external knowledge. These issues relate to the choice of partners and knowledge sources (Howells et al., 2004) as well as the choice of strategy to adopt in accessing external knowledge (Nieto and Santamaria, 2007). Thus, although it is recognized that openness to external knowledge helps firms to become more innovative, little is known about the relationship between openness and the performance benefits that firms derive from innovation. It follows that few lessons relevant to manufacturing sectors in developing countries can be drawn from the existing literature. In particular, the evidence on firms' decisions to cooperate for innovation and the potential benefits of such decisions is still sparse.

Therefore, the main purpose of this paper is to explore how the cooperation decisions of firms in a developing country (Nigeria) are related to their likelihood of innovating and the benefits they derive from innovation. Using a pioneer manufacturing innovation survey data set, the analyses in this paper are targeted towards answering the following specific questions:

- a) Are firms more likely to innovate when they exploit external knowledge through formal or informal means?
- b) How does the relationship between cooperation and innovation, as examined in a) above, vary with different innovation types?
- c) Are the performance benefits that firms derive from innovation associated with cooperation? In other words, can a difference be found between firms that exploit external knowledge and those that do not in terms of the likelihood of benefiting from innovation?

The rest of the paper is structured as follows. In the next section, the theoretical arguments for the research questions are laid out. These are followed by a description of the research data and methods. The results are discussed in Section 4 and the paper concludes in Section 5.

2. Literature

The discussion on firms' use of network resources in their innovation efforts is related to the so-called 'make-or-buy' strategic decision. In the innovation literature, although the 'make-or-buy' debate is often discussed in relation to research and development (R&D) and joint ventures, it is no less relevant to the decision of a firm to cooperate in its innovation efforts. Three distinct theoretical traditions – transaction cost economics (TCE), the resource-based

view (RBV) of the firm and evolutionary economics (EE) – serve to explain the trade-offs that a firm faces concerning its cooperation decisions. These theories are considered as complementary, at least in relation to the aim of this paper. A brief integrated discussion is presented in the following.

A central argument in TCE is that cost matters in the organization of economic activities, especially contractual relations (Williamson, 1979). With respect to production, knowledge is a major input and firms' decision to carry out knowledge-related transactions in decentralized markets or to integrate vertically is heavily dependent on costs (Shelanski and Klein, 1995; Williamson, 1998). Research in EE has shown that the implicit characteristics of knowledge also play a role in this decision (Brusoni et al., 2001). Some specific characteristics of knowledge that can lead to market failures in its transaction have also been emphasized. First, the partly tacit nature of knowledge makes it very difficult to transfer (Nelson and Winter, 1982). Second, imperfect appropriability conditions create a disincentive for market-based transactions involving knowledge-related resources (Pisano, 1990).

Thus, avoiding market imperfections and their associated costs incentivizes firms to internalize their innovation activities. However, internal costs may soar as a result of the necessary investments in learning and capacity building (Barney, 2001) as well as the 'added bureaucratic costs that accrue upon taking a transaction out of the market and organizing it internally' (Williamson, 1998, p.39). Between the choices, which Brusoni et al. (2001, p.600) refer to as 'the two extremes of decentralized markets and integrated hierarchies', firms have the option of accessing external intangible assets to complement their in-house capabilities through formal or informal cooperation. This solution is mainly attractive when the risks of cooperation are lower than those associated with pure market transactions and vertical integration.

The foregoing arguments are consistent with the RBV. Based on the seminal work of Penrose (1959), a firm is seen as a collection of resources (Wernerfelt, 1984) with which it builds strategic competences (Prahalad and Hamel, 1990). The resources can be classified into tangible and intangible ones; knowledge-related resources are intangible (Barney, 2001; Mowery et al., 1998) and therefore have strong tacit characteristics. Tacitness facilitates the appropriation of knowledge by limiting imitation but, as mentioned earlier, it simultaneously militates against the market-based transfer of knowledge-related resources. In fact, the market transaction of knowledge-related resources becomes increasingly difficult as the knowledge becomes more tacit (Teece et al., 1994). This market failure problem is overcome, to a large extent, through the institution of formal and informal cooperation (Cantner and Meder, 2007).

Besides the ‘make-or-buy’ dilemma, which is sometimes solved through cooperation, the firm faces another dilemma that accompanies the cooperative solution itself. In its external search, when a firm finds relevant knowledge resources, it has to make a decision on whether to acquire them or simply access them without necessarily securing ownership. Firms often find it preferable simply to gain access to complementary resources without having to devote their attention to acquiring ownership of such knowledge resources (Cantner and Meder, 2007). This option is attractive because it gives firms the opportunity to apply knowledge resources without fully bearing the costs of protecting them from erosion. Moreover, firms with a relatively weaker knowledge base can enjoy learning opportunities through interaction with the original knowledge owners. This is particularly true because technological knowledge is often tacit and the receiving firm may have difficulties in understanding and deploying it. A third reason why firms may prefer simply to access complementary knowledge resources rather than procure them relates to cost. It might be cheaper simply to share the knowledge base of an external agent than to develop it in-house or buy it from the original owner. This is particularly true when the knowledge does not have significant strategic potential in the sense that it is not widely applicable to the receiving firm’s production activities and leaving it outside the boundary of the firm does not pose an immediate threat of competition.

