ONSHORE AND OFFSHORE OUTSOURCING OF TECHNOLOGY DEVELOPMENT AND FIRM PERFORMANCE

C. Annique UN
University of South Carolina, Moore School of Business
Sonoco International Business Department
1705 College Street, Columbia, SC 29208 USA
Tel.: 1-803-777-0315, Fax: 1-803-777-3609, annique_un@moore.sc.edu

I analyze the impact of onshore and offshore outsourcing of technology development on firm performance. Despite the growth in the outsourcing of technology development, there is confusion in the literature regarding its benefits. I clarify the debate by proposing that these depend on the location of the outsourcing. Hence, I argue that whereas onshore outsourcing of technology development does not help improve firm performance because it limits the development of learning capabilities, in contrast, offshore outsourcing of technology development has a positive impact on firm performance because it forces the firm to develop new learning capabilities to access and integrate foreign knowledge.
(93 words)

Key words: offshore outsourcing, onshore outsourcing, technology, learning, performance

1. INTRODUCTION

In this paper I study differences in the impact of offshore and onshore outsourcing of technology development on firm performance. Firms have increased outsourcing the development of technologies to other firms inside (i.e. onshore) and outside (i.e. offshore) their home country. The current worldwide market for technology ranges from US$35 to US$50 billion per year and is increasing (Lichtenthaler, 2007). McKinsey Global Institute (2003) estimated that the total U.S. services offshoring market, which includes technology offshore outsourcing, was US$26 billion in 2001. Of these, US$8.3 billion went to Ireland, US$7.7 billion went to India, US$3.7 went to Canada, and the rest went to Caribbean countries. More recent studies also indicate that firms no longer just offshore outsource production activities; they also offshore outsource technology development (e.g., GAO, 2006; Manning, Massini, & Lewin, 2008).

Despite the importance of technology outsourcing, there is confusion in the literature regarding its benefits. Some authors argue that technology outsourcing is useful because it enables the firm to focus on its competence by not investing in its own technology development and instead relying on specialized suppliers (Dibbern et al., 2008; Manning et al., 2008). In contrast, other authors propose that technology outsourcing is harmful to the firm because the company limits its current and future ability to learn and create knowledge by relying on others for the technology (Fifarek, Veloso, & Davidson, 2008; 2008; Weigelt, 2009).

Hence, I contribute to the literature by proposing that to solve this debate one needs to look at the location of the knowledge the firm is obtaining and argue that there are differences in the benefits obtained from onshore and offshore technology outsourcing. I argue that whereas technology onshore outsourcing does not help improve firm financial performance because the greater similarity of onshore knowledge to the knowledge of the firm limits the development of learning capabilities, in contrast, technology offshore outsourcing has a positive impact on firm performance because the new and superior offshore knowledge forces the firm to develop new learning capabilities and knowledge.

The longitudinal analysis of a sample of manufacturing firms in Spain provides novel and interesting insights. They show that technology outsourcing tends to be unrelated to firm performance, but after separating it into onshore and offshore, the results show that whereas onshore technology outsourcing is not related to performance, offshore technology outsourcing is positively related to performance. The results also show that the causality runs in the proposed direction, that is, that offshore technology outsourcing has a positive impact on performance, rather than the other way around. Firms benefit from technology offshore outsourcing because offshore technologies force them to learn.

These arguments and findings contribute to two streams of literature. First, they contribute to the literature on technology outsourcing by showing that offshore outsourcing is indeed positive for firm financial performance, whereas onshore outsourcing is not necessarily so. This is an important distinction and finding, not only given the importance of offshore outsourcing of high-value added activities as a topic, but more importantly given the dearth of findings regarding its effect on performance. Previous studies have not directly compared the

impact of onshore and offshore technology outsourcing on performance, focusing instead on one or the other (e.g., Cha et al., 2008; Fifarek et al., 2008; Weigelt, 2009; Weigelt & Sarkar, 2009). This has resulted in calls for more research explaining whether offshore outsourcing of services is good or bad for firm's profitability and why (Bhalla, Sodhi, & Son, 2008; Manning et al., 2008).

Second, they contribute to the knowledge-based view (Grant, 1996; Kogut & Zander, 1992; Nonaka, 1994; Tsoukas, 1996) by uncovering and modifying an unstated assumption about outsourcing and explaining how a relaxation of the assumption results in differing predictions. The special nature of knowledge requires a different logic to explain the benefits of technology outsourcing than the logic used to explain the benefits of production outsourcing. At the same time, the special nature of knowledge and differences in knowledge across countries alter the logic used to explain the impact of onshore and offshore technology outsourcing on performance. Some types of outsourcing can actually force the firm to learn, and thus improving its financial performance.

The arguments and findings of the paper are also useful for managers. They show that when considering outsourcing the development of its technologies, offshore outsourcing appears to be better than onshore outsourcing. The reason is that because offshore outsourcing provides access to knowledge in another country that differs more than the knowledge available in the home country, it forces the firm to learn and develop its knowledge base, thus helping it improve its competitiveness. The paper explains how the logic governing technology outsourcing differs from the logic governing the outsourcing of other activities.

2. THEORY AND HYPOTHESES

2.1. The Knowledge-Based View and Technology Development

The KBV has proposed that knowledge is the essence of the existence and advantage of the firm. Although a firm controls tangible assets, it is not the control of such tangible assets per se but the knowledge that the company has that determines the use of those assets and explains its existence and its ability to compete (Grant, 1996; Kogut & Zander, 1992; Nonaka, 1994; Tsoukas, 1996) Thus, under this view, the advantage of the company does not come from the control of a particular asset, but from the knowledge the firm has that enables it to use the asset. This conceptualization is close to the view of Penrose (1959) that a company is a bundle of resources that provide services to the firm.

Knowledge is different from physical assets, and therefore its outsourcing is governed by a different logic. Different from the physical assets involved in production, knowledge is an intangible asset that has infinite economies of scale once it is produced, and at the same time has appropriability difficulties, which makes it into a quasi public good[1]. As a result, whereas in a

[1] A public good is one that is non-rivalrous, that is that the consumption of the good by one individual does not limit the supply available to other individuals, and non-excludable, that is, an individual cannot be excluded from using the good. In the case of knowledge, there is non-rival consumption and it is difficult to exclude others from using it once it has been revealed.

production activity the firm can exclude others from accessing the physical assets used to generate the product because it has clear property rights and control over the physical assets, in knowledge the firm does not have assets under control to exclude others from using the knowledge generated. Thus, once the firm creates the knowledge, if competitors obtain this knowledge they can use it in their own operations, unless the knowledge has been given a legal monopoly of exclusion, that is, it has been granted a patent. However, most knowledge is not patented, and in many cases patents are not well protected (Agrawal, 2006; Cohen, Nelson, & Walsh, 2000; Zhao, 2006).

The process of knowledge creation, such as the one in technology development generates much additional knowledge that is not directly embodied in the technology, but that nevertheless has value; this affects the benefits of technology outsourcing, as I explain below. There are three sources of additional knowledge. One source of such additional knowledge is knowledge on the failures encountered before the firm reaches success and discovers a new technology that actually works. The creation of technology is a highly uncertain process that results in many failures (Leiponen & Helfat, 2010). These failures are considered as such because they do not yield a workable technological outcome. However, they are not failures in the sense of learning (Sitkin, 1992; Van de Ven & Polley, 1992). The firm learns that a particular path or way of doing things is not appropriate, thus creating new knowledge that can be useful in the future when the firm undertakes modifications or extensions of the technology developed.

A second source of additional knowledge generated in the development of technology is the extension of the knowledge set of the individuals involved in the process of development. As the individuals work together and integrate different knowledge to generate new technology, they extend their own knowledge set (Hirst, Knippinberg, & Zhou, 2009; Taylor & Greve, 2006). After the creation of technology, the firm retains individuals with an expanded knowledge set that can help the firm generate additional technology in the future (Leonard-Barton, 1995; Nonaka & von Krogh, 2009). Moreover, these individuals involved in the technology development not only have an understanding of how the new technology has been developed and why and how to apply it, but also of why the technology works. They can adapt and alter the technology to new uses later on as they have an understanding of the conditions governing its behavior, enabling the firm to continue improving and upgrading the technology as new conditions that were not thought about previously but that appear later on.

A third source of additional knowledge generated during the development of technology is the tacit knowledge behind the technology. Much of the knowledge generated in the creation of the technology is hard to codify and transmit, because individuals know more than they can express (Nonaka, 1994; Polanyi, 1967). The development of a technology that can be applied in other parts of the firm or sold to other firms depends on the ability of the firm not only to create the new technology, but also of codifying and making the underlying knowledge explicit so that people that have not been involved in the creation of the technology can understand it. In many cases, this is not possible because the knowledge is complex and systemic (Kogut & Zander, 1992; Nonaka & Takeuchi, 1995). This tacit knowledge enables the firm that generates the technology to not only better understand the technology but also maintain a knowledge base that differs from competitors' and that is difficult to imitate (Dierickx & Cool, 1989). This tacit

knowledge created and accumulated in the generation of technology develops a built-in protection from imitation by competitors.

