Regional FDI Spillovers and Local Suppliers: Disentangling the Effects of Foreign Ownership, Technology Gap and Absorptive Capacity

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Abstract

FDI firms can generate important dynamic impacts via sourcing linkages with local suppliers. In this paper, I present novel evidence on the scale, nature and spillover impact of FDI firms in Nuevo Leon, Mexico. The main findings are three-fold. First, I find no differences between FDI and domestic producer firms regarding their level of use of local suppliers. In strong contrast, FDI firms are significantly more involved in a variety of knowledge transfer activities. This applies in particular to types of technological support, support with a direct positive impact on production processes of suppliers. In extension of these spillover-creating activities, suppliers of FDI firms are more likely to experience large technological and organizational impacts. Second, the technology gap between producer firms and suppliers plays a varied role. In general, a large technology gap lowers the supportiveness of producer firms. However, FDI firms offer more technological support when the gap with their suppliers of material inputs is large. A large technology gap also has a positive effect on a supplier experiencing a large positive impact from its business dealings with producer firms in general and with FDI firms in particular. Third, the level of absorptive capacity of suppliers is also important, as the findings indicate that several indicators of absorptive capacity are associated with local suppliers experiencing large technological and organizational impacts.

Key Words: FDI, input-output linkages, knowledge transfer activities, spillovers, technology gap, absorptive capacity, Mexico

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1. Introduction

Foreign direct investment (FDI) is increasingly seen as an important mechanism via which multinational enterprises (MNEs) disseminate new knowledge and technologies to a large number of developed and developing host economies (Venables and Barba Navaretti, 2005). The entrance of FDI firms benefits a host economy, as it enhances the overall level of technology, fostering economic growth (Caves, 1996). Furthermore, domestic firms may learn from and adopt new technologies that are incorporated into foreign-owned firms. Through channels including labor turnover, demonstration and imitation effects and input-output linkages between FDI firms and suppliers, technologies may be transferred from foreign-owned to domestic firms. As the domestic firms do not have to compensate the FDI firms for these extra-market transfers of technology, any resulting efficiency or productivity effects represent positive externality or spillover effects (Blomström and Kokko, 1998). The feature that these channels are usually most pronounced at the regional level underlines the importance of FDI spillovers for regional economic and technological development in host economies (Young et al., 1994; Phelps, 2008; Jordaan, 2009).

A growing part of recent applied research on FDI effects focuses on externalities that materialize via input-output linkages between FDI firms and local suppliers. One approach focuses on the detailed empirical identification of these input-output linkages. Consisting of case studies and small scale surveys in regions within individual host economies, the original interest of this approach rested on obtaining indicators of the static impact of FDI firms, representing the level of use of local suppliers (UNCTAD, 2001; Dunning and Lundan, 2008). More recent studies are focusing on identifying the dynamic impact of foreign-owned firms, where FDI firms act as source of new knowledge and technologies to their local suppliers (Potter et al., 2002, 2003). For instance, suppliers may learn about new technologies when FDI firms provide training programs to employees of their suppliers (Javorcik and Spatareanu, 2005; Javorcik, 2008). Also, personnel of FDI firms may visit the plants of their suppliers to offer assistance with quality control systems and other aspects of production processes (Potter et al., 2002). As a result of such support, suppliers may experience technological development and upgrading.

The second approach towards the analysis of externalities between FDI firms and their local suppliers consists of the econometric estimation of these spillover effects. An initial wave of empirical studies produced evidence that FDI firms generate positive externalities in the industries in which they operate, indicated by positive associations between FDI industry presence and productivity of domestic firms (e.g. Blomström and Persson, 1983; Kokko, 1994; Sjöholm, 1999). However, subsequent studies present findings that challenge the notion that such positive intra-industry spillovers are prevalent (Aitken and Harrison, 1999; Djankov and Hoekman, 2000). In response to the heterogeneous nature of the evidence on these spillovers, recent studies have started to distinguish between intra- and inter-industry FDI effects (Kugler, 2006; Jordaan, 2009). Regarding inter-industry spillovers, the focus lies in particular on identifying effects among suppliers. Furthermore, the distinction between intra- and inter-industry effects is accompanied by the inclusion of spatial dimensions of these effects. A good example of this is Blalock and Gertler (2008), who estimate FDI spillovers in Indonesia. They distinguish between intra- and inter-industry FDI participation in the region of a domestic firm. Their findings indicate that FDI externalities only occur between industries, suggesting that local suppliers are benefitting from extra-market technology transfers from their foreign-owned client firms (see Blalock and Gertler, 2008). Similar evidence of positive regional FDI spillovers among local suppliers in other host economies is presented by Girma and Wakelin (2007) and Driffield (2004) for the UK, Smarzynska and Spatareanu (2011) for Romania and Jordaan (2008a) for Mexico.

The purpose of the present paper is to build on these recent developments in applied research on FDI spillovers among local suppliers, whereby I attempt to combine the two approaches described above. Using unique data obtained from several purpose-built firm level surveys in the manufacturing sector of Nuevo Leon in Mexico, my study makes the following contributions to the literature. First, I address the central question that underlies all research on FDI effects, whether foreign-owned firms differ in their impact from comparable domestic firms. By design, econometric FDI spillover studies do not address this question, by estimating for associations between the industry presence of FDI and productivity of domestic firms. Case studies and surveys present detailed information on the scale and nature of FDI backward linkages, but usually rely on information obtained exclusively from FDI firms. Comparable domestic firms and local suppliers are usually not included in the research sample (for an exception, see Potter et al., 2002, 2003). In contrast to this exclusive focus on FDI firms, in the present study I compare the scale and nature of local linkages that FDI and comparable domestic producer firms establish with local suppliers. Furthermore, using a random sample of local suppliers, I investigate the impact of these linkages on the local suppliers and assess whether there are differences between the impacts of FDI and domestic producer firms.

Second, my analysis focuses explicitly on the roles that the technology gap and absorptive capacity of local suppliers play in externality-generating and –transmitting processes. Several econometric studies have attempted to estimate whether absorptive capacity of domestic firms influences FDI spillovers. This is done mainly by estimating for a relation between the technology gap between FDI and domestic firms and FDI spillovers, whereby this technology gap is interpreted as a direct inverse indicator of the level of absorptive capacity of domestic firms (Kokko, 1994; Girma, 2005). However, this interpretation of the technology gap can be challenged (Jordaan, 2009, 2011a). There is substantial evidence that a large instead of a small technology gap fosters the materialization of positive spillovers (e.g. Haskel et al., 2007; Jordaan, 2008b). Furthermore, the common interpretation of the technology gap is linked imperfectly to the underlying concept of catch up, originally developed to understand how international technology flows can facilitate processes of convergence between advanced and lagging countries (Gershenkron, 1962; Nelson, 1968). An additional reason to investigate the role of the technology gap in externality-transmitting processes is that the vast majority of studies have only looked at the effect of this gap on intra-industry FDI spillovers, leaving it unclear whether and how externalities to local suppliers are affected by technological differences between FDI and domestic firms.

To obtain new evidence on these issues, I separate the concepts of the technology gap and the level of absorptive capacity of domestic firms. I do this in two different settings. First, I look at whether the technology gap between producer firms and local suppliers influences the level of supportive linkages and knowledge transfer activities that producer firms are engaged in. For instance, it may be the case a producer firm hesitates to offer support when its suppliers are substantially technologically backwards. If so, a large technology gap will lead to smaller transfers of technologies. Alternatively, it may be the case that a large technology gap enhances support, when the gap reflects a large scope for suppliers to improve (Jordaan, 2009). If so, a large gap can lead to more support, fostering positive spillover effects. Second, I analyze whether and how the technology gap and the level of absorptive capacity influence the dynamic impact that suppliers experience. By estimating for separate effects of the technology gap and absorptive capacity, the analysis will shed new light on whether and how these two concepts can have independent effects on the materialization of positive spillovers. For both settings, I also investigate whether there are differences between FDI and domestic

producer firms, in particular to assess whether the technology gap plays a similar role for both types of firm.

The third contribution is that I conduct my analysis in a developing country setting. As mentioned earlier, FDI firms can play a central role in the international dissemination of new technologies. In the case of developing countries, FDI firm often represent the only or at least main source of new technologies to domestic firms (UNCTAD, 2005). Mexico is a good example of this. Not only is the Mexican economy characterized by a substantial and growing level of foreign participation, the operations and effects of FDI firms are expected to play a key role in future processes of economic and technological development in this host economy (OECD, 2009a, 2009b). In fact, the role of FDI firms can be of central importance, as the Mexican economy is trying to move away from low skilled, labor intensive industries towards specializing into more technology and skilled-labor intensive manufacturing activities. Detailed evidence on the existence and nature of linkages between FDI firms and Mexican firms is sparse, however. In this context, the findings of the study will generate importance policy implications that can assist national and regional governments of Mexico and other developing host economies to design and apply effective policies that facilitate the local positive technology impact of FDI firms.