By cooperating to gain access to additional knowledge assets for its innovation efforts, a firm maximizes value by combining its partners’ resources with its own and gaining access to complementarities (Gulati, 1995). In the literature, two approaches have been established by which firms typically gain access to external knowledge. A firm could collaborate formally with the potential knowledge source (Tether, 2002). Such collaborations usually involve the signing of some legally binding documents as in R&D joint ventures or technological agreements (Hagedoorn, 2002). Collaboration is often reciprocal in the sense that the knowledge-seeking firm has to give something in return for the knowledge it gains (Fehr and Gächter, 2000). Reciprocity, in turn, depends on the nature and source of the knowledge. For instance, when the collaboration partner is a non-business entity such as a university or public research institute, the firm may contribute in the form of research funding. However, when the partner is another firm, the knowledge-seeking firm has to share some of its knowledge with the partner in order to gain access to the latter’s knowledge base. The second way in which firms gain access to complementary knowledge resources is simply to tap into the identified external knowledge sources. This often occurs through informal knowledge diffusion or information exchange (Garcia-Torres and Hollanders, 2009; Tödtling

et al., 2009) and is especially useful when knowledge is neither tacit nor complex and specialized.

From the foregoing, it becomes clear that a firm's decision either to collaborate with or simply to tap into external knowledge sources is shaped by several factors, including the level of complexity or 'stickiness' of the knowledge and the source from which the knowledge is to be accessed. Nevertheless, the discussion on external knowledge complementarities and firm-level innovation can be summarized in the hypothesis that the deployment of external knowledge should be positively associated with innovation performance (Nooteboom et al., 2007). This hypothesis is supported in different strands of the literature, including marketing (Gemünden et al., 1996), innovation systems (Edquist, 1997; Freeman, 1995; Lundvall, 1992), business management (Jaruzelski and Dehoff, 2007) and several areas of economics and policy research (de Man and Duysters, 2005; Dodgson, 1993; Drejer and Holst Jørgensen, 2005; Frenz and Letto-Gillies, 2009; Hagedoorn, 2002; Håkansson, 1989; Hoppe and Ozdenoren, 2005; Mention, 2011; Panda and Ramanathan, 1996).

However, as Tödtling et al. (2009) note, 'there are no clear and general results regarding the relationship between networking and innovation. Findings seem to depend on the specific circumstances and conditions, such as sectors and firm sizes covered, countries and regions, and time period investigated'. Thus, while studies like those by Mention (2011) and Tether (2002) suggest that cooperation with universities and research organizations has a positive influence on more radical forms of innovation, other studies, such as that by Frenz and Letto-Gillies (2009), suggest that cooperation is much less useful than in-house efforts. Such complexities and contingencies highlight the need for context-specific studies to facilitate a proper understanding of the cooperation–innovation nexus. Freitas et al. (2011) imply as much by noting that national and industrial contexts shape the way in which firms use information sources. Consequently, lessons for policy and practice in the developed country context cannot necessarily apply to developing countries. For instance, it can be argued that firms operating within more advanced innovation systems may rely more on R&D sources, while those within weaker systems may not (Frenz and Letto-Gillies, 2009).

Indeed, in most African countries, the institutions are relatively weak and the innovation systems are much less advanced and connected. Firms operating within such contexts tend to rely more or less on certain types of cooperation partners to overcome the constraints to innovation. Specifically, Goedhuys et al. (2008) present evidence from Tanzania on the particular importance of informal market institutions, especially business

associations, in enhancing firm-level productivity. For a sample of Nigerian manufacturing firms, Oyeibisi et al. (1996) and Oyelaran-Oyeyinka (2006) report extensive collaboration among firms and weak research–industry collaboration. The apparent strong inter-firm collaboration is indicated by Oyelaran-Oyeyinka (2005) as being driven partly by competitive pressures. In his study of manufacturing firms in a Nigerian cluster, the author notes that the firms feel compelled to collaborate not only as a means of intra-cluster learning but also to overcome external competition. However, the relationship between the cooperation choices of firms and their likelihood of innovating is not well understood.¹ This is especially true when one considers the different types of innovation in which firms may engage. Moreover, although it is well established that being more open to external knowledge facilitates firm-level innovation, the question of whether it also plays a role in how much a firm benefits from its innovation efforts has not yet been analysed.

3. Methodology

3.1. Data

Apart from South Africa, where several rounds of innovation surveys have been implemented, African countries are just beginning to collect their own firm-level innovation data (AU-NEPAD, 2010; Gault and Mawoko, 2011; Muchie and Baskaran, 2011). The data used in this paper came from an innovation survey in Nigeria's manufacturing sector, which was undertaken at the end of 2007. The sample comprised 250 manufacturing firms (with a response rate of 68%) selected by a multi-stage (random) sampling approach from class 10-31. Selection was made from class 10 to class 31 of the 3-digit International Standard Industrial Classification (ISIC), Revision 3. The survey included only firms that had at least 10 employees, and the firms reported for the 2003–2006 period, giving information on, among other things, their collaboration partners, their external knowledge sources and the perceived impact of innovation on different aspects of performance.

¹ These gaps in the literature are largely due to the difficulties associated with obtaining micro-level data – such as is available through innovation surveys – that permit the relevant kinds of analysis. As far as I know, firm-level studies in Nigeria have relied either on self-collected data from a handful of firms or on the World Bank Enterprise Surveys, which, though very detailed and useful, do not include measures of the networking behaviour of firms.