2.2. Technology Outsourcing: A Different Logic from Activity Outsourcing

Some researchers have applied the logic of the outsourcing of activities, not only manufacturing but other activities such as call centers or business processing, to the analysis of technology outsourcing. However, such application fails to understand the underlying differences in nature and logic of knowledge creation and production activities.

The logic governing the impact of outsourcing of activities on performance is one of cost reduction. By subcontracting certain activities to external providers, the firm can specialize in areas in which it has an advantage and lower the production costs by subcontracting activities to specialized providers that can achieve the necessary scale economies. The subcontracting of activities enables the firm to maintain its competitive advantage. When the firm subcontracts activities to other companies, it continues to control the knowledge creation process and has some decision authority over the management of the activities outsourced to others. The firm can decide which types of components or systems needs to incorporate in its final products and subcontracts their production to other companies, which follow its specifications (Takeishi, 2001). In such circumstances, the firm is still in control of the knowledge used to create the product as it provides the specifications to the supplier on what it wants and how it wants it, with the supplier in control of making that happen (Takeishi, 2002). Although the firm may not learn the details on how the components are assembled together or how the employees are managed to assemble the components, it is still in control of the final product and how the parts coming from different suppliers fit within the overall structure of the product. Even if the firm is not undertaking the construction of the product, it can still determine the design of the components and their interactions, thus being in control of the component and architectural innovation of the product. Thus, many studies analyzing the outsourcing of production activities tend to propose that this is good for the firm.

However, the subcontracting of technology development differs from the subcontracting of production activities. The special nature of knowledge as an intangible asset whose production creates much additional knowledge results in a different logic. The logic governing the impact of technology outsourcing on performance is one of revenue destruction. By subcontracting the creation of technology to other companies, the firm limits its learning and ability to generate knowledge, even if it ends up receiving knowledge from the technology supplier. The company specifies the final product, a particular technology or an innovation, and relies on another company to generate the underlying knowledge that will result in the desired technology or innovation. The firm is no longer generating knowledge and instead relies on others for this.

As a result, although it obtains knowledge with the technology subcontracted, the firm misses out on the additional learning and knowledge that comes with the development of the technology: knowledge of the failures, learning in the individuals, and tacit knowledge. The company does not receive knowledge on the failure and thus the limitations of the technology and its applications, but a finalized technology with a defined set of applications. Moreover, the firms does not get employees with an expanded knowledge set and an increased ability to create

more knowledge in the future, but technology that has been created by these individuals and that now the employees in the firm have to use. Finally, the company does not get the tacit knowledge that has been developed in the process of generating the technology and that can explain why the technology works and under which conditions it can be modified and adapted, as well as the tacit knowledge of how to properly use the technology. It only receives the explicit knowledge that accompanies the technology. Thus, when outsourcing technology development to other firms, instead of understanding how and why the technology works as well as its limitations and ways in which it can be modified in the future, the firm merely understands how the technology can be applied to perform the specific task the company has requested the supplier to solve with the technological development. In this case, the company may have saved on the costs of developing the technology but at the expense of limiting its learning and not developing its ability to modify and extend the technology as well as develop new technologies in the future. In the extreme, a firm that outsources all its technology development to others would loose all its distinct knowledge and ability to learn, eventually ceases to exist as it no longer can create value on its own. The analysis of the relationship between technology outsourcing and firm performance would suggest a negative relationship.

2.3. Onshore and Offshore Outsourcing of Technology Development and Performance

However, this analysis of technology outsourcing is based on an unstated assumption that a firm cannot learn from the technologies it purchases. I challenge this assumption by arguing that the learning depends on the location from which the outsourced technology comes. Thus, I separate technology outsourcing into two types depending on the location of the technology that is being outsourced: onshore technology outsourcing is when the technology is being outsourced from firms from the same country, and offshore technology outsourcing is when the technology is being outsourced from firms from a foreign country[2]. I propose that offshore technology outsourcing in fact can help the firm improve its performance because it forces it to learn as it has to integrate knowledge that differs from the one prevailing in the country, while onshore technology outsourcing has a more limited impact on performance because the firm will learn less from knowledge that is prevailing in the country.

2.3.1. Offshore technology outsourcing and firm performance

Foreign knowledge differs from the knowledge prevailing in the country. Although globalization has resulted in an easier cross-border transfer of knowledge, supported by the rise of information technologies and the liberalization of markets, there are still significant barriers to the transfer of knowledge across countries (Almeida & Phene, 2008; Kogut, 1991; Tsai, 2001; Tsai & Ghoshal, 1998). First, knowledge transferred using information technologies is explicit knowledge that can be simplified, codified and transmitted, but the larger tacit knowledge base cannot be transferred across borders using information technologies (Nonaka & Takeuchi, 1995; Subramaniam & Venkatraman, 2001). This tacit knowledge that is complex and systemic remains embedded in a network of relationships among individuals, firms, and universities in particular locations, resulting in regional and national innovation systems (Nelson, 1993; Storz,

[2] I discuss types of outsourcing of technology. Hence I do not discuss offshoring that is undertaken within the firm, because in this case the firm is not outsourcing the technology development, but merely moving the technology development to a different location (e.g., Kuemmerle, 1997).

2009). Thus, despite the globalization of R&D, companies are still citing patents that are local rather than global (for a recent discussion, see Henderson, Jaffe, & Trajtenberg, 2005) and complex knowledge moves across firms through the local exchange of personnel (Saxenian, 1994; Song, 2002).

The offshoring of technology is not based on a search for low cost, as the logic of production outsourcing suggests, but of new and superior knowledge. A common misunderstanding of technology offshoring is the view that it is done by setting up R&D operations in low-cost countries (e.g., India, China). However, this is not offshore outsourcing of technologies, but offshoring of R&D within the firm. The R&D centers are still under the control of the firm, which happen to be located in another country. Different from these actions, technology offshore outsourcing involves the purchasing of technologies from firms located in other countries. These are technologies that the company acquires to help it improve its competitiveness, which in most cases come from high-cost countries, such as robotics technology from Japanese companies (Katila & Ahuja, 2002) or ship building technology from Denmark (Pyndt & Pedersen, 2006). In technology outsourcing the goal is to obtain better technology that can provide the firm with an advantage; a cheaper technology that is below par will not help the firm improve its competitiveness.

I argue that offshore technology outsourcing induces the firm to learn and create knowledge, despite being a type of outsourcing of technology development to other companies, thus helping the firm improve its performance. Three reasons explain this, going from less to more challenging and thus resulting in higher learning: differences in conditions, differences in complementary knowledge, and differences in assumptions. First, the foreign technology is developed to be adapted to the realities of the home country of the company in which it is created. Its transfer to the host country would require its adaptation to the realities of the host country. This induces the firm that obtains the technology to learn how it works to be able to adapt it to the realities of the host country. Second, the foreign technology is developed to be used with available complementary technologies that are common in the country. Such complementary technologies may not be widely available in the host country where the technology is being transferred. This induces the firm that obtains the outsourced technology to learn how the technology works in combination with the complementary technologies and to develop such complementary technologies if they are not available in the firm or country. Third, the foreign technology has been developed under different assumptions about interactions with its environment. This requires the firm to understand such assumptions for properly implementing the foreign technology. As a result, it has to challenge its own assumptions on how things work in the country because the assumptions are only revealed in contrast to differing assumptions. This challenging of assumptions generates new knowledge not only on how to use the foreign technology, but also on how and maybe even why the foreign technology works differently in the country of origin of the company.

2.3.2. Onshore technology outsourcing and firm performance

In contrast, domestic knowledge does not differ as much as knowledge of the firm as foreign knowledge and there are fewer barriers to the diffusion of domestic knowledge within the country. Knowledge within the country is more easily accessible and thus diffused among firms.

Although companies can establish barriers to the diffusion of knowledge, such knowledge can spill over to nearby companies through three mechanisms: competition, demonstration, and worker mobility. In the competition effect, firms that face a more sophisticated competitor are forced to find ways to improve to counter the competitive advantage of the firm. In the demonstration effect, companies with a competitive advantage become examples that other firms imitate. In the mobility effect, workers trained in the better firm move to other firms and bring with them their knowledge on the sources of advantage of the competitor (Corredoira & Rosenkopf, 2010; Saxenian, 1994; Song, 2002). In addition to these unwanted transfers of knowledge, companies sometimes establish direct transfers of knowledge with nearby competitors by establishing collaborations and relationships. These unwanted transfers of knowledge through spillovers tend to be localized; for this reason foreign companies that want to reduce spillovers locate away from their competitors (Shaver & Flyer, 2000).