The paper is constructed as follows. In section two, I discuss the concept of FDI spillovers and I present a selective review of empirical findings on the relation between spillovers and sourcing linkages between FDI firms and local suppliers. I also use this section to challenge the common interpretation of the technology gap as representing a direct inverse indicator of absorptive capacity of domestic firms. Alternatively, I argue that large technological differences may foster positive spillover effects, as they reflect a large potential scope of improvement among suppliers. Section three presents a brief overview of the main findings on FDI spillovers and their regional dimensions in the Mexican economy. This section also discusses the regional set up of the present study and presents findings from dichotomous comparisons between FDI firms and domestic producer firms. Regarding the static impact, I find only marginal differences between FDI firms and Mexican producer firms. As for the dynamic impact, the findings indicate that the producer firms offer a variety of types of technological and organizational support to their local suppliers, suggesting that local suppliers are experiencing positive spillover effects. In contrast to the static impact, I find substantial and significant differences between the dynamic impact of FDI and domestic producer firms, as FDI firms offer several forms of support more frequently. This difference in most pronounced when it comes to support of a technological nature, support that has a direct positive impact on actual production processes of local suppliers.

Section four presents the findings from multivariate analysis on determinants of knowledge transfer activities and the impact that these activities generate among local suppliers. The analysis of determinants of the provision of support confirms that FDI firms are significantly more likely to offer support. Next, producer firms are less likely to offer support when the technology gap with their suppliers is large. However, FDI firms are more likely to offer support when their local suppliers are technologically backward. This suggests that whereas FDI firms interpret a large technology gap as an indicator that the scope for improvement of their local suppliers is large, domestic producer firms lower their support when facing a large technology gap. FDI firms only offer more support under a large technology gap when it concerns technological support, support with a direct impact on production processes of suppliers. The findings from the multivariate analysis of determinants of a local supplier experiencing a large positive impact from its business dealings with producer firms indicate that suppliers of FDI firms are significantly more likely to have experienced such an impact. This finding is robust to controlling for the feature that FDI firms offer more support and that FDI firms offer more support when the technology gap is large.

The positive effect of having FDI client firms is also robust to the possibility that local suppliers with a high level of absorptive capacity self-select into becoming suppliers of FDI firms. It could be the case that suppliers prefer to operate as suppliers to foreign-owned firms; if so, (part of) the estimated positive effect of having FDI client firms would be capturing this. However, I find no evidence that the estimations are affected by such self-selection. As for the independent effect of the technology gap, a local supplier is more likely to experience large technological improvements when this gap is large. At the same time, absorptive capacity is also important, as I find that several indicators of the level of absorptive capacity of a local supplier significantly enhance the probability that the supplier experiences a large positive impact.

Finally, section five summarizes the main findings and discusses policy implications.

2. FDI Spillovers: Local Linkages, Technology Gap and Absorptive Capacity

FDI firms can generate important technology impacts in host economies. In addition to enhancing the overall level of technology in these countries, domestic firms may benefit from indirect effects materializing in the form of spillovers or externalities. For instance, the entrance of a foreign-owned firm may expose domestic firms to a new piece of technology. If the domestic firms learn from and absorb the new technology, any resulting productivity effects constitute externalities, as there is no market that captures this technology transfer (Blomström and Kokko, 1998; Jordaan, 2009). Next to these demonstration effects, processes of labor turnover between FDI firms and domestic firms may also generate spillover effects, when domestic firms benefit from irreversible skills that workers gained while working for FDI firms (Lipsey, 2004). The third channel that can transmit positive externalities are inter-firm linkages between FDI firms and their supplier and/or client firms[1].

Despite the growing acceptance of the notion that FDI spillovers represent an important component of the positive impact that FDI firms can generate, the body of empirical evidence is far less clear on the prevalence of positive FDI externalities (Hanson, 2001; Rodrik, 1999; Jordaan, 2009). Partly as response to the heterogeneous nature of the evidence of positive intra-industry spillovers, recent research is trying to improve identification strategies to obtain more robust evidence. In particular, several studies have started to distinguish between intra- and inter-industry externalities. It may be the case that positive intra-industry FDI spillovers are limited. FDI have an interest in protection their technology-based ownership-specific advantages, which gives them an incentive to lower any positive spillovers that may benefit their competitors that operate in the same industries. In contrast, FDI firms may be less concerned about positive technological spillovers that may be transferred to other industries, in particular to input-supplying industries (Kugler, 2006; Moran, 2005).

Importantly, recent econometric studies on FDI spillovers combine this distinction between intra- and inter-industry externalities with the specific acceptance that these spillover effects have regional dimensions. As mentioned earlier, Blalock and Gertler (2008) present evidence of positive intra-regional inter-industry FDI spillovers in Indonesia. Other studies that also present evidence of such positive regional spillovers among local suppliers include Girma and Wakelin (2007) and Driffield (2004) for the UK, Liu (2008) for China, Javorcik

[1] The entrance of new FDI firms may also create a competition effect, where domestic firms are forced to become more efficient as a result of the increase in competition on the market. In this case, FDI firms do not act as source of new technologies, but affect the conduct of domestic firms, representing a form of pecuniary externalities. Another aspect of this competition effect is that it may generate positive or negative externalities (see Aitken and Harrison, 1999; Venables and Barba Navaretti, 2005).

and Spatareanu (2011) for Romania and Jordaan (2008a, 2008b) for Mexico. In extension of this, several other studies also estimate for the presence of inter-regional FDI spillovers in host economies (e.g. Girma, 2005; Driffield, 2006). Overall, the findings from these studies can be tentatively summarized as indicating that positive intra-regional FDI spillovers are more likely to be of an inter-industry nature. At the same time, the findings are too diverse to conclude that such effects arise in all cases, and findings from studies that include inter-regional dimensions of inter-industry FDI spillovers are almost as heterogeneous as the original body of evidence on nation-wide intra-industry FDI effects (see Jordaan, 2009).

It is important to consider that findings of a positive association between the industry presence of FDI and productivity of domestic firms in input-supplying industries represent only indirect evidence that input-output linkages are the main channel via which positive externalities are transmitted. Also, such evidence does not clarify how and why such effects occur. To understand better how such spillover effects can arise, evidence from case studies and purpose-built surveys is more useful. Originally, the emphasis of this research approach rested on identifying the level of use of local suppliers by FDI firms. Harking back to Hirschman (1958), this interest relates to identifying the scale of multiplier effects or static impact that FDI firms can generate via the purchase of inputs in host economies[2]. More recently, the interest in this research has shifted towards identifying the nature and types of input-output linkages between FDI firms and suppliers, in order to obtain a better understanding of the dynamic impact of these linkages. Dynamic effects arise when input-output linkages generate flows of knowledge and technologies to domestic suppliers.

One reason why input-output linkages are conducive to the creation of flows of technology is that markets for inputs are usually characterized by limited numbers of buying and supplying firms, firms that are in frequent contact (Lall, 1980; UNCTAD, 2001). As such, input markets are not characterized by "at arm's length" market transactions between anonymous and homogeneous economic agents. Instead, markets for inputs are often characterized by close relationships between buying and supplying firms, which fosters the transmission of ideas and information, especially at the regional level within a host economy (Potter et al., 2002; Phelps, 2008; Jordaan, 2009).

Furthermore, FDI firms are often engaged in a variety of knowledge transfer activities, trying to improve the performance of their suppliers (Javorcik, 2008). Although FDI firms receive benefits in return for the support that they provide in the form of e.g. more cost effective or better quality inputs, the assumption is that in practice FDI firms will be unable to obtain complete compensation for their support. Therefore, supportive linkages are likely to result in the materialization of positive externalities of some degree (Blomström and Kokko, 1998). This is especially the case when a supplier can use the support it receives from one client firm to improve its performance for other client firms (Potter et al., 2003)[3].

Potter et al. (2002, 2003) provide detailed findings on the scale and nature of supportive linkages that FDI firms can establish. In their survey among domestic and FDI firms in the UK, they find that the informal sharing of views and ideas, personal contacts between personnel of FDI firms and domestic firms and visits by FDI staff to inspect production processes of their suppliers all constitute important ways via which knowledge and technologies are shared. Their findings indicate that assistance with quality control systems, production development and cost control processes occur most frequently. Javorcik and

[2] For surveys of research on the static impact of FDI firms, see UNCTAD (2001) and Dunning and Lundan (2008).

[3] Another reason why FDI firms may offer support to (potential) local suppliers is to promote competition, which may result in efficiency or productivity improvements of the local supplier base (see Pack and Saggi, 2001). However, it is likely that the amount of support that is offered for this reason will be much smaller than support offered directly to individual suppliers, as it will be much more difficult for FDI firms to obtain compensation for generic support offered to a local supplier base.

Spatareanu (2005) present evidence from the Czech Republic that FDI firms are engaged in particular in financial support and the provision of training programs for employees of suppliers (see also Javorcik, 2008). Crone and Roper (2001) find in their survey among FDI firms in Northern Ireland that ongoing audits of suppliers' products and direct assistance with improving production processes are important types of knowledge transfer activities. Overall, such findings indicate that FDI firms can be an important source of new technologies to their suppliers. The actual types and degree of support and knowledge transfer activities that are created may vary between different host economies and regional contexts, but is it clear that supportive linkages between FDI firms and suppliers offer an important explanation for the materialization of positive spillover effects among domestic firms in input-supplying industries.