3.2. Description of Variables

3.2.1. Dependent Variables (Regression)

The survey questionnaire asked firms directly whether they had been able to introduce an innovation during the specified period or whether they had abandoned it at some point after they had started (see Appendix 1 for a list of questionnaire items). Innovation is defined broadly to include changes in products, production processes, marketing approaches or organizational practices. The basic requirement for any of these changes to be regarded as innovative is that newness to the firm. Successful innovation received a score of 2, ongoing/abandoned innovation a score of 1 and no innovation a score of 0. The questionnaire items allow us to distinguish four different innovation types: product, process, marketing and organizational innovations. The variables were created as follows. The sum of the scores for all the items under each innovation type was computed for each firm. These scores were then recoded as 0 (for no innovation) and 1 (for innovation). A binary variable, which indicates whether or not the firm had introduced any innovation at all, was obtained by summing and recoding the four innovation types. These five variables together form the dependent variables in the regression analyses to address the first research question.

3.2.2. Independent Variables (Regression)

The explanatory variables for the regression analyses were constructed as follows. Twelve possible collaboration partners were listed in the survey instrument: competitors, customers, suppliers, associated companies within a firm's corporate group, consulting and marketing firms, private research institutes, public research institutes, universities or other higher education institutions, government ministries, financial institutions, training institutions and industry associations. One question asked firms to indicate whether or not they engaged in collaboration or any form of joint activity with each of these actors (1 if yes and 0 if no). In another question, nine possible external sources of information were listed in the survey instrument and each firm was asked to indicate on a 0 (not used)–1–2–3 (very important) scale the degree of use of each source. Following previous work, such as that by Duysters and Lokshin (2011), Laursen and Salter (2006) and Leiponen and Helfat (2010), the core variables used in the econometric analyses were constructed using these two questions as follows. The variable COLLAB is a binary variable indicating whether or not a firm collaborated with any actor during the reference period. The binary value was obtained from recoding the sum of the scores on all the twelve questionnaire items relating to collaboration (all non-zero scores became 1). The variable EXKNOW captures whether or not a firm had

made use of any external knowledge sources. Its construction, using the nine questionnaire items relating to external knowledge sources, is similar to that of COLLAB.

3.2.3. Control Variables (Regression)

Controls for firm characteristics were included. As suggested in the literature, the age of a firm (Huergo and Jaumandreu, 2004) as well as the way it is managed (van der Panne et al., 2003) affect its innovation potential. AGE was measured as the logarithm of the age of the firm in 2006. Typically, the quality of management is proxied by the qualifications of the top decision maker in the firm but that measure is mostly missing in the data set. In its place I use the measure ORG, the logarithm of the number of levels in the firm's organizational structure. The underlying intuition is that flatter, decentralized organizations are more effective in realizing their goals (Zheng et al., 2010) and therefore a flatter organizational structure will be more conducive to innovation. Additional controls were included for other variables, such as size (Cohen, 2005), ownership (Aralica et al., 2008), staff qualifications and training (Romijn and Albaladejo, 2002), which have been identified as also affecting the potential for innovation. SIZE was measured as the logarithm of the number of employees in 2006. Control for firm ownership was included as a categorical variable (OWNER). This variable captures the different types of ownership of the firms in the sample and was coded from 1 to 7 in the following order: domestic private ownership, domestic public ownership, ownership by a foreign corporation, ownership by a foreign individual, joint ventureship or private limited liability. Dummy variables were included for whether the firm had implemented any staff training (STRG) programmes during the reference period and possessed a separate budget for innovation (IBUDG). These two factors can be thought of as potentially contributing positively to a firm's absorptive capacity. The use of the Internet for business purposes (ICT) was also controlled for, because in the context of developing countries, the adoption of new technologies such as the Internet is seen as an important way for firms to enhance or augment their capabilities (Oyelaran-Oyeyinka and Lal, 2006).

Appendix 2 contains a summary of all the variables described so far. Although there are a few significant correlations, the coefficients are too low to imply serious multicollinearity problems. Besides, the average variance inflation factor was 1.2 and the condition number was 9.13. These values are well below the acceptable limits and suggest that the multicollinearity among the variables is inconsequential (O'Brien, 2007).

3.2.4. Performance Variables (Non-parametric Analyses)

The measures of performance applied in the non-parametric analyses addressing the third research question were derived from Likert-type items in which firms indicated whether they had experienced an increase, stagnation or decline in the following: profit, market shares, diversification, product differentiation, positive environmental impact, compliance with regulations, employment and rejection/return of products. For the analyses, each of the performance variables was coded 1 if the firm had reported an increase and 0 otherwise, the reverse being the case for the last variable. This coding scheme enables a direct comparison of the firms that actually gained performance improvements during the reference period with those that did not.

3.3. Econometric Analyses

The first two questions that this paper raises relate to the relationship between a firm's decision to search for external knowledge and its probability of innovating. Specifically, this relationship is explored first for the firm's probability of innovating at all, and then for the probability that the firm will implement any product, process, marketing or organizational innovation. Given that the dependent variables are binary, logit models were employed to estimate their response to the explanatory variables. The logit model is specified as follows. Given that the probability of a firm implementing an innovation as a result of an external knowledge search is p , then the probability that this will not occur is $1 - p$. The logit model suggests that the quantity $\ln\left(\frac{p}{1-p}\right)$, which is the log-odds of a firm being an innovative firm as opposed to a non-innovative one, conditional upon given explanatory variables, is a linear function of the explanatory variables, X_i . This is represented mathematically as:

$$\text{logit}(p) = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_i X_i + \varepsilon_0 \quad (1)$$

where β_0 is the intercept, X_i represents the vector of explanatory variables, β_i the vector of estimates and ε_0 the residual. The ratio $\frac{p}{1-p}$, which compares the probability of a firm being innovative with the probability of it being non-innovative, conditional upon each explanatory variable, can be easily obtained by exponentiating the coefficients β_i obtained from estimating equation (1). This ratio, alongside the marginal effects of each independent variable, is reported in Tables 3 and 4, and its interpretation is straightforward. Values greater

than one suggest that, conditional upon the given explanatory variable for which the value was obtained, a firm has a higher likelihood of having implemented an innovation. Values lower than one mean the direct opposite. The marginal effects simply capture the increase in the probability of innovating as the independent variables increase in value.