The result is a higher similarity in the knowledge that the firm may obtain from the company from which it outsources its technology domestically; such similarity reduces the pressures to learn and create new knowledge, and thus, its ultimate performance. The similarities are highest in the areas that would challenge the firm to learn the most. First, technology created by a company in the country will likely be built on shared assumptions with the company that outsources it. As a result, the firm that receives the technology will not have to analyze the assumptions it holds on the environment and how these differ from the assumptions on which the technology is built. Thus, it will not learn and create new knowledge. Second, technology created in the country is developed with an understanding of the complementary technologies that are needed to use the technology. Even if the firm does not have the complementary technologies, it will be easier for it to obtain them in the country as the technology is developed with the availability of these in mind, thus limiting learning. Third, the technology is likely to be adapted to the realities of the firm. The provider of the technology may generate the technology not only as a generic technology but also as an adapted technology to the needs of its customers. When this is not the case, the firm may learn how to adapt the technology to its needs and thus generate some new knowledge. However, such learning will be more limited than if it had to learn not only how to adapt the technology, but also to develop the complementary knowledge and challenge the assumptions upon which the technology is created as in the case of foreign technology. Thus, there is limited learning in technology onshore outsourcing, which limits the ability of the firm to generate knowledge and thus its competitiveness and performance.

2.3.3. Offshore and onshore technology outsourcing and firm performance

These differences in the learning that accompanies offshore and onshore technology outsourcing result in differences in the performance of the firms that undertake them. Offshore technology outsourcing may in fact lead to learning and the creation of new knowledge because the firm has to deal the differences in use of the technology, complementary knowledge and assumptions of the foreign technology to be able to implement and use it. Thus, the firm will still create knowledge, which combined with the foreign knowledge it has obtained will make it different and better than some competitors, thus helping it perform. In contrast, onshore technology outsourcing may in fact not help the firm learn much because the similarities in assumptions and complementary knowledge do not challenge the firm to create new knowledge. The firm may not even be challenged to adapt the technology to its realty. All this, limits its

knowledge creation and, thus, its advantage and associated performance. These arguments support the following hypothesis:

Hypothesis 1: Technology offshore outsourcing has a higher positive impact on firm performance than technology onshore outsourcing.

3. RESEARCH DESIGN

3.1. Data

I test the hypotheses on a sample of 785 manufacturing firms operating in Spain during the period of 1990-2002. The study of manufacturing firms in Spain is appropriate for testing the hypotheses. First, tangible products are more likely to be influenced by technology offshore outsourcing than services. Second, Spain is an appropriate empirical setting because it is neither at the forefront of technological development nor at the bottom among countries, but rather in the middle like the majority of the countries in the world. Therefore, findings from this study will be directly applicable to most of the countries in the world except the few technology leaders, such as the United States and Japan.

Data come from a survey of manufacturing firms conducted by the Foundation State-Owned Enterprise (*Fundación Empresa Pública*) in Spain, and covers the years 1990-2002. The Ministry of Commerce, Tourism and Industry in collaboration with the Foundation State-Owned Enterprise compiled the data. These organizations chose the firms for the survey based on size. All firms with more than 200 employees were included in the sample. Firms with between 10 and 200 employees were selected through a random stratified sample. The survey was collected through a detailed questionnaire of 107 questions with 500 fields designed to capture all aspects of the strategy of the firm. Firms in the database cover 21 industries and therefore are representative of the underlying population of manufacturing firms in the country.

The way in which data was collected and distributed helps reduce biases inherent in any survey and increases confidence in the quality of the data. First, the survey is explicitly collected for research purposes. Hence, there is no incentive for the firm to present the state of the firm in a better light to obtain subsidies or to present the state of the firm in a worse light to avoid tax liabilities. Second, data is collected under a confidentiality agreement. As a result, the database used does not contain variables that would help identify the firm. This limits my ability to collect additional information or verify the data because I do not know the identity of the firm. However, it has the benefit of reducing the incentive of misrepresentation by managers. Third, the survey uses detailed questions about the variables. It does not use Likert-type scales on the perception of the manager about a particular variable to avoid response bias. Fourth, data collected in one year is checked for errors and discrepancies with previous years to ensure its quality and comparability across time.

The database has been used by other researchers to study internationalization (e.g., Salomon & Shaver, 2005) and R&D investment (Cuervo-Cazurra & Un, 2007). However, it has not been used to explore the relationship between technology outsourcing and firm performance.

3.2. Variables and Measures

The dependent variable is firm performance. I measure this in three different ways as done in other studies analyzing firm performance (e.g., Contractor et al., 2007): Return on sales (ROS) (Ramaswamy, 1995), return on assets (ROA) (Berman et al., 1999), and return on equity (ROE) (Boone, Van Olffen, & Van Witteloostuijn, 2005). Return on sales is earnings before interests, taxes, and depreciation divided by total sales and multiplied by 100. Return on assets is earnings before interests, taxes, and depreciation divided by total assets and multiplied by 100. Return on equity is earnings before interests, taxes, and depreciation divided by total equity and multiplied by 100.

The independent variables of interest are technology onshore outsourcing and technology offshore outsourcing. They are based on the amount of money that the firm paid for outsourced R&D, which is the amount of money paid to other firms, universities, or other entities dedicated to scientific or technological research, to obtain new scientific or technological knowledge or to develop commercially-viable innovations for the firm. As such, they capture the idea of technology outsourcing as the payments made to sources outside the firm for the development of technologies rather than developing them in-house as discussed in this study. Based on this total outsourced R&D expenditure, technology offshore outsourcing is measured as the ratio of the expenses paid to firms in foreign countries for use of their technologies divided by total sales and multiplied by 100. In the questionnaire, the manager was asked the following question: "Indicate if in the year X the firm paid for licenses and technical assistance from abroad and the amount paid". Technology onshore outsourcing is measured by subtracting technology offshore outsourcing from total outsourced R&D expenditure, then dividing by total sales and multiplying by 100.

I control for other determinants of performance traditionally discussed in the literature. First, I control for the size of the firm because larger firms have increased complexity that may affecting performance (Greve, 2008). I measure size with the natural log of the number of employees. Second, I control for firm diversification because the literature has widely discussed how diversification affects performance (Rumelt, 1974). I measure diversification with an indicator of percentage of total sales that other product lines besides the main one represents. Third, I control for the level of internationalization of the firm because the literature has also discussed this in detail (Contractor, Kundu, & Hsu, 2003). I measure internationalization with an indicator of the percentage of total sales that foreign sales represent. Fourth, I control for the industry of operation of the firm because performance varies across industries thanks to differences in the intensity of competition. I measure industry with bivariate indicators of the industry of operation of the firm at the two-digit level of the CNAE codes, the Spanish equivalent of the SIC codes. Fifth, I control for the year because the business cycle may affect firm performance. I measure year with a bivariate indicator of the year. Seventh, I control for other unobserved firm-specific factors that affect performance using random and fixed effect models, taking advantage of the panel nature of the dataset.

3.3. Methods of Analysis

Since the dependent variables are continuous and I have a panel of 13 years of data (1990-2002), I run multiple analyses to control for potential problems in the error structure and to provide robustness to the results. I lag the variables by one year as actions taken in the previous year are likely to affect performance in the subsequent year; as a result, I have an effective panel of 12 years. First, I run a regression controlling for firm-specific effects using random and fixed effect models, clustering the error terms by firms to take into account that multiple observations of the firm across years are not independent from each other. Second, I run random and fixed effect regressions with AR1 correction for autocorrelation to take into account that there may be trends in the data. Third, I run a GEE model with controls for serial correlation and clustering errors by firm to take into account both serial correlation and non-independence of firm observations across time. The general specification I use in the models is the following:

$$\textit{Firm performance (ROE, ROS, ROA)}_{it} = \beta_0 + \beta_1 * \textit{Technology onshore outsourcing}_{it-1} + \beta_2 * \textit{Technology offshore outsourcing}_{it-1} + \beta_3 * \textit{Size}_{it-1} + \beta_4 * \textit{Diversification}_{it-1} + \beta_5 * \textit{Internationalization}_{it-1} + \beta_j * \textit{Industry}_j + \beta_k * \textit{Year}_k + e$$

Hypothesis 1 is supported if β_1 is smaller than β_2. By including both types of technology outsourcing in the same model we can compare the effect that technology offshore outsourcing and technology onshore outsourcing has on firm performance in relationship to not outsourcing technology.

4. RESULTS

4.1. Technology Offshore Outsourcing and Technology Onshore Outsourcing

Before discussing the results from testing the hypotheses, I study in detail the behavior of firms regarding technology outsourcing to provide some background to the discussion of the results. Their study is particularly relevant because there are no previous studies comparing technology offshore outsourcing and technology onshore outsourcing.