2.2. Technology Gap and Absorptive Capacity

Another response to the heterogeneous nature of the evidence on positive intra-industry FDI spillovers has been the development of research that tries to identify endogenous factors that influence the level and perhaps also the nature of these FDI effects (Blomström and Kokko, 2003; Venables and Barba Navaretti, 2005). Although there is a variety of factors that may have such an effect, the majority of econometric research focuses on identifying the effect of the technology gap between FDI firms and domestic firms on FDI externalities, in the context of identifying the importance of the level of absorptive capacity of domestic firms (Jordaan, 2009)[4].

The main problem with the concept of absorptive capacity arises when trying to identify its effect empirically. The reason for this is that there is no direct measure of this concept. The majority of research uses the level of technological differences between FDI and domestic firms as proxy for absorptive capacity, where a large technology gap is equated with a low level of absorptive capacity of domestic firms. For instance, Girma (2005) finds in his study on FDI spillovers in the UK that positive spillovers only materialize when the technology gap is small, interpreting this as evidence that FDI spillovers only occur among those domestic firms with a sufficient level of absorptive capacity. Taki (2005) presents similar findings for Indonesia. Kokko (1994) finds for Mexico that a positive association between industry wide FDI and productivity of domestic firms does not apply to industries that are characterized by a large FDI presence and a large technology gap.

However, a closer examination of the interpretation of the technology gap as direct inverse indicator of absorptive capacity suggests that this interpretation can be challenged (Jordaan, 2009). The concept of absorptive capacity is linked to the underlying concept of catch up, originally proposed to understand when and how flows of technology between advanced and lagging countries can foster processes of catch up between the two types of country (Gershenkron, 1962; Nelson and Phelps, 1966; Nelson, 1968; Cohen and Levinthal, 1989, 1990; Keller, 1996). Lagging countries need a sufficient level of absorptive capacity to be able to absorb technology flows from advanced countries. However, the second key component of the notion of catch up is that the level of technological differences between the two groups of countries needs to be sufficiently large for meaningful catch up effects to occur. When the technology gap is large, there is sufficient scope for lagging countries to learn and advance, indicating that there is a positive relation between technological spillovers and the technology gap. Translating this to the occurrence of FDI spillovers, the importance of a sufficiently large technology gap for meaningful effects to occur suggests that, all else equal,

[4] Other factors that may influence FDI spillovers include the motivation of a FDI firm to invest in a host economy (Driffield and Love, 2007), its nationality (Haskel et al., 2007) and the level of foreign participation in the firm (Sjöholm and Blomström, 1999).

positive FDI spillovers may be promoted rather than hindered by a large technology gap (see Findlay, 1978; Blomström and Wang, 1992). Furthermore, as Rodrik (1992) argues, it is important to consider that the materialization of externality effects partly depends on active participation by externality receiving agents (see also Goh, 2005). This suggest that it may be a plausible assumption that domestic firms will increase their efforts to absorb technologies when the technology gap is large, as a large gap indicates that there are large benefits to be obtained from doing so. In other words, domestic firms may try to enhance their level of absorptive capacity when the technology gap is large enough. All else equal, this would result in an estimated positive relation between a large technology gap and positive FDI spillovers.

There is substantial evidence that such a positive relation between a large technology gap and positive FDI spillovers exists (Jordaan, 2009). For a variety of host economies, Haskel et al. (2007), Castellani and Zanfei (2003), Zukowska-Gagelmann (2000) and Jordaan (2005, 2008b) all find a positive productivity effect of an interaction variable between the industry presence of FDI and the industry level of technological differences between FDI and domestic firms. Also, Jordaan (2005) finds that intra-industry FDI spillovers only materialize in high tech industries in Mexico. Furthermore, Blomström and Wolff (1994), Sjöholm (1999) and Jordaan (2008a, 2008b) all find a direct positive effect of the technology gap on positive intra-industry FDI spillovers. Evidence on the effect of the technology gap on inter-industry spillovers among suppliers is more limited, but the few studies that do address this relation find a positive effect of the technology gap. Nicolina and Resmini (2010) estimate FDI spillovers for Bulgaria, Poland and Romania and find that positive spillovers among suppliers are most pronounced in high tech industries, industries with a presumable large technology gap between FDI firms and suppliers. Békés et al. (2009) and Jordaan (2008b) find a positive effect of a large technology gap on positive inter-industry FDI spillovers for Hungary and Mexico respectively.

2.3. Hypotheses

It is clear that FDI firms can generate important technology impacts when they act as source of new knowledge and technologies to domestic firms in host economies. Although the large body of evidence is heterogeneous of nature, it appears that positive FDI spillovers are more likely to be of an inter-industry than an intra-industry nature. In particular, FDI firms may generate positive spillover effects among suppliers at the regional level within a host economy. Having said this, there are certain aspects of the evidence that require more investigation. The purpose of this paper is to conduct a study on FDI linkages that tries to address these aspects. To do so, I address the following hypotheses:

(a) Foreign-owned producer firms generate a larger dynamic impact among local suppliers than domestic producer firms

Econometric research on FDI spillovers and case and survey based studies on FDI backward linkages focus on the impact that foreign-owned firms create. This means that they do not address the central question that underlies all research on FDI effects, whether the impact of foreign-owned firms differs from the impact that domestic firms create. Especially from the point of view of host economy governments that tend to offer substantial financial incentives to attract more FDI firms, the question whether and how FDI firms are actually different in their impact is a very relevant one. I address this hypothesis in two ways. First, I look at the level and nature of knowledge transfer activities that producer firms are engaged in. Especially in the case of developing host economies, detailed evidence on FDI linkages that may transmit technologies to domestic firms is limited. In extension of presenting new

evidence on such linkages, I assess whether and how FDI and domestic producer firms differ in the level and nature of their knowledge transfer activities. Second, I assess whether type of ownership matters for the positive impact that actual local suppliers experience from their business dealings with producer firms.

(b) The technology gap between producer firms and local suppliers promotes rather than hinders the dynamic impact among local suppliers

Empirical evidence on the effect of the technology gap is conflicting of nature. Also, the standard interpretation of what the technology gap captures can be challenged. Especially given the fact that findings that a small or a large gap promotes positive FDI spillover leads to completely opposing policy implications, more detailed evidence of what the effect of the technology gap is and what the explanations for this effect may be is called for. Following the discussion in the previous section, the hypothesis reflects that large technological differences between FDI firms and local suppliers can promote positive spillovers. Instead of reflecting the inverse level of absorptive capacity of a supplier, I expect that the technology gap reflects the scope for improvement of a supplier, offering incentives to local suppliers to try to absorb new technologies. I address the hypothesis as follows. First, I look at whether the technology gap influences the degree to which producer firms are engaged in knowledge transfer activities, activities that are closely related to the occurrence of positive spillovers among suppliers. Second, I analyze the relationship between the level of technological differences between producer firms and local suppliers and the dynamic impact that suppliers experience from their business dealings with the producer firms.

(c) The level of absorptive capacity of a supplier influences the dynamic impact that local suppliers experience

The common interpretation of the technology gap as direct inverse indicator of the level of absorptive capacity of domestic firms is inaccurate. Of course, this does not mean that this level of absorptive capacity of domestic firms is not important for spillovers to occur. Instead, the main implication of rejecting the common interpretation of what the technology gap captures is that alternative indicators of the capacity of domestic firms to learn from and adopt new technologies need to be explored. I address the hypothesis on the effect of absorptive capacity in the present study by investigating whether supplier characteristics that capture aspects of the level of absorptive capacity of the suppliers are important for allowing the dynamic impact between producer firms and suppliers to materialize.

3. Research Setting and the Static and Dynamic Impact of FDI and Mexican Producer Firms

3.1. Introduction

Mexico represents a good developing host economy to study the effects of FDI firms. It belongs to a select group of developing countries that have received substantial inflows of inward FDI for several decades (UNCTAD, 2005). Furthermore, the introduction of trade liberalization in the late 1980s, followed by the creation of the North American Free Trade Agreement (NAFTA) in 1994 have increased levels of inward FDI markedly (Cuevas et al., 2005; Jordaan, 2008c; OECD, 2009a, 2009b). To indicate the growing level of foreign participation in the Mexican economy, the share of the stock of inward FDI in Mexico's total GDP has increased from a little over 8% in 1990 to more than 27% in 2006 (Jordaan, 2008c).

As a result, FDI firms will play a central role in current and future processes of economic and technological development in this host economy (OECD, 2009a, 2009b).

There is considerable econometric evidence that FDI firms generate spillover effects among Mexican firms. Well-known evidence on intra-industry externalities, based on unpublished manufacturing data for the 1970s, shows positive associations between the industry presence of FDI and productivity of Mexican firms (Blomström and Persson, 1983; Kokko, 1994, 1996; Blomström and Wolff, 1994; Blomström et al., 2000)[5] More recent evidence, based on unpublished national and regional manufacturing census data for the 1990s also identifies positive FDI spillovers. For instance, Jordaan (2005, 2010) finds evidence of a positive association between industry FDI and productivity of Mexican firms at the national level. Similar evidence for Mexican regions is presented by Jordaan (2008a, 2008b).