It is worth mentioning that besides the models reported in Tables 3 and 4, alternative models including the quadratic term of the age variable were estimated, in order to account for the non-linear relationship between age and the likelihood of innovation that has been reported earlier in the literature (Huergo and Jaumandreu, 2004). However, such non-linearity could not be confirmed in the present sample. In fact, the results of the alternative models (not reported) do not show any substantial difference from the results reported in Tables 3 and 4 and appear to be less efficient by showing higher information criteria values. Including the quadratic term of the organizational structure variable also made no difference to the results. This suggests that the simpler models are preferable, at least in terms of efficiency.

In addition, it should be noted that the four different innovation types are potentially interdependent. It should be expected that the implementation of one type of innovation will influence the likelihood of the other types. Moreover, in the empirical set-up of this paper, the same factors are assumed to be associated with all of the innovation types, a scenario that makes interdependence even more likely. To account for this interdependence, a multivariate probit was analysed. In this alternative empirical set-up, a simultaneous system of four probit equations was estimated instead of four separate ones (see Appendix 3 for details). The results are not qualitatively different from those reported in Table 4. Therefore, I have chosen to focus on discussing the logistic results for the additional benefit that the odds ratios are easily obtained and interpreted.

The third question that this paper addresses considers the relationship between the external search for knowledge and the benefits that a firm derives from its innovation efforts. A comparison is made here between innovative firms that engage in collaboration or use external knowledge sources and those that do not. The comparison was made in Wilcoxon–Mann–Whitney (WMW) tests. The WMW test is a non-parametric alternative to the t-test for comparing two independent groups. It is a rank-sum procedure based purely on the order of the observations in the two groups and makes no strict distributional assumptions. When data are ordinal, as is the case with the performance variables considered here, the WMW test is preferable to the t-test because the intervals between adjacent values are not constant. Starting from as few as eight pairs of observations, the WMW test statistic (U) is approximated by a normal distribution (Mann and Whitney, 1947), in which case the standardized z -value can be

used to test hypotheses. In Table 5, the results reported are for the hypothesis that the innovative firms are equally likely to report each of the listed innovation benefits whether or not they collaborated or used external knowledge sources.

4. Results and Discussion

4.1. Descriptive Results²

The pattern of the collaboration among the sampled firms is detailed in Table 1, from which the apparent importance of customers and the weak connection between firms and institutional organizations like research institutes and educational institutions are evident.³ The results for the entire range of innovation knowledge sources for Nigerian manufacturing firms (Table 2) indicate that the most important sources are customers, then suppliers. Alongside these, a range of other sources, such as industry associations and fairs and exhibitions, are among the key sources of innovation. Notable is the fact that institutional sources are among the least important sources of knowledge to the firms. These results indicate that firms' innovation activities are strongly determined by relations between themselves and their suppliers and customers.

There are demand-side and supply-side explanations for the weak research–industry connection. On the one hand, the relatively weak connection between firms and research-based sources might be linked to low levels of absorptive capacity in the firms and the level of difficulties associated with their innovation efforts. It is plausible that the firms may not rely much on universities and research institutions because they may find it difficult to appropriate such knowledge. Moreover, the innovation types in Nigerian firms, as captured in this study, broadly include imitation and incremental changes that do not necessarily have to rely on science for their success. On the other hand, the weak connection may be due to systemic characteristics, as suggested earlier by Frenz and Letto-Gillies (2009). Considering the huge costs of R&D, which are usually beyond the reach of most firms in developing countries, it stands to reason that firms will source new knowledge from publicly funded universities and research institutes. However, most of these organizations, at least in the Nigerian context, are poorly funded and often themselves dependent on foreign donors. Thus, their output may not necessarily be relevant to domestic industrial needs. Moreover, a huge communication gap may also exist between the research and the industrial sector due to the

² Some of these descriptive results appear in a much earlier version of this paper, Egbetokun and Siyanbola (2011).

³ Very much the same trend was observed when only innovative firms were used in this analysis.

cultural and methodological incongruence between them. For instance, firms are typically uncomfortable with the open dissemination of research results, which is completely normal for researchers (Fontana et al., 2006). In addition, in several universities, the curricula are outdated, so the teaching and research fall far behind industry in time. There is also a difference in the research motivations. Firms typically prefer research targeted towards profit, while research organizations typically concentrate more on advancing the frontier of knowledge. Specifically, until very recently, in Nigeria the largest and best universities and research organizations were publicly (even if poorly) funded, so their research objectives do not necessarily coincide with the profit-oriented demands of industry.

Table 1: Pattern of firms' collaboration in Nigerian manufacturing firms, by type of actor, for the years 2003–2006 (n=170)

Actor	% Innovators*
Customers	63
Associated Companies	51
Marketing Firms	51
Private Research Institutes	42
Competitors	41
Industry Associations	41
Suppliers	40
Financial Institutions	37
Public Research Institutes	35
Training Institutions	34
Higher Education Institutions	29
Government Ministries	29

* Multiple response items

Of the 170 firms in the sample, 143 (84.1%) had carried out at least one innovative activity during the 2003–2006 reference period. Of these, about 87% had been involved in formal cooperation or joint action with one or more actors against only 33% of non-innovators. About 62% of the innovative firms informally interacted with external sources of knowledge in their innovative efforts as opposed to only 19% of non-innovators. When compared in z-tests, the proportion of the innovative firms that collaborated or made use of external knowledge sources during the reference period was confirmed to be significantly higher at both the 5% and the 1% level of significance. These results suggest a strong association between a firm's knowledge search decisions and its probability of innovating. However, they were obtained by univariate tests. In the next section, the relationship between

the probability of a firm innovating and its knowledge search decisions is tested in a multivariate framework.