First, I analyze the evolution of technology offshore and onshore outsourcing over time. Figure 1 provides the percentage of firms that undertake technology offshore outsourcing in comparison to those that undertake technology onshore outsourcing over the period of 1990-2002. During this period, on average, 11% of firms undertake technology offshore outsourcing while 20% use technology onshore outsourcing. While the percentage of firms undertaking onshore outsourcing increases from less than 15% in 1990 to nearly 25% in 2002, the percentage of firms that offshore outsource the development of their technologies remains steady at around 11%. In terms of percentage of firms undertaking outsourcing, more of them outsource from onshore sources rather than from offshore sources. This evidence is contrary to the claims that more firms are offshore outsourcing the development of their technologies (e.g., Fifarek et al., 2008).

*** Insert Figure 1 about here ***

Second, I study the average expenditure on technology offshore outsourcing and technology onshore outsourcing over time. Figure 2 provides the evolution of the figures for

firms that are actively outsourcing technology. During the period studied, firms that outsource technology spent an average of 1% of sales on offshore outsourcing and an average of 1.6% of sales on technology onshore outsourcing. However, whereas the average expenditure on technology onshore outsourcing has remained relatively flat over the period, oscillating between 0.8% and 1.2% of sales, technology offshore outsourcing appears to have an upward trend, moving from 1.1% at the beginning of the period to 2.1% close to the end of the period. Firms that offshore outsource the development of their technologies spent more on foreign technologies than on domestic ones, and they have tended to increase this expenditure.

*** Insert Figure 2 about here ***

Third, I study differences in technology offshore outsourcing and onshore outsourcing across industries. Figure 3 shows the percentage of firms that undertake technology offshore outsourcing and onshore outsourcing by industry. Firms are classified into 20 industries by the SEPI Foundation, the provider of the data, by their two-digit CNAE code. Technology offshore and onshore outsourcing occurs in all industries, but varies across industry. The percentage of firms that undertake offshore outsourcing in the chemical, vehicle, and other transportation industries is relatively similar to the percentage of firms that undertake onshore outsourcing. In contrast, in the metallurgy and office equipment industries, more firms outsource technology at home than those that outsource abroad, while in printing more firms use offshore outsourcing than onshore outsourcing. There is no clear pattern of technology offshore or onshore outsourcing across industries.

*** Insert Figure 3 about here ***

Fourth, I analyze differences in technology offshore and onshore outsourcing across firms of different sizes. Figure 4 shows the percentage of firms undertaking technology offshore outsourcing and onshore outsourcing by firm size. Whereas small firms tend to use technology onshore outsourcing more frequently than offshore outsourcing, as firms grow the percentages tend to become similar, with a comparable percentage of large firms using technology onshore outsourcing and technology offshore outsourcing.

*** Insert Figure 4 about here ***

4.2. Impact of Technology Offshore Outsourcing and Technology Onshore Outsourcing on Firm Performance

Table 1 shows the correlation matrix and additional descriptive statistics for variables that are used in testing the hypotheses. It is interesting to note that there are more positive significant correlations between technology offshore outsourcing and indicators of firm performance than between technology onshore outsourcing and firm performance. Overall, there are limited high correlations among the predictors, reducing the possible multicollinearity problems. Nevertheless, I checked for the possibility of multicollinearity, excluding highly correlated variables, such as size, from the model. The results of interest do not change significantly, indicating limited multicollinearity problems (Greene, 2000). I also run the variance inflation

matrix and found the parameters to be below the levels that would indicate potential multicollinearity problems.

*** Insert Table 1 about here ***

Table 2 presents the results from testing the hypothesis. Overall, the results support Hypothesis 1. The coefficient of technology offshore outsourcing is positive and statistically significant, while the coefficient of technology onshore outsourcing is not statistically different from zero across the different models. The specific coefficients vary across dependent variables and methods of analysis. As an illustration of the magnitude of the impact of technology offshore outsourcing I discuss the impact of this on the three dependent variables under a random effects regression with errors clustered by firm (models 2a, 2b and 2c). The coefficients of technology offshore outsourcing are 0.006 for ROS, 0.017 for ROA, and 0.019 for ROE, respectively. Taking into account that the dependent variables are expressed in percentage while the independent variable is expressed in per thousandth, these coefficients indicate that investing an additional 1% of sales in technology offshore outsourcing would increase ROS by 0.06%, ROA by 0.17% and ROE by 0.19% respectively. The findings are not only statistically significant but also have economic significance.

*** Insert Table 2 about here ***

These findings are novel and important. Despite the increasing importance of technology outsourcing and the heated debate regarding its merits, it is not clear whether it is good for firm performance. I have argued and found support for the idea that technology offshore outsourcing is better for performance than technology onshore outsourcing. I explained that this was the case because technology offshore outsourcing induces the firm to learn and create knowledge despite relying on others for technology development and thus missing out on the learning and additional knowledge generated in the process, while technology onshore outsourcing has a limited impact on learning. These findings support the idea that KBV research on technology outsourcing needs to distinguish between onshore and offshore outsourcing when analyzing the likely impact on firm performance, because they have different implications for learning and associated performance.

4.3. Robustness Checks

I conducted additional analyses, not presented here for the sake of brevity, to check for the robustness of the results. First, I introduced additional controls for variables that may enable the firm to replicate the benefits of technology offshore outsourcing. Thus, I controlled for the firm being a domestic multinational corporation (MNC) or is a subsidiary of a foreign firm because these firms may be able to obtain foreign technology and thus replicate the benefits of offshore technology outsourcing, and I also controlled for internal R&D investments because a firm may be able to replicate the learning benefits of technology development through internal R&D investments. The results of the analyses with these controls show that technology offshore outsourcing has a positive and statistically significant coefficient, while technology onshore outsourcing has a coefficient that is not statistically significant. I did not include these controls in the results presented on the paper because they are not directly controlling for alternative

explanations of performance, but for alternative influences to technology outsourcing. Second, I excluded MNCs and subsidiaries of foreign MNCs from the analyses to check that the ability of these firms to access foreign markets was not explaining the findings. The results of the analyses that exclude these firms show that the coefficient of technology offshore outsourcing is positive and statistically significant while the coefficient of technology onshore outsourcing is not statistically different from zero. These findings give additional confidence to the analyses presented here. Fourth, I used the natural logarithm of total sales and the natural logarithm of total assets as alternative measures of size. The results are consistent with the ones reported here. However, I do not use these results because the coefficients of these alternative measures of size show indicators above the threshold indicator that reveal the presence of potential collinearity problems. Fifth, to address the issue of reverse causality, I run analyses of the impact of performance on technology outsourcing. The analysis of the two types of technology outsourcing as dependent variables and the three types of performance as independent variables and the controls describes show that the coefficient of performance is not statistically different from zero. Thus, I can conclude with confidence that it is in fact the undertaking of technology offshore outsourcing that improves performance, and not that better performing firms are the ones that undertake technology offshore outsourcing. Sixth, I ran the analyses with additional time lags to analyze how the relationship between technology offshore outsourcing and performance holds over time. I find that the coefficients of technology offshore outsourcing are positive and statistically significant when analyzing data with no time lags and one year of time lag, but that these coefficients loose statistical significance with additional time lags. This finding adds additional depth to the paper. It indicates that technology offshore outsourcing provides firms with a temporary rather than sustainable competitive advantage over competitors. Seventh, I run the analyses with an indicator of the total technology outsourcing, which is the sum of technology offshore and onshore outsourcing, to analyze how technology outsourcing in general affects firm performance. The coefficient of this indicator is either positive and statistically significant or positive but not statistically significant depending on the type of analysis run, thus reflecting the underlying influence of technology offshore outsourcing. This finding adds additional depth to the paper. Eight, I analyze the separate impact of technology offshore outsourcing and technology onshore outsourcing. Thus, I run analyses in which I include one type of technology outsourcing and exclude the other, but use the same controls discussed. I find that the coefficient of technology offshore outsourcing in the absence of technology onshore outsourcing is positive and statistically significant, while the coefficient of technology onshore outsourcing in the absence of technology offshore outsourcing is not statistically significant. These findings provide additional confidence on the robustness of the results discussed.

5. CONCLUSIONS

In this paper I have studied the differences between offshore and onshore outsourcing of technology on firm performance. The increase in technology outsourcing in recent times has been accompanied by a growing debate regarding its benefits, with one camp arguing for a positive relationship because of a reduction of costs and another arguing for a negative relationship because of the limitations on learning. I have questioned the application of the logic from the outsourcing of activities to the analysis of the outsourcing of technology development s

failing to understand the characteristics of knowledge and its development. I have also modified the arguments of the knowledge based view of technology outsourcing by arguing that there is in fact learning associated with outsourcing, and that this learning varies depending on the location from which the technology development is outsourced. Hence, I have proposed that whereas onshore outsourcing of technology development limits learning and thus the improvement of performance, offshore outsourcing of technology development leads to learning and thus has a positive impact on performance. The empirical analyses show that technology offshore outsourcing is positively related to firm performance, whereas onshore outsourcing of technologies has no significant effect on firm performance.