Furthermore, there are also indications that regional dimensions of FDI spillovers are important and that suppliers of FDI firms may experience positive externalities. Regarding the regional dimensions, Aitken et al. (1997) find that positive market access spillover are confined at the state level. Jordaan (2005) estimates FDI spillovers for agglomerated and non-agglomerated industries and finds that positive spillovers only occur in the first type of industry. Regarding the occurrence of externalities among local suppliers, Jordaan (2008a) estimates FDI spillovers using regional 2-digit manufacturing industry data and finds a positive association between productivity of Mexican firms and inter-industry regional foreign participation. Related to this, Jordaan and Rodriguez-Oreggia (2010) conduct a panel data study on drivers of regional growth for the period 1989-2005 that shows a positive effect of regional FDI on regional growth. Finally, Jordaan (2008b) uses more detailed manufacturing industry data for Mexico City and states that share a border with the US, representing the regions in Mexico containing the vast majority of FDI investment. The findings indicate that positive associations between FDI and productivity of Mexican firms apply in particular to Mexican firms in regional input supplying industries, suggesting that local suppliers of FDI firms are enjoying positive externalities.

In addition to these quantitative findings, some studies present indications that FDI firms may be involved in knowledge transfer activities. Overall, the impression exists that technology transfers from FDI firms to domestic firms are limited, however (OECD, 2009a, 2009b). Survey findings from the early 1990s indicate that FDI firms are mainly involved in helping suppliers with quality control procedures (UNCTC, 1992). Padilla-Perez (2008) presents survey findings of a similar nature, although the number of Mexican suppliers that receives support appears to be limited. Ivarsson and Alvstam (2005a, 2005b) present detailed findings from their case study of the Swedish multinational Volvo in Puebla. They follow UNCTAD (2001) in distinguishing between assistance with product technology, production technology and training of suppliers. Overall, their findings indicate that assistance with product technology occurs most frequently.

3.2. Research Setting and Design

The regional economy where the study is conducted is Nuevo Leon in Mexico. This state, also known as the manufacturing belt of Mexico, is located in the north-east of Mexico and contains the second largest agglomeration of economic activity after Mexico City (Vellinga, 2000; Gutierrez Garza, 1997; Jordaan, 2009). Importantly, Nuevo Leon has grown in

[55] Evidence for the 1980s is more heterogeneous. Whereas Aitken et al. (1996) find no evidence of significant wage spillovers, Aitken et al. (1997) present evidence of positive market access spillovers, indicated by a positive effect of the presence of exporting FDI firms on the probability that a Mexican firm is active on international markets. In contrast, Grether (1999) finds evidence of negative productivity effects.

importance following the introduction of trade liberalization in the late 1980s and has actively and successfully pursued policies of trade promotion and economic liberalization. Also, its manufacturing sector is characterized by a considerable level of foreign participation, offering good opportunities to identify and analyze the effects of FDI firms (Jordaan, 2009; Vellinga, 2000, 1995; Jordaan and Harteveld, 1997). Finally, with respect to the analysis of spillover effects via input-output linkages between FDI firms and local suppliers, the earlier-referred to study by Jordaan (2008b) finds a positive association between the industry presence of FDI and productivity of Mexican firms in input-supplying industries in Nuevo Leon.

In cooperation with the ITESM University, in 2000-2001 I carried out extensive fieldwork and applied several purpose-built firm level surveys among FDI and Mexican firms in key sectors of the manufacturing sector of Nuevo Leon. Using information from the local branch of INEGI, the local affiliate of the American Chamber of Commerce and local industry associations we compiled a list of 180 foreign-owned and Mexican producer firms that had more than 150 employees and were active in the car, electronics or chemical industries. Following a pilot study among 30 of these firms, we contacted all firms on the list to participate in the producer firm survey. 82 firms participated, representing a response rate of 46%. The appendix contains information on some of the characteristics of this sample of firms. Next, we conducted a survey among local firms that operate as supplier to the producer firms in the region. Here we faced the important problem that asking producer firms for contact details of their suppliers would inevitable result in a biased sample (see Potter et al., 2003). Therefore, we constructed a second list of firms containing all manufacturing firms in the regional economy that had less than 150 employees and were registered with local industry associations. We treated this list of 1,100 firms as the pool of potential suppliers to the producer firms. Using this list, we carried out a telephone survey to identify actual suppliers. After a three month period, 356 firms had participated[6]. Of the participating firms, 300 firms indicated to supply products to the producer firms[7]. Following a pilot study, we contacted these firms to participate in the supplier survey. 100 suppliers participated in this survey, representing a response rate of 33%. In the appendix we list some of the important characteristics of the sample of supplier firms.

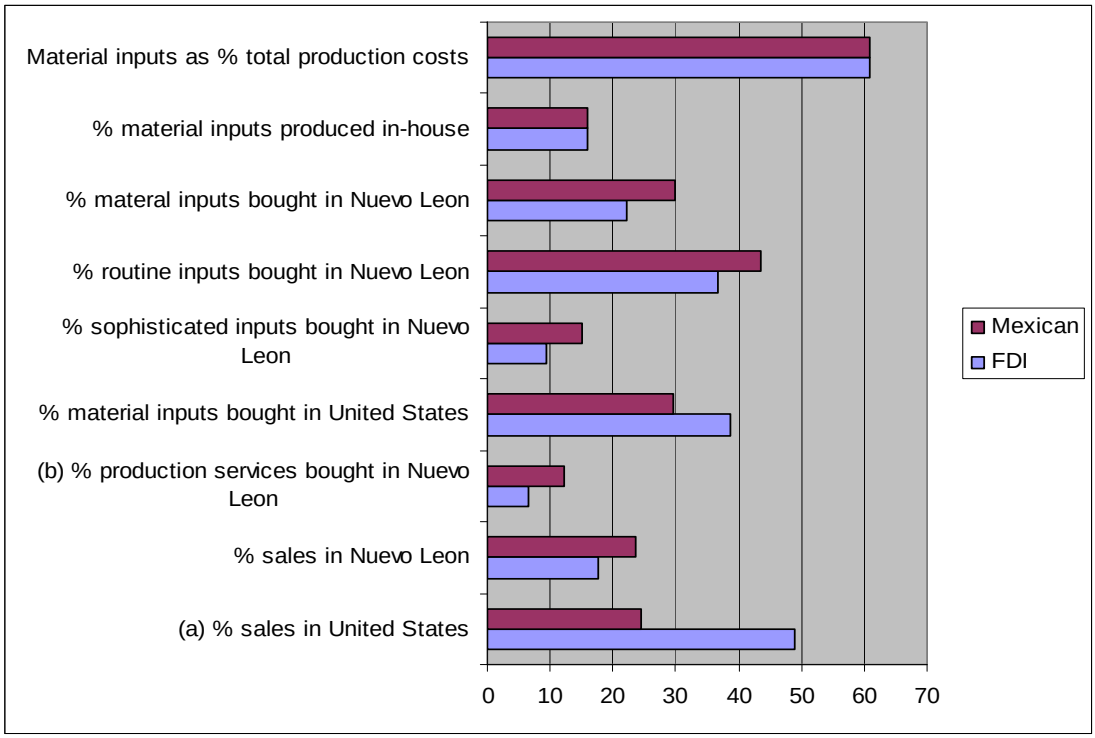
3.3. Static and Dynamic Impact: Comparing FDI and Domestic Producer Firms

The first component of the local impact of FDI firms concerns their static impact, related to the level of use of suppliers. Figure one presents several key indicators of the static impact of foreign-owned and domestic producer firms. The main impression that emerges is that FDI firms and domestic producer firms are markedly similar. Both types of firm report a similar importance of material inputs in overall production costs. They also produce a comparable level of inputs themselves in-house. Mexican firms do source more of their material inputs from local suppliers, but the difference with FDI firms is not significant. The sample average of local sourcing is 26%, which is substantial and in line with findings by e.g. UNCTC (1992) and Martinez-Solano and Phelps (2003). The marked similarity in local sourcing applies to

[6] We tried to contact all firms on the list. The most important reason for non-response was that the telephone number of a firm was no longer in operation, or that a firm did not answer the phone. In the case that a firm did not respond to a telephone call, the company was called back the next day, with a maximum number of 5 days. Looking at the non-respondents, the vast majority consists of micro firms, employing 1 to 5 employees.

[7] It is not the case that a firm's decision not to participate is associated with not being a supplier to FDI or Mexican producer firms in the region. The firms were told at the start of the telephone interview that the survey was conducted to obtain information on their firm characteristics and the overall functioning of the regional economy, after which they indicated whether or not they wanted to participate in the telephone survey.