Table 2: Sources of information/knowledge for innovation activities in Nigerian manufacturing firms, for the years 2003–2006 (n=143)⁴

Knowledge Sources	Mean Ranks	Percentages			
		Very Important	Moderately Important	Not Important	Not Used
Customers	1.62	46.9	9.8	2.1	41.3
Suppliers	1.29	30.1	16.1	6.3	47.6
Industry Associations	1.24	27.3	18.9	4.2	49.7
Fairs and Exhibitions	1.22	22.4	23.8	7.7	46.2
Government Ministries	1.17	21.7	23.1	6.3	49
Professional Journals and Trade Publications	1.17	22.4	22.4	5.6	49.7
Consulting Firms	1.15	21.0	23.1	5.6	50.3
Educational and Research Institutions	1.11	24.5	16.1	5.6	53.8
Client Firms	1.05	23.8	13.3	7.0	55.9

4.2. Cooperation and the Likelihood of Innovating

The results of the estimations to assess the relationship between external knowledge searches and innovation are contained in Table 3. Both collaboration and external knowledge sourcing are positively and significantly associated with the likelihood of innovating. Although formal collaboration appears to be slightly more strongly associated with the propensity to innovate, the difference is not significant. A typical firm is six times as likely to innovate when it engages in formal collaboration but five times as likely when it accesses external knowledge informally. Similarly, the probability of a collaborating firm innovating is 13% times higher than that of a firm that does not collaborate. Accessing external knowledge informally is associated with an increase of about 12% in the likelihood of innovation. Of all the control variables, only the existence of an innovation budget is significant. Consistent with previous studies, these results suggest that firms are more likely to innovate when they exploit external knowledge through formal or informal means. Given that the existing literature is replete with evidence from developed countries, the results of this analysis provide an insight into the situation in the context of developing countries. In particular, these results demonstrate that

⁴ The survey questionnaire asked firms to rate the sources that they had used ‘in their innovation efforts’. To avoid any inconsistencies, only the innovation-active firms were included in this specific analysis.

cooperation and the use of external knowledge are also important for firms in latecomer contexts such as Nigeria. Additionally, as noted earlier, accounting for potential non-linearities in age and organizational structure do not affect the results.

In Table 4, the relationships observed in Table 3 are broken down according to the four innovation types measured in this study. The results indicate that the relationship between the deployment of external knowledge and innovativeness is generally positive but not equally important for the four innovation types. From a methodological perspective, this result suggests two things. First, the relationship between networking and innovativeness is more nuanced when innovation is considered at a lower level of disaggregation. Second, the bias towards technological product and process innovation that prevails in the literature does not provide a comprehensive picture of the relationship between innovation and the knowledge search behaviour of firms.

Table 3: Logistic regression results: relationship between external knowledge search and innovation

	Odds Ratio (Robust SE)	Marginal Effects (Robust SE)
COLLAB	6.493** (4.049)	0.133*** (0.039)
EXKNOW	5.271* (3.569)	0.118*** (0.046)
STRG	0.804 (0.492)	-0.015 (0.043)
ORG	1.083 (0.540)	0.006 (0.035)
AGE	1.135 (0.317)	0.009 (0.019)
OWNER	0.895 (0.137)	-0.008 (0.011)
ICT	3.415 (2.722)	0.087 (0.055)
IBUDG	23.02** (22.013)	0.223*** (0.052)
CONSTANT	0.149* (0.116)	
N	170	
McFadden R ²	0.46	
Log Lik.	-40.16	
Akaike's IC	98.33	
Chi Sq.	40.47***	
% Correctly Classified	90.6	

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

A statistical comparison of the estimates⁵ across the four models in Table 4 reveals almost no significant differences. The only exception is that the coefficient of EXKNOW for process innovation is significantly higher than the corresponding coefficient for organizational innovation. Collectively, these results indicate that the deployment of external knowledge either through formal or through informal means is equally important for most innovation types, the only caveat being that informally accessing external knowledge might be much more useful for process than for organizational innovation. In other words, when it comes to the helpfulness of network resources for innovation, all innovation types are essentially the same. Besides the fact that process innovation seems to be significantly more responsive to the deployment of external knowledge (acquired by informal means) than organizational innovation, there is no empirical support, at least from the analyses in this paper, for discrimination between innovation types when firms choose to form alliances or make use of network resources for innovation.

Another noteworthy result from Table 4 is that organizational innovation seems to benefit less from formal collaboration. Of all the four innovation types, it is the only one for which the marginal effect of COLLAB is smaller than that of EXKNOW. Specifically, while the use of informal external knowledge is associated with an increase of 37% in the propensity to innovate, formal collaboration is associated with a 23% increase. This suggests that for the purpose of implementing organizational innovation, there is less need for collaboration. This finding is intuitive when one considers that most of the activities captured by the organizational innovation measure are those that the firms can either perform efficiently in-house or for which they can secure assistance from external agents without the need to collaborate formally. The same cannot be said of the other innovation types. From a managerial perspective, these results are important as they provide some hints regarding what firms need to pay attention to when making knowledge search decisions.