The paper also contributes to the literature on technology outsourcing, by being among the first to explain and provide evidence for the need to be careful in separating the discussion of outsourcing into onshore outsourcing and offshore outsourcing to fully understand their impact on firm performance. In contrast to other studies that apply the logic of production outsourcing to technology outsourcing, I explain how the characteristics of knowledge modify the logic and predictions regarding the benefits of technology outsourcing. The theoretical explanation and evidence presented in this study can help advance the debate about whether technology offshore outsourcing is good or bad for firms.

The paper makes important contributions to the KBV by challenging previous arguments and developing theory. I extend the KBV to explain how technology outsourcing, in particular offshore outsourcing, can in fact lead to learning. This argument modifies the traditional application of the KBV to technology outsourcing by highlighting the importance of the location of the outsourced knowledge and its differences with the knowledge in the firm. Although the KBV has recognized that access to diversity of knowledge is critical for learning and thus performance (Eisenhardt & Santos, 2002; Grant, 1996; Kogut & Zander, 1992; Spender & Grant, 1996), the theory has not fully realized how dissimilarity of external knowledge provides greater learning opportunities. Technology offshore outsourcing enables the firm to have access to new and better technologies that force it to learn and create knowledge. An important implication here is that a firm can upgrade its learning capabilities and achieve higher performance not only by developing its own technologies, but also by using foreign technologies and learning how to manage diversity.

This study can provide guidance to managers in two ways. First, for managers who wish to undertake technology offshore outsourcing, the study shows that this is good for profitability. Technology offshore outsourcing provides the firm with access to dissimilar technologies that force the firm to learn and create new knowledge. These learning processes are difficult for competitors to observe and therefore imitate. As a result, this allows the firm to enjoy a sustainable competitive advantage and superior profitability. Second, managers need to be cautious about onshore technology outsourcing because it does not appear to have a positive impact on profitability. The technologies tend to be similar to the ones that the firm already has and thus do not force it to learn.

There are several limitations of the study that can be resolved in future studies. First, I study one particular way to obtain foreign technologies, which is purchasing the technologies developed by other firms using contracts. There are other ways to obtain technologies such as

acquiring companies that are developing the technologies (Dunning & Narula, 1995; Katila & Ahuja, 2001), and forming R&D alliances (Sampson, 2007). Future studies can analyze the relative impact of the different ways to obtain foreign technologies on performance. Second, I analyze firms in a country that is not at the forefront of technology development. The findings can be generalized to firms in countries not at the technological frontier, which are the majority of the countries in the world. However, the arguments may not be generalizable to firms in the few countries that at the forefront of technology, for which the offshore outsourcing of the development of technologies to other countries may have a different impact on financial performance since foreign technologies may not provide an advantage. Future studies can analyze how the different levels of technological development of countries affect the impact of technology offshore outsourcing on performance. Third, the main purpose of the study was to compare the impact of technology onshore and offshore outsourcing on firm performance. I do not analyze the different degrees of similarity and dissimilarity of technologies outsourced from different countries or firms on firm performance. Future studies can examine whether there is a differential impact of sources and recipients of technologies beyond what is done in the present study. Finally, I argued that differences in learning explain the proposed relationships, but I did not measure these mechanisms. Future studies can measure the learning to provide a more fine-grained explanation for why offshore outsourcing is better than onshore outsourcing.

In conclusion, this is the first study to explain and analyze the impact of technology offshore and onshore outsourcing on firm performance. It opens avenues for further research on the impact of offshore outsourcing on performance. By separating the general discussion into onshore outsourcing and offshore outsourcing we also see that the theoretical arguments are depending on the location of the knowledge, further advancing theory.

REFERENCES

Agrawal, A. J. (2006), 'Engaging the inventor: Exploring licensing strategies for university inventions and the role of latent knowledge', *Strategic Management Journal*, **27**(1): 63-79.

Berman, S. L., Wicks, A., Kotha, S., & Jones, T. M. (1999), 'Does stakeholder orientation matter?', The relationship between stakeholder management models and firm financial performance. *Academy of Management Journal*, **42**(5): 488-506.

Bhalla, A., Sodhi, M., & Son, B. (2008), 'Is more IT offshoring better?: An exploratory study of western companies offshoring to South East Asia', *Journal of Operations Management*, **26**: 322-335.

Boone, C., Van Olffen, W., & Van Witteloostuijn, A. (2005), 'Team locus-of-control composition, leadership structure, information acquisition, and financial performance', *Academy of Management Journal*, **48**(5): 889-909.

Cha, H. S., Pingry, D. E., & Thatcher, M. E. (2008), 'Managing the knowledge supply chain: An organizational learning model of information technology offshore outsourcing', *MIS Quarterly*, **32**: 281-306.

Cohen, W. M. & Levinthal, D. A. (1990), 'Absorptive capacity: A new perspective on learning and innovation', *Administrative Science Quarterly*, **35**: 128-152.

Cohen, W. M., Nelson, R. R., & Walsh, J. P. (2000), 'Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent (or Not)', *NBER Working Paper* No. 7552.

Contractor, F. J., Kumar, V., & Kundu, S. K. (2007), 'Nature of the relationship between international expansion and performance: The case of emerging market firms', *Journal of World Business*, **42**: 401-417.

Contractor, F.J., Kundu, S. K., & Hsu, C. C. (2003), 'A three-stage theory of international expansion: The link between multinationality and performance in the service sector', *Journal of International Business Studies*, **34**(1): 5–19.

Corredoira, R. A. & Rosenkopf, L. (2010), 'Should auld acquaintance be forgot?, The reverse transfer of knowledge through mobility ties', *Strategic Management Journal*, **31**(2): 159-181.

Coucke, K. & Sleuwaegen, L. (2008), 'Offshoring as a survival strategy: Evidence from manufacturing firms in Belgium', *Journal of International Business Studies*, **39**(8): 1261-1277.

Cuervo-Cazurra, A. & Un, C. A. (2007), 'Regional economic integration and R&D investment', *Research Policy*, **36**: 227-246.

De Fontenay, C. C. & Gans, J. S. (2008), 'A bargaining perspective on strategic outsourcing and supply competition', *Strategic Management Journal*, **29**(8): 819-839.

Dibbern, J., Winkler, J., & Heinzl, A. (2008), 'Explaining variations in client extra costs between software projects offshored to India', *MIS Quarterly*, **32**: 333-366.

Dierickx, I. & Cool, K. (1989), 'Asset stock accumulation and sustainability of competitive advantage', *Management Science*, **35**(12): 1504-1511.

Drazin, R. & Rao, H. (2002), 'Harnessing managerial knowledge to implement product-line extensions: How do mutual fund families allocate portfolio managers to old and new funds?' *Academy of Management Journal*, **45**(3): 609-619.

Dunning, J. H. & Narula, R. (1995), 'The R&D activities of foreign firms in the United States', *International Studies of Management & Organization*, **25**: 39-73.

Eisenhardt, K. M. & Santos, F. M. (2002), 'Knowledge-based view: A new theory of strategy?' In A. Pettigrew, H. Thomas and R. Whittington (Eds.), *Handbook of Strategy and Management.* Thousands Oak, CA: Sage.

Fifarek, V., Veloso, F. M., & Davidson, C. I. (2008), 'Offshoring technology innovation: A case study of rare-earth technology', *Journal of Operations Management*, **26**: 222-238.

GAO Reports. (2006), 'Offshoring: U.S. semiconductor and software industries increasingly produce in China and India: GAO-06-423'.

Gomes, L. & Ramaswamy, K. (1999), 'An empirical examination of the form of the relationship between multinationality and performance', *Journal of International Business Studies,* **30**: 173-187.

Grant, R. M. (1996), 'Toward a knowledge-based theory of the firm', *Strategic Management Journal*, **17**: 109-122.

Greene, W. H. (2000), *Econometric analysis* (4th ed.). Upper Saddle River, NJ: Prentice-Hall.

Greve, H. R. (2008), 'A behavioral theory of firm growth: Sequential attention to size and performance goals', *Academy of Management Journal*, **51**(3): 476-494.

Henderson, R., Jaffe, A., & Trajtenberg, M. (2005), 'Patent citations and the geography of knowledge spillovers: A reassessment: Comment', *American Economic Review*, **95**(1): 461-464.

Hirst, G., Van Knippenberg, D., & Zhou, J. (2009), 'A cross-level perspective on employee creativity: Goal orientation, team learning behavior, and individual creativity', *Academy of Management Journal*, **52**(2): 280-293.