Figure 1 Static Impact FDI and Domestic Producer Firms



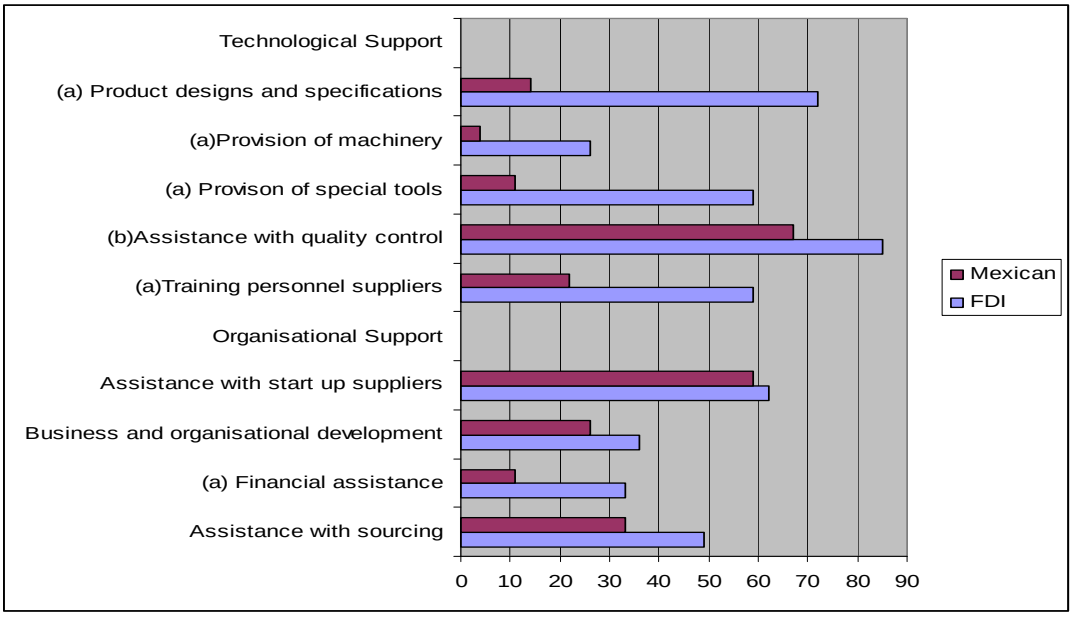
Source: Producer Survey. a and b indicate significance levels of 1 and 5%, based on Equality of Means test. Material input variables measured as % of total material input costs. Production services measured as % of total production costs. Sales variables measured as % of total sales.

both routine and sophisticated inputs. As for the level of international sourcing, FDI firms do purchase more of their inputs from the US, but again the difference with the domestic producer firms is insignificant. The only significant differences appear to exist in the use of local providers of production services and the level of international sales[8]. However, in related research I conduct multivariate analysis to identify determinants of the level of use of local suppliers by the producer firms and find that, once I control for the effects of firm size, use of parts and components and type of production processes, there is no significant difference in the level of use of local production services between FDI and Mexican firms (see Jordaan, 2011b). Therefore, the only difference between FDI and domestic producer firms is that FDI firms sell a larger share of their products on international markets.

The second component of the local impact of foreign-owned firms concerns their dynamic impact. Figures two and three present findings on the nature and degree of knowledge transfer activities that the producer firms engage in. I distinguish between FDI and domestic producer firms and between support offered to suppliers of material inputs and providers of production services. In the survey, we distinguished between two main types of support. Technological support concerns support with a direct impact on production processes

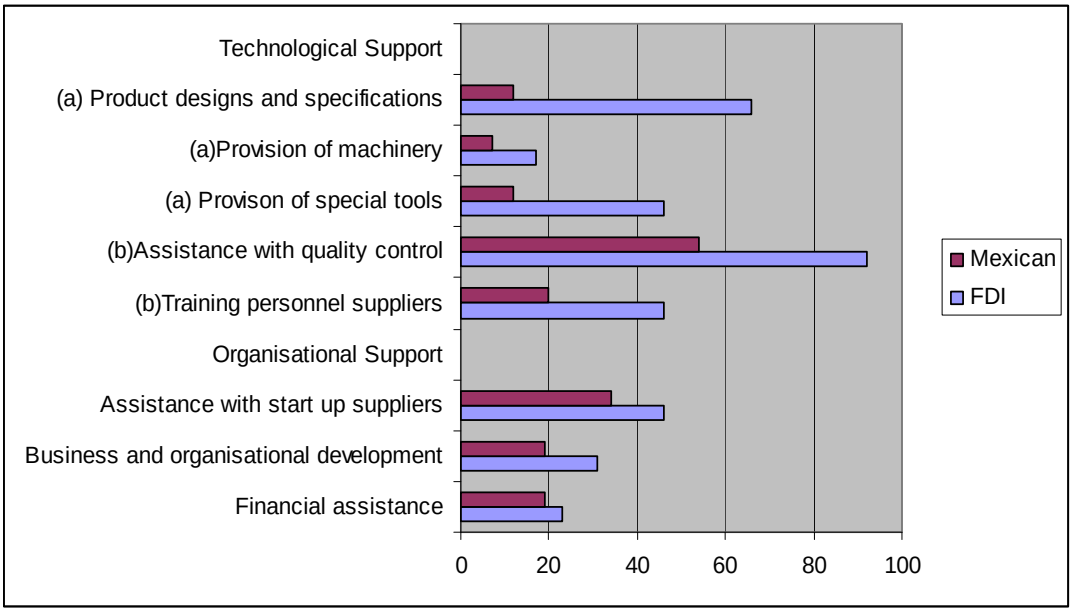
[8] Local production services are usually not included in surveys on the static impact of FDI firms, which tend to focus on material inputs. Production services capture situations where intermediate inputs leave the factory of a producer firm to receive some form of treatment by a local firm. After the treatment, the input is returned to the producer firm to be re-integrated into the production process. Production services include activities such as metal plating and stamping, plastic molding, surface conversion and coating and product finishing activities. The sample average of locally purchased production services is about 10% of total production costs, indicating the importance of including local providers of this type of input in the survey.

Figure 2 Knowledge transfer activities to suppliers of material inputs



Source: Producer Survey. The table shows % of producer firms that indicate that they provide a particular type of support frequently. a and b indicate significance levels of 1 and 5 %, based on Kruskal-Wallis test.

Figure 3 Knowledge transfer activities to suppliers of production services



Source: Producer Survey. The table shows % of producer firms that indicate that they provide a particular type of support frequently. a and b indicate significance levels of 1 and 5 %, based on Kruskal-Wallis test.

of suppliers. This category includes the provision of product designs and specifications, the provision of machinery and special tools, assistance with quality control systems and the provision of training programs for personnel of suppliers. Organizational support represents support that is aimed at improving the overall business performance of suppliers, including general business support, assistance during the start-up phase of a new supplier, financial support and assistance with the sourcing of inputs.

The findings on the supportive linkages are interesting in several respects. Overall, FDI firms are involved in the provision of a variety of both technological and organizational support, both to suppliers of material inputs and providers of production services. Setting aside for the moment any differences with domestic producer firms, FDI firms are most engaged in helping local suppliers with quality control systems and procedures. Almost 85% of the FDI firms indicate to offer this type of support frequently. Second most important is the provision of product designs and specifications, followed by the provision or lending of special tools and the provision of training programs for suppliers. Overall, it does seem to be the case that FDI firms are more supportive to their suppliers of material inputs. Also, it appears that the foreign-owned firms are more engaged in the provision of support of a technological nature. Having said so, especially given the feature that only those FDI firms that offer frequent support are considered to offer any support at all, the scores for several types of organizational support indicate that many FDI firms are involved in the provision of organizational support. For instance, one out of every three FDI firms offers frequent financial support, and half of the firms frequently provide help to suppliers with their input sourcing practices.

Next, a comparison of the responses given by FDI firms and domestic firms indicates that there are significant differences between the two types of firm regarding their involvement in supportive linkages. There are several types of support where FDI firms are significantly more active. This finding is very suggestive, in particular given the findings presented in figure 1 that show that FDI and domestic producer firms are markedly similar in terms of the static impact that they create. In contrast to this strong degree of similarity, FDI firms are very different when it comes to the provision of support to local suppliers. Another distinctive feature of the differences between FDI and domestic producer firms is that FDI firms are more supportive in particular when it comes to providing support of a technological nature, including help with quality control systems, the training of suppliers' personnel and the provision of special machinery. This applies both to support offered to suppliers of material inputs and providers of production services. In other words, FDI firms are more involved in those types of support that have a direct positive impact on actual production processes of local suppliers. This indicates that FDI firms are a particularly good source of new knowledge and technologies to local suppliers, suggesting that the foreign-owned firms are a better source of positive local spillovers than domestic producer firms.

4. Foreign Ownership, Technology Gap and Absorptive Capacity

The previous section has identified important differences in the local dynamic impact between FDI and domestic producer firms. In particular, FDI firms are more supportive when it comes to offering support with a direct positive impact on the production processes of their suppliers. Having said this, this finding is based only on dichotomous comparisons between the two types of producer firm, unconditional on other factors that may be important for the provision of support. Also, although it is a plausible assumption that supportive linkages will generate positive externalities among the suppliers, differences in supportiveness may not translate directly into differences in the impact that foreign-owned and domestic producer firms create. For instance, it may be the case that although domestic firms offer support less frequently,

they are more effective in the provision of the support, which could result in a larger dynamic local impact.

In this section, I conduct multivariate analysis to identify factors that influence the level of supportiveness of the producer firms and the impact that suppliers experience from their business dealings with the producer firms. In this analysis, I focus in particular on identifying the effects of type of ownership of the producer firms, the technology gap between producer firms and their local suppliers and the level of absorptive capacity of the suppliers.