Surprisingly, the greatest likelihood of firms innovating as a result of cooperation is not seen in product and process innovation but in marketing and organizational innovation. For marketing innovation, formal collaboration is associated with a 43% increase in the propensity to innovate. For organizational innovation, informal external knowledge sourcing is associated with a 37% increase in the propensity to innovate. This particular finding appears to be counter-intuitive since the knowledge intensity of marketing and organizational

⁵ A series of Wald tests was carried out following the *suest* command in STATA. The procedure was as follows. Using the *suest* command, estimates from the equations for each innovation type were combined in pairs (e.g. product–process). Wald tests of the hypothesis that the coefficients are not different across equations were then performed.

innovations should ordinarily be less than that of product or process innovation. However, for firms in developing countries such as Nigeria, where there is a great deal of informality in the manufacturing sector, it has been argued that marketing and organizational innovations are of major importance (OECD, 2005). Thus, the foregoing results find an explanation in the fact that the firms might be devoting a comparatively higher level of attention to making marketing and organizational changes, a behaviour that could be reflected in their knowledge search decisions.

4.3. Cooperation and Innovation Benefits

Table 5 shows the distribution of the innovation benefits reported by the firms. Although a total of 143 firms in the sample analysed reported at least one innovation type, not all of them responded to the questions on performance improvement, which is why the number of observations used for each item in Table 5 differs.

The first point that is worth mentioning from Table 5 is the large proportion of firms that indicated having felt the benefits of innovation in various aspects of their performance, irrespective of whether they collaborated or used external information sources. For instance, about 90% had increased profit and market shares, and over 70% indicated that the rate at which customers rejected or returned their products had reduced. Besides the economic benefits, innovation has also helped the firms to be more socially benign. For instance, 84% of them became more environmentally friendly as a result of being more innovative. This particular benefit can be traced to changes in waste management procedures as well as improvements in quality control within the firms. Moreover, considering the high rate of unemployment in Nigeria, increasing employment by the firms could have long-term macroeconomic benefits.

The WMW comparison results suggest that the propensity of innovative firms to benefit from innovation is not associated with their knowledge search decisions. The individual z-statistics comparing the percentages across rows within columns A and B are not reported in Table 5 since none of them is significant. It actually seems obvious by merely looking at the percentages themselves that neither firms that collaborate nor those that use external sources of information report greater innovation benefits.

Table 4: Logistic regression, explaining innovative performance by innovation type across Nigerian manufacturing firms

Independent Variables	Product Innovation		Process Innovation		Marketing Innovation		Organizational Innovation	
	Odds Ratio	Marginal Effects	Odds Ratio	Marginal Effects	Odds Ratio	Marginal Effects	Odds Ratio	Marginal Effects
COLLAB	6.922*** (3.664)	0.242*** (0.054)	7.036*** (3.301)	0.237*** (0.048)	13.530*** (10.530)	0.431*** (0.112)	4.597** (2.648)	0.227** (0.078)
EXKNOW	6.396*** (3.037)	0.232*** (0.047)	4.169** (1.990)	0.173*** (0.050)	6.689*** (2.751)	0.315*** (0.046)	12.03*** (5.063)	0.369*** (0.031)
STRG	1.287 (0.585)	0.031 (0.056)	0.956 (0.433)	-0.005 (0.055)	0.908 (0.376)	-0.016 (0.069)	0.658 (0.288)	-0.062 (0.064)
ORG	1.065 (0.289)	0.008 (0.034)	0.901 (0.258)	-0.013 (0.035)	1.027 (0.235)	0.004 (0.038)	1.262 (0.294)	0.035 (0.034)
AGE	1.062 (0.168)	0.008 (0.019)	1.081 (0.189)	0.009 (0.021)	0.955 (0.155)	-0.008 (0.027)	0.897 (0.158)	-0.016 (0.026)
OWNER	1.022 (0.119)	0.003 (0.015)	0.834 (0.096)	-0.022 (0.014)	0.956 (0.102)	-0.008 (0.018)	0.978 (0.111)	-0.003 (0.017)
ICT	2.553 (1.231)	0.117* (0.057)	1.504 (0.729)	0.049 (0.058)	2.586 (1.369)	0.157 (0.082)	1.498 (0.676)	0.060 (0.067)
IBUDG	3.675** (1.640)	0.162*** (0.048)	7.128*** (3.715)	0.238*** (0.049)	1.686 (0.689)	0.086 (0.067)	1.516 (0.642)	0.062 (0.063)
CONSTANT	0.044*** (0.034)		0.154** (0.104)		0.013*** (0.015)		0.103** (0.077)	
N	170		170		170		170	
McFadden R ²	0.35		0.33		0.28		0.32	
Log Lik.	-67.89		-66.06		-84.33		-78.68	
Akaike's IC	153.80		150.10		186.70		175.40	
Chi Sq.	39.41***		41.16***		33.71***		42.81***	
% Correctly Classified	81.76		84.12		77.06		81.76	

Note: Robust standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Consequently, the use of network partners does not intensify the performance benefits that firms receive from their innovation efforts. While openness to external knowledge might help firms to become better at innovating, it may not necessarily assist them in reaping the benefits derivable from their innovation efforts. An important implication of this is that neither cooperation nor the use of external information sources for innovation is to be seen as an end in itself but only as a means to enhance innovativeness. The effect of innovation on performance is entirely different and appears to be independent of a firm's networking decisions, at least in the sample analysed here.