Katila, R. & Ahuja, G. (2002), 'Something old, something new: A longitudinal study of search behavior and new product introduction', *Academy of Management Journal*, **45:** 1183-1194.

Kogut, B. & Zander, U. (1992), 'Knowledge of the firm, combinative capabilities, and the replication of technology', *Organization Science,* **3**: 383-397.

Kogut, B. & Zander, U. (1993), 'Knowledge of the firm and the evolutionary theory of the multinational corporation', *Journal of International Business Studies,* **24**: 625-645.

Kogut, B. (1991), 'Country capabilities and the permeability of borders', *Strategic Management Journal*, **12:** 33-47.

Leiponen, A. & Helfat, C. E. (2010), 'Innovation objectives, knowledge sources, and the benefits of breadth', *Strategic Management Journal*, **31**(2): 224-236.

Leonard-Barton, D. (1995), *Wellsprings of knowledge: building and sustaining the sources of innovation*. Boston, Mass.: Harvard Business School Press.

Lichtenthaler, U. (2007), 'The drivers of technology licensing: an industry comparison', *California Management Review*, **49**: 67-89.

Manning, S., Massini, S., & Lewin, A. (2008), 'A dynamic perspective on next-generation offshoring: The global sourcing of science and engineering talent', *Academy of Management Perspectives*, **22**: 35-54.

Maskell, P., Pedersen, T., Petersen, B., & Dick-Nielsen, J. (2007), 'Learning paths to offshore outsourcing: From cost reduction to knowledge seeking', *Industry & Innovation*, **14**: 239-257.

McKinsey Global Institute. (2003), *Offshoring: Is it a win-win game?* San Francisco: McKinsey &Co., Inc.

Mol, M. J., van Tulder, R. J. M., & Beije, P. R. (2005), 'Antecedents and performance consequences of international outsourcing'. *International Business Review*, **14**: 599-617.
Nelson, R. R. (1993), *National innovation systems: a comparative analysis*. Oxford: Oxford University Press.
Nicholls-Nixon, C. L. & Woo, C. Y. (2003), 'Technology sourcing and output of established firm in a regime of encompassing technological change', *Strategic Management Journal*, **24**(7):651-666.
Nonaka, I. & Takeuchi, H. (1995), *The knowledge-creating company: How Japanese create the dynamics of innovation*. Oxford: Oxford University Press.
Nonaka, I. & von Krogh, G. (2009), 'Tacit knowledge and knowledge conversion: Controversy and advancement in organizational knowledge creation theory', *Organization Science*, **20**(3): 635-652.
Nonaka, I. (1994), 'A dynamic theory of organizational knowledge creation', *Organization Science*, **5**: 14-37.
Phene, A. & Almeida, P. (2008), 'Innovation in multinational subsidiaries: The role of knowledge assimilation and subsidiary capabilities', *Journal of International Business Studies*, **39**(5): 901-919.
Polanyi, M. (1967), *The tacit dimension*. London: Routledge.
Pyndt, J. & Pedersen, T. (2006), *Managing global offshoring strategies*. Copenhagen Business School Press.
Ramaswamy, K. (1995), 'Multinationality, configuration, and performance: A study of MNEs in the US drug and pharmaceutical industry', *Journal of International Management* **1**: 231–253.
Rumelt, R. P. (1974), *Strategy, structure, and economic performance*. Boston: Division of Research, Graduate School of Business Administration, Harvard University. Harvard University Press.
Safizadeh, M. H., Field, J. M., & Ritzman, L. P. (2008), 'Sourcing practices and boundaries of the firm in the financial services industry', *Strategic Management Journal*, **29**(1): 79-91.
Salomon, R. & Shaver, J. M. (2005), 'Export and domestic sales: Their interrelationship and determinants', *Strategic Management Journal*, **26**: 855-871.
Sampson, R. C. (2007), 'R&D alliances and firm performance: The impact of technological diversity and alliance organization on innovation', *Academy of Management Journal*, **50:** 364-386.
Saxenian, A. (1994), *Regional advantage: culture and competition in Silicon Valley and Route 128*. Cambridge, MA: Harvard University Press.
Shaver, J. M. & Flyer, F. (2000), 'Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States', *Strategic Management Journal*, **21**(12): 1175-1193.
Sitkin, S. B. (1992), 'Learning through failure: 'The strategy of small losses', *Research in Organizational Behavior*, **14**: 231-266.
Song, J., Almeida, P., & Wu, G. (2002), 'Learning-by-hiring: When is mobility more likely to facilitate interfirm knowledge transfer?' *Management Science*, **49**(4): 351-365.
Spender, J.-C. & Grant, R. M. (1996), 'Knowledge and the firm: Overview', *Strategic Management Journal*, **17**: 5-9.
Storz, C. (2008), 'Dynamics in innovation systems: Evidence from Japan's game software industry', *Research Policy*, **37**: 1480-1491.

Subramaniam, M. & Venkatraman, N. (2001), 'Determinants of transnational new product development capability: Testing the influence of transferring and deploying tacit overseas knowledge', *Strategic Management Journal*, **22**: 359-378.

Takeishi, A. (2001), 'Bridging inter- and intra-firm boundaries: Management of supplier involvement in automobile product development', *Strategic Management Journal*, **22**(5): 403-433.

Takeishi, A. (2002), 'Knowledge partitioning in the interfirm division of labor: The case of automotive product Development', *Organization Science*, **13**(3): 321-338.

Taylor, A. & Greve, H. R. (2006), 'Superman or the fantastic four? Knowledge combination and experience in innovative teams', *Academy of Management Journal*, **4**: 723-740.

Tsai, W. & Ghoshal, S. (1998), 'Social capital and value creation: The role of intrafirm networks', *Academy of Management Journal*, **41**(4): 464-476.

Tsai, W. (2001), 'Knowledge transfer in interorganizational networks: Effects of network position and absorptive capacity on business unit innovation and performance', *Academy of Management Journal*, **44**(5): 996-1004.

Tsoukas, H. (1996), 'The firm as a distributed knowledge system: A constructionist approach', *Strategic Management Journal*, **17**, 11-25.

Van De Ven, A. H. & Polley, D. (1992), 'Learning while innovating', *Organization Science*, **3**(1): 92-116.

Weigelt, C. & Sarkar, M. B. (2009), 'Learning from supply-side agents: The impact of technology solution providers' experiential diversity on clients' innovation adoption', *Academy of Management Journal*, **52**(1): 37-60.

Weigelt, C. (2009), 'The impact of outsourcing new technologies on integrative capabilities and performance', *Strategic Management Journal*, **30**: 595-616.

Zhao, M. (2006), 'Conducting R&D in countries with weak intellectual property rights protection', *Management Science*, **52**(8): 1185-1199.

Figure 1
Percentage of firms undertaking technology offshore outsourcing and technology onshore outsourcing over time