4.1. Provision of Support by Producer Firms

To identify the effects of type of ownership and the technology gap on the level of supportiveness of the producer firms, I estimate regression models of the following specification:

$$(1)\ \text{Support}(i) = \beta 0 + \beta \text{FDI}(i) + \beta\ \text{TECHGAP}(i) + \beta\ \text{TECHGAP*FDI} + \beta\ \text{X}(i) + \beta\ \text{INDUSTRY}(i) + \varepsilon(i)$$

The dependent variable is a binary variable taking the value of 1 when producer firm i offers support frequently and 0 when a producer firm offers support sometimes, occasionally or offers no support. The dichotomous nature of the variable makes the use of the logit regression model appropriate, relating to the odds that a producer firm offers support. These odds are defined as the ratio of the probability that a firm offers support frequently (π) and the probability that the firm does not offer support frequently ($1-\pi$). Taking the log of this ratio gives the logit, which is used as dependent variable of the regression model that can be estimated with maximum likelihood techniques. The estimation of this type of logit model is very appropriate for the present analysis. It has been used frequently in similar research settings (see e.g. McCann and Fingleton, 1996) and is in line with approaches and interpretations of the OECD Oslo Manual and the European Community Innovation Surveys. The logit model becomes:

$$(2)\ \text{Ln}(\pi/1-\pi)(i) = \beta 0 + \beta \text{FDI}(i) + \beta\ \text{TECHGAP}(i) + \beta\ \text{TECHGAP*FDI} + \beta\ \text{X}(i) + \beta\ \text{INDUSTRY}(i) + \varepsilon(i)$$

The variable FDI takes the value of 1 when a producer firm is foreign-owned and 0 otherwise[9]. Given the findings in the previous section, I expect a positive effect of this variable.

The variable TECHGAP captures the level of technological differences between a producer firms and its local suppliers. Previous research has only considered the direct impact of the technology gap on FDI spillovers. However, the technology gap may also affect the level of supportiveness of a producer firm, which subsequently can affect the level of spillovers accruing to domestic firms. I interpret the technology gap as indicating the scope of the potential improvements that suppliers can achieve. Following this interpretation, I expect a positive relation between the technology gap and the provision of support. The variable TECHGAP is measured as follows. It takes the value of 1 when a producer firm indicates that large technological differences with their local suppliers are among the two most important reasons preventing the firm from increasing its level of local sourcing[10]. I also include an

[9] See the appendix for a list with all the variables with measurements.

[10] The variable TECHGAP is constructed in this way because producer firms indicated that the most important reason for not increasing their level of use of local suppliers is the absence of suppliers. All the other reasons

interaction variable between the variables FDI and TECHGAP to test whether foreign-owned firms differ in their level of supportiveness from Mexican producer firms when facing a large technology gap with local suppliers.

Striving towards the specification of a parsimonious regression model, I include five control variables in X. I control for the age (AGE) of a producer firm, given findings from research on determinants of the static impact of producer firms that show that older firms generate a larger static impact (e.g. Driffield and Moor, 2000; UNCTAD, 2001). In a similar fashion, I expect that producer firms with more experience in the regional economy will generate a larger dynamic impact. I control for the size of a producer firm (SIZE) under the assumption that larger firms have more resources to devote to the provision of support (Jordaan, 2011b). I also include a variable labeled MAT, capturing the relative importance of material inputs in total input costs. I expect a positive effect of this variable when a larger reliance on material inputs (as opposed to raw materials and intermediate inputs) fosters a producer firm's supportiveness to local suppliers (see Jordaan, 2011b).

Next, I need to control for the feature that producer firms may participate in the Maquiladora program. It is well reported that many Maquiladora firms in Mexico are poorly integrated into their local economies (CEPAL, 1996; Buitelaar and Padilla Perez, 2000; Ramirez, 2003). Having said this, there is a recent development where younger generation Maquiladora firms may be advancing linkages into their local environments (Carrillo and Hualde, 1998; Sargent and Matthews, 2004; Jordaan, 2011b). These younger generation Maquiladora firms are more engaged in actual production rather than mere assembly style operations and are more autonomous regarding decisions on their level and nature of local sourcing (Sargent and Matthews, 2008; Carrillo, 2004). To capture the effect of participation in the Maquiladora program and the possibility that younger generation Maquiladora firms have a different local impact, I include two variables in the model. I include a dummy variable labeled MAQUILA to capture those Maquiladora firms that have been in operation in Nuevo Leon for more than 15 years. I expect a negative effect of this variable, as it captures first generation assembly style Maquiladora firms. The second variable is a dummy variable labeled NEWMAQUILA, which takes the value of 1 when a producer firm operates in the Maquiladora program. If younger generation Maquiladora firms are more integrated into the local economy of Nuevo Leon, this variable will have a positive effect on the probability that a producer firm offers support.

Finally, I need to address two econometric issues. First, I need to control for the possible presence of structural differences in supportiveness between industries and municipalities. To capture the industry effect, I include dummy variables for the car, electronics and chemical industries (INDUSTRY). As for the municipality effect, it may be the case that certain municipalities are characterized by higher levels of support. This may be the case when suppliers locate in proximity to producer firms that they know or expect to be more supportive. Also, municipalities may have a high level of agglomeration of economic activity in general. This may facilitate formal and informal inter-firm contacts, promoting the occurrence of knowledge spillovers (see Storper and Venables, 2004). To control for this spatial effect, I estimate the regression model allowing for clustered standard errors at the municipality level.

Second, I need to consider the issue of how to interpret the estimated effect of the interaction variable between FDI and TECHGAP. In a standard OLS regression, the estimated β coefficient of the interaction variable captures the direct and full effect of the interaction variable on the dependent variable. This is not the case when estimating logit or probit

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that firms indicated to prevent a larger use of local suppliers, including a large technology gap, apply to characteristics of existing local suppliers.

regression models, however (Greene, 2003; Ai and Norton, 2003). The reason for this is that in these regression models, the estimated effect of an interaction variable also depends on the values of the other control variables. This means that the directly estimated β coefficient only represents the marginal effect of the interaction variable. In fact, it may even be the case that whereas the directly estimated effect of the interaction variable is not significantly different from 0, the actual interaction effect does exist (Norton et al., 2004). Also, the sign of the estimated β coefficient is unreliable. Therefore, in addition to reporting the directly estimated (marginal) effect of the interaction variable between FDI and TECHGAP, I also report an adjusted β coefficient with corresponding z statistic that I obtain from applying the procedure as discussed by Ai and Norton (2003) and Norton et al. (2004). This procedure uses the cross-partial derivative of the expected value of the dependent variable with respect to the interaction variable and gives the average (full) effect of the interaction variable.

Empirical Findings on Determinants of Knowledge Transfer Activities

To recapitulate, the full regression model on determinants of a producer firm offering support is:

$$(3)\ \mathrm{Ln}(\pi/1-\pi) = \beta 0 + \beta\ \mathrm{AGE} + \beta\ \mathrm{SIZE} + \beta\ \mathrm{MAT} + \beta\ \mathrm{MAQUILA} + \beta\ \mathrm{NEWMAQUILA} + \beta\ \mathrm{FDI} + \beta\ \mathrm{TECHGAP} + \beta\ \mathrm{FDI*TECHGAP} + \beta\ \mathrm{INDUSTRY} + \varepsilon$$

The main findings from estimating the regression model on the various types of technological and organizational support are presented in table 1. The first column with findings presents the results from estimating the model with the frequent provision of aggregate technological support to suppliers of material inputs as dependent variable. The estimated positive effect of the size variable indicates that large firms are more likely to offer support, as expected. Producer firms that have a large share of material inputs in total inputs also provide more support. As for the two Maquiladora effects, the estimated negative effect of the MAQUILA variable indicates that first generation assembly style firms are less likely to offer support. In contrast, younger generation Maquiladora firms are more likely to offer support, in line with the idea that these firms are creating more substantial linkages with their local environment.

Next, the estimated effect of type of ownership is positive, indicating that FDI firms are more likely to offer support. This finding represents important support for the findings in the previous section that identify the marked supportiveness of foreign-owned firms. The importance of the finding here is that FDI firms are more supportive, even when controlling for a range of other factors that are associated with supportiveness.

In contrast, the estimated effect of the technology gap variable is negative. This indicates that a producer firm offers less support when its suppliers are technologically substantially backward. The technology gap lowers support provided by a producer firm, lowering any positive spillover effects that may materialize among local suppliers. This provides an explanation for findings from econometric studies on FDI spillovers that find a negative relation between the technology gap and FDI spillovers (Girma, 2005; Taki, 2005). However, rather than capturing the effect of a low level of absorptive capacity of domestic firms, the present findings indicate that the negative relation can be explained by the feature that a large technology gap makes it less likely that producer firms offer support. As this lowers the amount of technologies that are transferred to domestic firms, less support will generate smaller spillover effects.