Table 5: Innovation benefits among cooperative and non-cooperative firms

	Total		(A)				(B)			
			Collaboration ^b				External Info. Sources ^c			
			Yes		No		Yes		No	
	N	%	n	%	n	%	n	%	n	%
Increased Profit	113	89.4	106	90.6	7	71.4	76	93.4	37	81.1
Increased Market Shares	111	87.4	104	88.5	7	71.4	71	87.3	40	87.5
Diversification	101	82.2	93	83.9	8	62.5	67	82.1	34	82.4
Product Differentiation	107	80.4	98	79.6	9	88.9	69	82.6	38	76.3
Positive Environmental Impact	106	84.0	100	85.0	6	66.7	69	84.1	37	83.8
Compliance with Regulations	108	86.1	101	86.1	7	85.7	73	87.7	35	82.9
Increased Employment	109	61.5	104	60.6	5	80.0	71	57.7	38	68.4
Reduced Rejection/Return of Products	104	73.1	96	72.9	8	75.0	68	73.5	36	72.2

Note: All percentages are expressed with respect to the preceding column. The total N values are different and less than 143 due to missing responses.^{b,c} For all the rows, the null hypothesis $\Pr(\text{Yes}) = \Pr(\text{No})$ cannot be rejected at 5% significance, two-tailed. The average z-statistics are -0.42 and 0.01, respectively.

5. Conclusions

This paper addressed questions concerning the relationship between networking – in terms of collaboration and the use of external sources of knowledge – and innovativeness of firms using a unique data set within the context of the manufacturing sector in Nigeria. The most important external sources of knowledge for innovation are customers, suppliers of machinery and equipment as well as industry associations and fairs and exhibitions. Worthy of note is the fact that research-based and government sources are among the least important sources of knowledge to the firms. In sum, firms' innovation activities are strongly

determined by relations between themselves and their suppliers and customers in Nigeria. I have offered demand- and supply-side explanations, which are valid not only for the Nigerian context but also for similar contexts.

The econometric results support the hypothesis of a positive relationship between the probability of a firm innovating and both formal and informal knowledge sourcing. The relationship between networking and innovativeness was also found to be positive for the four innovation types considered in this paper. These results are robust to different specifications. However, the greatest usefulness of network resources for innovation is not seen in product and process innovation but in marketing and organizational innovation. Explanations for this are found in the nature of the business environment as well as the way in which firms approach innovation. In terms of the performance benefits derived from innovation, firms that networked were found not to be better off than firms that did not.

This study has some managerial implications. The results highlight the need for firms to be more open in their innovation efforts. This has been the main conclusion from several previous studies but the present study confirms its relevance to Nigerian firms. More importantly, the results of this paper show that it is not necessarily correct to assume that networking will enhance firm performance as it does the potential to innovate. Thus, enjoying the performance benefits derivable from innovation requires strategic commitment that goes beyond merely forming partnerships or securing external knowledge informally. Finally, the results point to the fact that all the innovation types are essentially the same with respect to the effect network resources have on them. Thus, it makes little sense to engage network partners selectively for certain innovation types at the expense of others.

An important limitation of the analyses in this paper is that they reveal very little about the direction of causality. Are firms becoming more innovative because they use external knowledge or are they seeking external knowledge because they are already innovative and thereby have a greater need to complement their internal knowledge with external knowledge? Providing answers to this type of question requires panel data, which are hard to come by in the research context. Another shortcoming of the analyses is the usual problems of endogeneity and unobserved heterogeneity associated with the use of cross-sectional data. Quite regrettably, even if more waves of the innovation survey that has been used become available, they will most likely only provide repeated cross-sectional rather than true panel data. This creates the need for alternative data sources or a combination of complementary data sources. Finally, the results in this paper are based on a relatively small

sample of firms. Larger samples might yield markedly diverse results, confirming some of those presented herein while possibly confounding others.

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Appendix 1: The innovation proxies as contained in the survey questionnaire

Innovation Activities		
PRODUCT (n=170)	Yes	Started but later abandoned
Introduced new product	49.4	0.6
Improved an existing product	59.4	0.6
Developed a new product	41.8	1.2
PROCESS (n=170)		
Introduced new process	52.4	0.6
Improved an existing process	51.8	1.2
Developed or modified an existing process	44.1	1.2
Product licence	37.1	-
Process licence	27.1	-
Modified licence*	69.1	-
ORGANIZATIONAL (n=170)		
Changes in management routine	32.4	1.2
Introduced new quality control methods	40.0	16.5
Introduced maintenance routines	37.6	12.4
Changed plant layout	20.6	18.2
Introduced waste management procedures	31.2	12.4
Implemented an in-house training programme	28.8	20.6
MARKETING (n=170)		
Introduced a new marketing technique	39.4	8.2
Developed a new domestic market	25.3	15.3
Developed a new market abroad	12.4	14.1

*n=68 (only the firms that had either a product or a process licence)