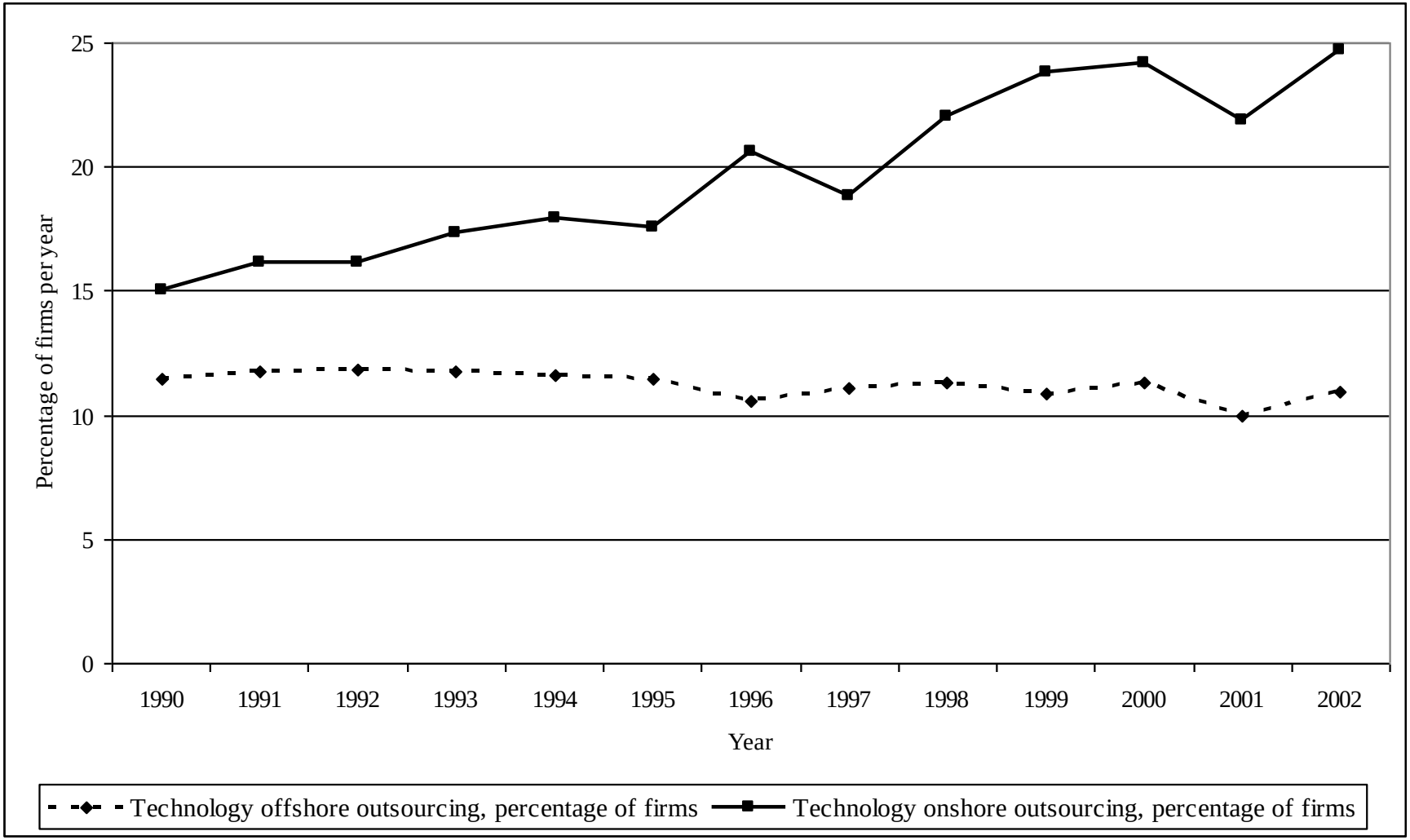

Figure 2
Average expenditures on technology offshore outsourcing and technology onshore outsourcing over time for outsourcing-active firms

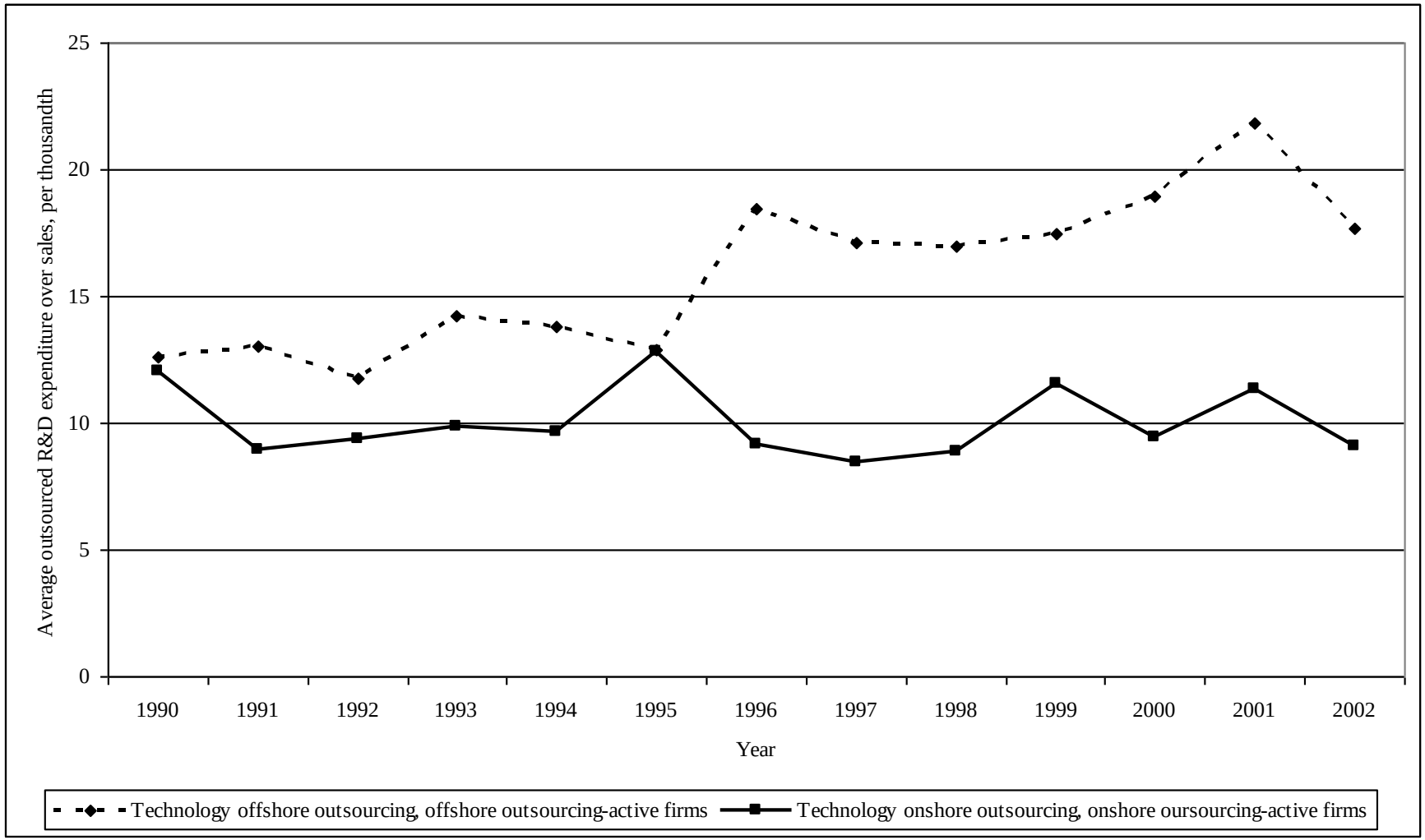

Figure 3

Percentage of firms that undertake technology offshore outsourcing and technology onshore outsourcing by industry

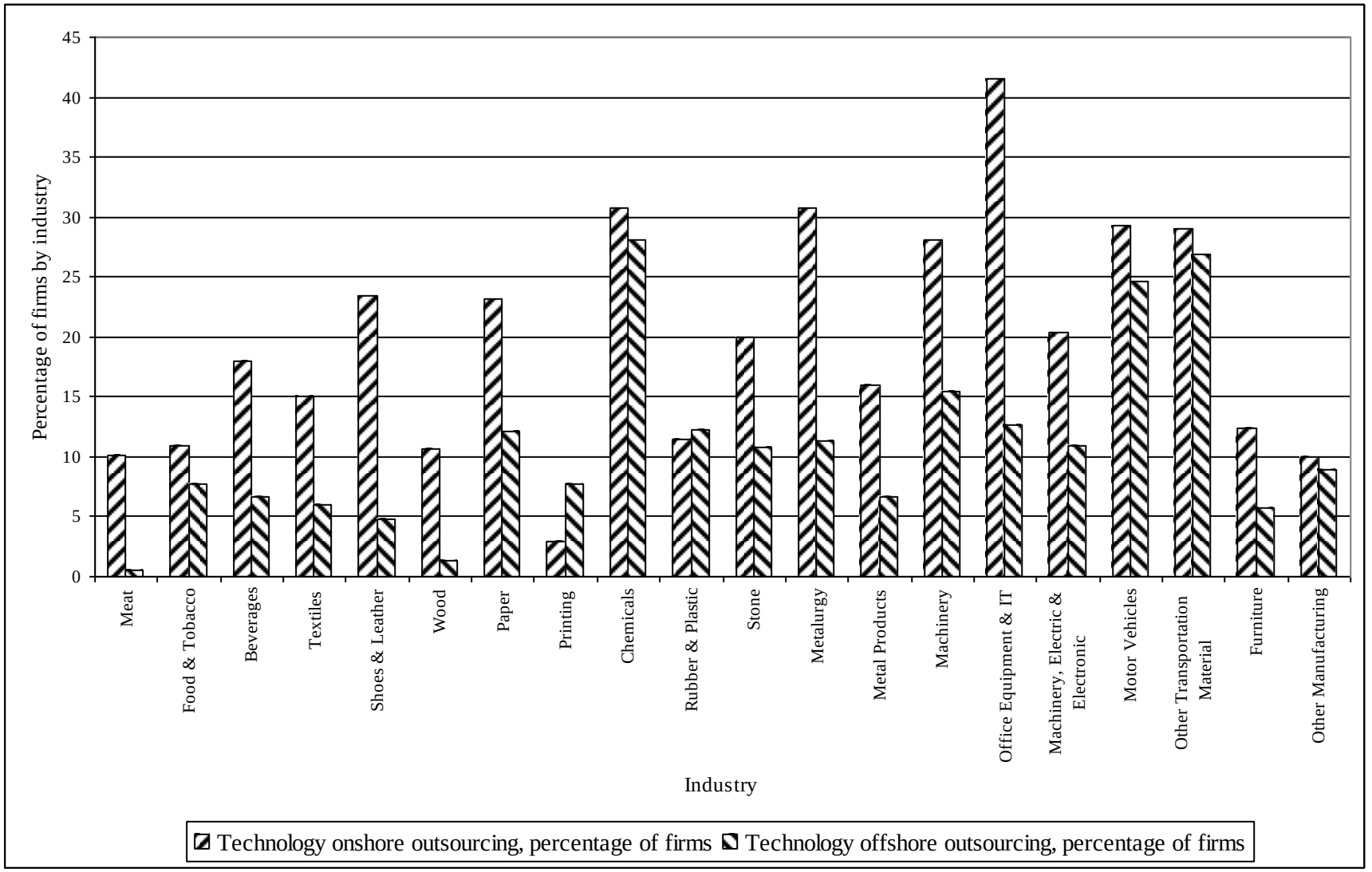

Figure 4
Percentage of firms undertaking technology offshore outsourcing and technology onshore outsourcing by firm size