However, the estimated effect of the interaction variable between the technology gap and type of ownership is significant and positive. This applies to both the directly estimated effect and the adjusted β coefficient. According to this finding, FDI firms are more likely to

Table 1 FDI and the Technology Gap as Determinants of Knowledge Transfer Activities

	Support offered to Suppliers Material Inputs										Support offered to Providers Production Services				
	Techn Support	**Designs**	**Mach**	**Tools**	**Control**	**Training**	**New Supp**	**Business**	**Finance**	**Inputs**	**Designs**	**Mach**	**Tools**	**Control**	**Training**
AGE	0.23 (0.50)	-0.23 (1.05)	-0.31 (0.92)	0.65 (1.78)c	-0.85 (2.80)a	-0.14 (0.60)	-0.55 (1.60)	-0.22 (0.27)	-0.14 (0.60)	-0.08 (0.30)	-0.37 (1.09)	0.41 (0.73)	0.23 (0.56)	-0.82 (3.32)a	0.35 (1.43)
SIZE	0.33 (2.98)a	0.85 (2.63)a	0.09 (0.50)	0.19 (0.64)	0.10 (0.61)	0.21 (3.53)a	0.85 (3.55)a	0.31 (1.72)c	0.25 (0.77)	0.14 (0.45)	0.27 (0.77)	-0.28 (0.82)	-0.19 (0.80)	0.15 (0.74)	0.18 (0.40)
MAT	1.94 (3.62)a	1.89 (2.80)a	0.79 (1.71)c	0.92 (1.70)c	0.90 (1.78)c	0.60 (1.06)	0.67 (1.36)	0.68 (1.78)c	0.60 (1.42)	-0.24 (0.45)	3.39 (5.86)a	1.26 (0.78)	0.91 (2.49)a	0.84 (2.53)a	0.26 (0.48)
MAQUILA	-2.67 (3.02)a	-2.66 (3.44)a	-2.51 (2.21)b	-1.67 (2.58)a	-0.83 (2.11)b	-1.29 (3.18)a	-1.41 (2.19)b	-0.83 (2.11)b	-0.31 (0.76)	-0.33 (0.95)	-9.80 (12.54)a	-7.12 (3.78)a	-0.41 (0.71)	-1.08 (1.47)	0.38 (0.66)
NEWMAQUILA	4.52 (3.10)a	4.70 (3.01)a	4.68 (3.06)a	3.24 (3.53)a	1.39 (1.96)b	2.71 (3.00)a	2.24 (1.92)b	1.39 (1.96)b	1.54 (2.24)b	1.81 (1.73)c	18.56 (12.22)a	9.52 (3.17)a	0.93 (1.13)	1.65 (2.84)a	1.22 (1.36)
FDI	1.38 (3.42)a	2.31 (3.43)a	0.37 (0.66)	1.34 (2.28)b	-0.06 (0.34)	0.81 (2.08)b	0.14 (0.36)	-0.15 (0.26)	0.78 (2.39)b	-0.04 (0.55)	9.14 (5.43)a	1.67 (3.14)a	0.81 (1.71)c	1.42 (2.33)a	0.80 (2.38)a
TECHGAP	-6.85 (7.18)a	-6.67 (8.11)a	-6.45 (7.29)a	-5.89 (9.62)a	-2.02 (0.13)	-5.87 (5.90)a	0.04 (0.11)	0.07 (0.13)	-5.20 (8.79)a	-6.42 (6.79)a	-7.07 (4.63)a	-5.56 (3.08)a	-4.45 (5.21)a	0.65 (1.38)	1.24 (1.49)
FDI* TECHGAP	6.52 (5.45)a	5.09 (6.12)a	6.89 (7.95)a	6.36 (5.30)a	2.34 (1.71)c	5.91 (6.64)a	-0.52 (0.72)	0.53 (1.28)	5.21 (7.41)a	6.77 (5.05)a	6.22 (3.49)a	5.01 (4.54)a	4.96 (5.35)a	-0.48 (0.58)	-1.03 (1.02)
Adjusted FDI*TECHGAP	0.37 (1.90)b	-0.012 (0.06)	0.35 (2.06)b	0.44 (1.83)b	0.67 (2.74)a	0.33 (1.90)b	-0.19 (0.85)	0.11 (0.46)	0.15 (0.73)	0.56 (1.92)b	0.06 (0.13)	-0.01 (0.27)	0.30 (1.33)	-0.16 (0.91)	-0.07 (0.21)
Industry	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Log Likelihood	-25.52	-20.54	-18.11	-24.09	-26.22	-28.51	-28.36	-32.28	-32.04	-39.34	-12.79		-25.26	-21.53	-20.68
LR Chi square	28.76	39.10	15.50	28.84	10.41	22.28	21.28	8.60	12.40	20.53	44.42		11.34	14.41	20.74
Significance model	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00		0.00	0.00	0.00
R square	0.36	0.49	0.30	0.37	0.17	0.28	0.27	0.12	0.19	0.26	0.63	0.18	0.26		0.33
Observations	82	82	82	82	82	82	82	82	82	82	64	64	64	64	64

Absolute value of t statistic in parentheses. a, b and c indicate significance levels of 1, 5 and 10%. Adjusted FDI*TECHGAP presents adjusted β coefficient and absolute value z statistic based on Norton et al. (2004). R square is McFadden. In all regressions, F test rejects that industry dummies have coefficients equal to 0.

Techsupport = overall technological support, Designs = provision of product designs and specifications, Mach = provision of machinery, tools = provision of special machinery, Control = support with quality control measures and procedures, Training = training personnel suppliers, Newsup = assistance for new suppliers, Business = business and organizational support, Finance = financial support, Inputs = support with sourcing practices and procedures.

offer support to their local suppliers when the level of technological differences with these domestic firms is large. This suggest that whereas Mexican producer firms see a large technology gap as an obstruction to provide support, foreign-owned firms perceive such a large gap as representing a large potential scope for improvement of their suppliers. This finding offers an explanation for econometric evidence of several studies that find a positive effect of an interaction variable between FDI and the technology gap (Haskel et al., 2007; Zukowska-Gagelmann, 2000; Jordaan, 2005). FDI firms offer more support when they interpret a large technology gap as indicating a large scope for their suppliers to improve, resulting in larger FDI spillover effects.

The next set of columns present the findings from estimating the regression model for the various individual types of technological and organizational support that the producer firms offer to suppliers of material inputs. Most variables show a considerable consistency in their estimated effect. For several types of support, the positive effect of firm size and reliance on material inputs is confirmed. Also, in almost all cases the variable capturing first generation Maquiladora firms is negatively associated with the likelihood that a producer firm offers support. At the same time, the variable capturing younger generation Maquiladora firms carries a significant positive coefficient in most regressions, confirming the notion that there are structural differences in local connectedness between Maquiladora firms of different generations. This applies to both technological and organizational support.

As for type of ownership, FDI firms are more supportive when it concerns types of technological support. Except for financial support, type of ownership does not matter for the provision of organizational support. Again, this is in line with the findings from the dichotomous comparisons between FDI and domestic producer firms in the previous section. The negative effect of the technology gap applies to all but one type of technological support. Importantly, the estimated positive effect of the interaction variable between the technology gap and FDI also applies mainly to types of technological support. Looking at the adjusted β coefficient of the interaction variable, the positive effect materializes for the lending of machinery, the provision of special tools, assistance with quality control and the provision of training programs for employees of suppliers. When it comes to support of an organizational nature, the estimated effect of the interaction variable is insignificant. An explanation for this importance difference may be that FDI firms are better able to assess potential improvements of their suppliers when it comes to evaluating the scope to improve actual production processes of these firms. This may be much more difficult when it comes to assessing whether and to what extent suppliers can make substantial improvements from receiving organizational support, support that has a far weaker link with actual production processes. In other words, the positive effect of the technology gap on the supportiveness of FDI firms materializes only in those situations where FDI firms are in a position to assess the potential of their suppliers to experience improvements of a technological nature.

Finally, the last set of findings presents the effects of the control variables on the provision of technological support to providers of production services. The estimated effects of the main variables of interest are more varied compared to the previous regressions. In two out of five cases, the estimated effect of the Maquiladora variables confirms the existence of structural differences between Maquiladora firms of different generations. This variability does not apply to type of ownership, as the findings indicate that the FDI variable has a positive effect on the provision of support for all five types of technological support. The negative effect of the technology gap applies to support in the form of product designs and specifications, the provision of special machinery and the lending of special tools. Importantly, the adjusted β coefficient of the interaction variable between the technology gap and FDI is not significantly associated with the provision of support, suggesting that there is no difference between FDI and domestic firms in their response to large technological

differences with providers of production services. This may be explained by the feature that FDI firms are much less familiar with production services. When FDI firms have knowledge and experience in the production of material inputs, they are in a good position to evaluate and predict potential improvements of suppliers of material inputs, resulting in more technological support to suppliers that are technologically backward. Production services are much more specialized activities, however, activities that producer firms may have much less experience with. If this is the case, it will be much more difficult for FDI firms to assess whether local providers that are technologically less advanced will be able to achieve substantial improvements. This would explain the estimated insignificant effect of the interaction variable between FDI and the technology gap for the provision of support to such providers of production services.

4.2. Determinants of the Impact on Local Suppliers

So far, the analysis has established that FDI firms offer support significantly more frequently. Furthermore, the technology gap appears to play a dual role. In general, the technology gap lowers the amount of support that is offered to suppliers, which may result in less spillover effects. At the same time, FDI firms offer more technological support to suppliers of material inputs when the technology gap is large, suggesting that FDI firms interpret a large gap as representing a large scope for potential technological improvements. To assess whether these factors also play a role when it comes to influencing the actual impact that is created by input-output linkages between the producer firms and their suppliers, in this section I estimate regression models to identify factors that are associated with the positive impact among the suppliers.