Appendix 2: Description of independent variables

Variable Name	Variables	Description	Mean	SD	1	2	3	4	5	6	7	8	9
COLLAB	Collaboration	Constructed measure of whether or not the firm engages in joint activity with any of 12 listed actors. 1 if this is so and 0 otherwise	0.78	0.41	-								
EXKNOW	Use of external knowledge sources	Constructed measure of whether or not the firm uses any of 9 listed external knowledge sources	0.55	0.49	0.29**	-							
SIZE	Size	Measured as the logarithm of the firm's employees in 2006	3.03	1.24	-0.20		-						
AGE	Age	Logarithm of the difference between the reference year of the survey (2006) and the firm's year of establishment	2.46	1.37	0.13	0.08	-0.17	-					
OWNER	Ownership	The types of stakeholders that own the firm. Possibilities include Nigerian or foreign individuals, firms or government and partnerships among these	2.09	1.87	0.05	0.04	0.39	0.05	-				
ORG	Organizational structure	Logarithm of the number of levels in the firm's organizational structure	0.93	0.83	0.18	0.07	0.25	0.14	0.17*	-			
STRG	Staff training	The incidence of training programmes for staff. 1 if there is and 0 otherwise	0.56	0.49	-0.07	0.01	0.22	-0.02	0.31**	0.10	-		
ICT	Internet use	An indicator of whether or not the firm uses the Internet in any of its activities. Measured via a binary variable taking the value 1 if firm uses the Internet and 0 otherwise	0.77	0.43	0.28**	0.11	-0.20	0.14	0.23**	-0.04	0.18*	-	
IBUDG	Innovation budget	A binary variable indicating whether or not the firm has a separate budget for innovation	0.52	0.50	0.20**	-0.01	-0.08	0.02	0.08	0.06	0.23**	0.16*	-

Appendix 3: The Multivariate Probit Analysis

The multivariate probit model is desirable when the dependent variables in a set of otherwise independent equations are potentially interdependent. This is indeed the case in this paper since the four innovation types being analysed are not necessarily independent. In fact, the pairwise correlation between them all is significant (Appendix Table 1). Consequently, the pairwise correlation (ρ) of the error terms from the estimation equations is expected to be greater than zero. The multivariate specification that allows one to control for this interdependence takes the form

$$y_n^* = \beta_n' X + \epsilon_n$$

$$y_n = \begin{cases} 1, & y_n^* > 0 \\ 0, & \text{otherwise} \end{cases}$$

where y_n^* is the observed variable and y_n is the unobserved latent variable. In this empirical set-up, n stands as an equation counter and ranges from 1 to 4 since there are four equations in total. Solving this system of equations requires the evaluation of multivariate normal distribution functions, a problem that is best solved by simulated maximum likelihood (SML).

Appendix Table 1: Correlation between different innovation types

	Product	Process	Marketing	Organizational
Product	-			
Process	0.6414*	-		
Marketing	0.3636*	0.3946*	-	
Organisational	0.4956*	0.4858*	0.5452*	-

* $p < 0.01$

The *mvprobit* routine in STATA performs this evaluation using the Geweke-Hajivassiliou-Keane (GHK) simulator (Cappellari and Jenkins, 2003). This method is known to be sensitive to the number of observations drawn in each step of the iteration procedure so the authors recommend using a draws at least as large as the square root of the total number of observations. For the analysis reported in Appendix Table 2, I have used 25 draws in the *mvprobit* routine instead of the default 5. It should be noted that probit models give estimates that are very similar to those of logit models (Cameron and Trivedi, 2005, pp. 471-3). Therefore, results from the *mvprobit* could be held up to those obtained from logit models in Table 4.

The multivariate probit results (Appendix Table 2) suggest interdependence across the equations ($\rho > 0$, $p < 0.05$ for most of the equations). Consequently, the apparent explanatory power of the separate equation models might be upward biased. To check this, I have obtained the normalised Aldrich-Nelson pseudo- R^2 for all the models. This gives reliable approximations of the goodness of fit for models with discrete dependent variables (Veall and Zimmerman, 1992; Hagle and Mitchell II, 1992) and is very easy to calculate using the estimated log-likelihood for the null and alternative models. The results confirm the presence of upward bias in the separate equation models (Appendix Table 3). Notwithstanding, the results of the multivariate estimation differ from those obtained by estimating separate equations only in terms of the magnitude of the coefficients; the patterns and significance levels remain the same. This suggests robustness of the results of the analyses. And for the added benefit that the can be easily obtained and interpreted (Cameron and Trivedi, 2005, pp. 472), I have discussed the logit models in the text.

Appendix Table 2: Results of multivariate probit analysis

Independent Variables	Innovation Types, Coefficients			
	(1) Product	(2) Process	(3) Marketing	(4) Organizational
COLLAB	2.971*** (0.880)	3.254*** (0.991)	3.622** (1.428)	2.259** (0.667)
EXKNOW	2.832*** (0.714)	2.102** (0.533)	3.069*** (0.713)	4.331*** (1.001)
STRG	1.054 (0.291)	0.878 (0.245)	0.934 (0.227)	0.825 (0.211)
ORG	1.075 (0.170)	0.952 (0.154)	1.023 (0.146)	1.077 (0.157)
AGE	1.036 (0.095)	1.030 (0.092)	0.956 (0.081)	0.963 (0.081)
OWNER	1.026 (0.073)	0.902 (0.062)	0.989 (0.064)	0.991 (0.064)
ICT	1.682 (0.523)	1.206 (0.382)	1.721 (0.519)	1.369 (0.412)
IBUDG	1.962* (0.514)	2.704*** (0.727)	1.408 (0.337)	1.344 (0.327)
CONSTANT	0.177*** (0.075)	0.399* (0.150)	0.101*** (0.049)	0.256*** (0.099)
<i>N</i>	170			
Aldrich-Nelson R^2	0.29			
Log Lik.	-274.3			
Akaike's IC	632.5			
Chi Sq.	137.6***			
ρ	(1,2): 0.522*** (1,3): 0.126	(2,3): 0.269 (2,4): 0.475***	(3,4): 0.537***	(4,1): 0.488***

Standard errors in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ **Appendix Table 3: Comparison of fit, multivariate and separate equation models**

Model	Pseudo R^2
Multivariate probit	0.29
Logit	
Product	0.42
Process	0.41
Marketing	0.36
Organizational	0.40
Average	0.40