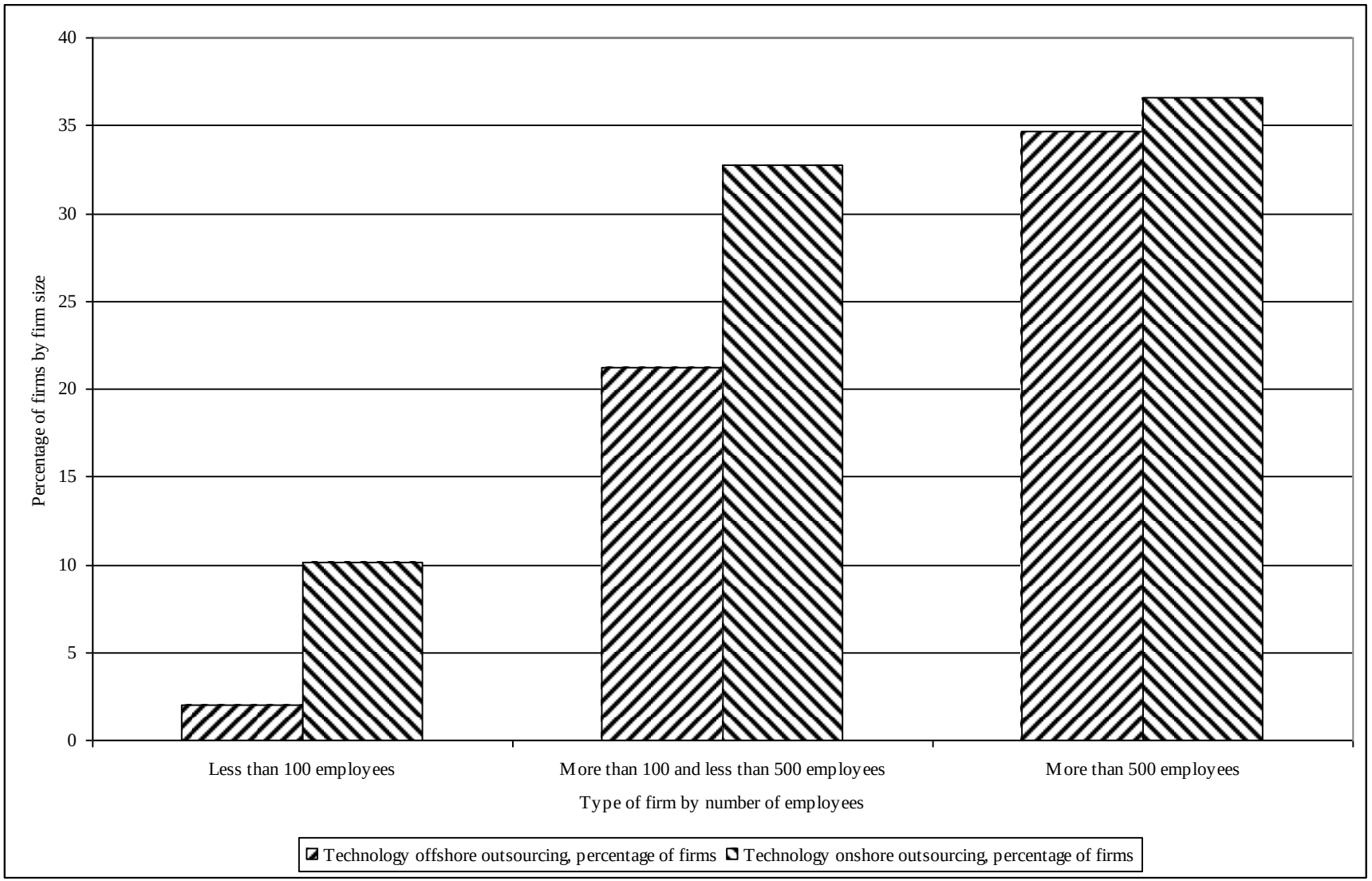

Table 1
Summary statistics and correlation matrix

Variable	Mean	Std. Dev.	1	2	3	4	5	6	7
1. ROS	9.192	9.798	1.000						
2. ROA	20.963	23.145	0.615 ***	1.000					
3. ROE	27.413	27.845	0.645 ***	0.669 ***	1.000				
4. Technology offshore outsourcing	2.321	30.917	0.020 +	0.010	0.017	1.000			
5. Technology onshore outsourcings	0.447	14.385	-0.002	0.008	-0.007	-0.297 ***	1.000		
6. Size	4.406	1.478	0.111 ***	-0.064 ***	-0.015	0.065 ***	-0.030 **	1.000	
7. Diversification	29.000	24.875	0.038 ***	-0.009	-0.009	0.004	-0.044 ***	0.223 ***	1.000
8. Internationalization	17.543	25.039	0.038 ***	-0.048 ***	-0.007	0.033 **	-0.020 +	0.383 ***	0.232 ***

Significance levels: + $p < 0.10$, * $p< 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 2
Results of the analyses of technology offshore outsourcing and onshore outsourcing on performance

	Random effects regression with errors clustered by firm			Fixed effects regression with errors clustered by firm			Random effects regression with AR1 correction for serial correlation			GEE population averaged with AR1 disturbances and clustered errors by firm		
	ROS	ROA	ROE	ROS	ROA	ROE	ROS	ROA	ROE	ROS	ROA	ROE
	Model 2a	Model 2b	Model 2c	Model 2d	Model 2e	Model 2f	Model 2g	Model 2h	Model 2i	Model 2j	Model 2k	Model 2l
Technology offshore outsourcing	0.006***	0.017***	0.019***	0.007***	0.018***	0.024***	0.009*	0.019*	0.024*	0.009***	0.021***	0.172**
	(0.001)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.004)	(0.008)	(0.011)	(0.001)	(0.003)	(0.065)
Technology onshore outsourcings	0.003	0.008	0.005	-0.0006	0.004	0.002	0.002	-0.010	-0.002	0.018	0.047	-0.001
	(0.011)	(0.020)	(0.021)	(0.011)	(0.020)	(0.021)	(0.005)	(0.008)	(0.011)	(0.014)	(0.037)	(0.049)
Size	0.047	-1.447**	-0.473	-0.352	0.022	1.124	-0.247***	-1.431***	-0.516**	0.275	-1.755***	-0.761
	(0.245)	(0.445)	(0.502)	(0.558)	(1.279)	(1.522)	(0.069)	(0.154)	(0.157)	(0.201)	(0.501)	(0.547)
Diversification	-0.006	-0.020	-0.015	-0.008	-0.030	-0.017	-0.004	-0.010	-0.027**	-0.002	0.0284	-0.010
	(0.008)	(0.020)	(0.022)	(0.010)	(0.026)	(0.029)	(0.003)	(0.007)	(0.009)	(0.008)	(0.020)	(0.022)
Internationalization	0.009	0.024	0.009	0.0179	0.060*	0.019	0.005	0.00651	0.028*	0.003	0.003	0.043
	(0.010)	(0.021)	(0.023)	(0.013)	(0.027)	(0.031)	(0.003)	(0.00761)	(0.011)	(0.011)	(0.021)	(0.025)
Industry controls	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Year controls	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included	Included
Constant	9.722***	37.140***	34.670***	27.770***	87.330***	20.430**	8.171***	34.730***	35.320***	8.433***	34.640***	34.900***
	(1.608)	(3.665)	(4.610)	(4.331)	(8.901)	(7.819)	(0.482)	(1.504)	(1.182)	(1.657)	(3.624)	(4.695)
Chi2 or F	179.9***	244.3***	194.6***	e(chi2)	e(chi2)	e(chi2)	524.5***	867.0***	1061.0***	195.3***	263.6***	98.42***

Industry and year controls are included in the models but not reported here. Data is lagged by one year. Robust standard errors appear in parentheses.
Number of observations: 9420. Number of firms: 785. Number of years: 12. Significance levels: + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$