To identify such factors, I use information from the supplier survey among local firms to estimate regression models of the following specification:

$$(3)\ \text{Impact}(i) = \beta 0 + \beta\ \text{FDISUPPLIER}(i) + \beta\ \text{TECHSUPPORT}(i) + \beta\ \text{ORGSUPPORT}(i) + \beta\ \text{CONTRACT} + \beta\ \text{TECHGAP} + \beta\ \text{ABSCAP} + \beta\ \text{FDI*TECHGAP} + \varepsilon(i)$$

The dependent variable IMPACT takes the value of 1 when supplier i indicates to have experienced a large positive impact from its business dealings with the producer firms in the regional economy. It takes the value of 0 when the positive impact is moderate, small or non-existent[11]. Similar to the previous regression model, the nature of the dependent variable makes the logit regression model appropriate. The dependent variable is the logit of the ratio that a supplier experiences a large positive impact (μ) over the probability that a supplier does not experience such a large positive impact ($1-\mu$):

$$(4)\ \text{Ln}(\mu/1-\mu) = \beta 0 + \beta\ \text{FDISUPPLIER}(i) + \beta\ \text{TECHSUPPORT}(i) + \beta\ \text{ORGSUPPORT}(i) + \beta\ \text{CONTRACT} + \beta\ \text{TECHGAP} + \beta\ \text{ABSCAP} + \beta\ \text{FDI*TECHGAP} + \varepsilon(i)$$

The variable FDISUPPLIER takes the value of 1 when a supplier's client firms in the region consists only or mainly of FDI firms[12]. I expect to find a positive effect of this variable. The variables TECHSUPPORT and ORGSUPPORT control for the level of technological and

[11] In this sense I exercise restrictiveness, by only considering those suppliers that have experienced a large positive impact to have experienced any positive impact at all.

[12] See the appendix for a full description of the variables.

organizational support of a supplier's client firms. I expect a positive effect of both these variables, under the clear assumption that suppliers that receive more support are more likely to experience a large positive impact. I also include a dummy variable CONTRACT which captures the nature of the contacts between a supplier and its client firms. This variable takes the value of 1 when suppliers operate with standard purchasing orders, representing "arm's length" market transactions. I expect a negative effect of this variable, as frequent contacts and mutual coordination between buying and supplying firms are more conducive to the creation of flows of knowledge and technologies (UNCTAD, 2001).

As discussed earlier, there are important problems in empirical research on FDI effects that interpret the technology gap as direct inverse indicator of the level of absorptive capacity of domestic firms. Therefore, I include separate control variables to capture the effect of the technology gap and absorptive capacity. The variable TECHGAP captures the level of technological differences between a supplier and its client firms. In the supplier survey, firms were asked to indicate on a Likert scale the size of the technology gap with their client firms, where a high score indicates a large technology gap. Given my interpretation of what the technology gap captures, and given previous findings for Mexico (e.g. Blomström and Wolff, 1994; Jordaan, 2005), I expect a positive effect of the technology gap on the impact that a supplier experiences.

To capture the level of absorptive capacity of a supplier, I include three proxy variables of this capacity. I control for the size of a supplier (SIZE), as a large firm is likely to have more resources to devote to absorbing new technologies (Aitken and Harrison, Blyde et al., 2004). I also include a variable that measures the level of experience (EXPERIENCE) that a supplier has with producing inputs for producer firms in the region. I expect a positive effect of this variable, under the assumption that domestic firms that have been operating in the regional economy for some time as supplier have more experience in absorbing new technologies. Third, I include a variable that captures the overall level of experience and skills of a supplier with modern production technologies (QUALITY). I proxy this level with a variable that captures the degree to which suppliers have problems with quality control systems and technical production issues. This variable is measured on a Likert scale, whereby a high score indicates a high frequency of problems[13].

Finally, I estimate the regression model allowing for clustered standard errors at the level of the nature of the product that a supplier provides. Most suppliers indicated to be active in more than one industry, making it difficult to include standard industry dummies to the regression model. Instead, I estimate the regression model allowing for clustered standard errors for suppliers supplying raw materials, material inputs, production services or (replacement) machinery parts.

Empirical Findings on Determinants of Positive Impact among Suppliers

The main findings from estimating regression model (4) are presented in table 2. The first part of the table shows the estimated effects of the control variables on a supplier firm having experienced an overall large positive impact. The estimated positive effect of the size variable indicates that a large supplier is better able to absorb new technologies. The estimated positive effect of the experience variable further confirms the positive effect of the level of absorptive capacity of a supplier. The other indicator of absorptive capacity, the degree to which a supplier experiences problems with quality control and technical production issues, has an estimated negative effect, in line with expectations. Overall therefore, these findings confirm

[13] I also experimented with a variable capturing the level of exports of a supplier as indicator of absorptive capacity (see Abraham et al., 2007), but this variable had no significant effect in preliminary regressions.

Table 2 FDI, Technology Gap, Absorptive Capacity and the Impact on Local Suppliers

	Large overall impact			Large technological impact			Large organizational impact		
	Full sample	**No production services**	**No material inputs**	**Full sample**	**No production services**	**No material inputs**	**Full sample**	**No production services**	**No material inputs**
SIZE	0.20 (2.91)a	0.24 (0.69)	0.45 (4.13)a	0.28 (1.90)b	-0.15 (0.55)	0.42 (2.45)a	0.27 (1.90)b	0.01 (0.10)	0.29 (1.72)c
EXPERIENCE	0.60 (2.08)b	0.71 (2.34)a	1.24 (3.20)a	0.32 (1.32)	0.50 (1.24)	1.24 (3.83)a	1.88 (3.76)a	2.74 (4.83)a	0.40 (1.20)
QUALITY	-1.37 (2.75)a	-1.20 (1.90)a	-1.80 (1.52)	-0.12 (0.40)	-0.22 (0.55)	-0.26 (1.50)	-1.07 (2.95)a	-1.26 (2.64)a	0.57 (0.93)
CONTRACT	-1.23 (1.59)	-1.06 (1.40)	-1.44 (0.95)	-0.37 (6.41)a	-0.32 (2.18)b	-0.18 (1.45)	0.52 (2.77)a	0.67 (6.62)a	0.72 (2.34)a
TECHSUPORT	-0.06 (0.62)	0.27 (2.45)a	0.42 (1.27)	0.38 (10.19)a	0.30 (10.28)a	0.42 (5.80)a	0.01 (0.18)	0.09 (1.10)	-0.19 (1.54)
ORGSUPPORT	0.19 (3.14)a	0.07 (1.60)	0.39 (7.95)a	0.05 (0.41)	0.04 (0.35)	0.25 (0.56)	0.15 (1.39)	0.25 (2.35)a	0.18 (0.67)
FDI	2.24 (4.77)a	2.08 (7.03)a	2.33 (2.79)a	0.65 (5.52)a	0.57 (2.08)b	1.01 (2.01)b	0.69 (3.67)a	0.65 (2.01)b	1.51 (5.78)a
TECHGAP	1.42 (3.76)a	1.79 (4.35)a	0.87 (1.61)	1.25 (4.57)a	1.18 (1.74)c	1.37 (3.42)a	-0.16 (0.20)	-0.21 (0.18)	-0.09 (0.14)
FDI*TECHGAP	-1.10 (1.39)	-0.58 (0.60)	-1.42 (1.23)	4.71 (5.53)a	5.27 (8.39)a	4.43 (4.24)a	0.12 (0.46)	-0.09 (0.68)	0.07 (0.08)
Adjusted FDI*TECHGAP	-0.19 (0.75)	-0.10 (0.29)	-0.27 (0.76)	0.34 (3.38)a	0.44 (5.77)a	0.15 (0.67)	0.03 (0.17)	-0.08 (0.04)	-0.07 (0.04)
Wald test exogeneity supplier status	0.52 (0.47)	1.67 (0.20)	2.96 (0.09)	0.26 (0.61)	2.43 (0.14)	2.25 (0.17)	0.41 (0.52)	1.11 (0.30)	1.17 (0.32)
Log Likelihood	-42.89	-29.95	-33.22	-56.81	-40.66	-40.86	-51.57	036.20	-36.22
Chi square	37.24 (0.00)	30.84 (0.00)	26.10 (0.00)	21.17 (0.00)	11.60 (0.00)	25.09 (0.00)	14.04 (0.00)	15.39 (0.00)	15.72 (0.00)
R-square	0.32	0.36	0.29	0.16	0.13	0.24	0.12	ty0.18	0.19
Observations	100	67	70	100	67	70	100	67	70

Absolute value of t statistic in parentheses. a, b and c indicate significance levels of 1, 5 and 10%. Adjusted FDI*TECHGAP presents adjusted β coefficient and absolute value z statistic based on Norton et al. (2004). R square is McFadden. Large overall impact is summation of large technological and large organizational impact. Large technological impact is summation of large impact in areas of use of product designs and specifications, use of machinery, use of special tools, increase in human capital. Large organizational impact is summation of positive impact in areas of business and organizational improvement, finance and sourcing of inputs.

the notion that the level of absorptive capacity of a supplier is important for the materialization of a positive impact.

The level of supportiveness of client firms is also important. For the overall impact, it appears that organizational support is the most important. However, the findings for the sub-samples of suppliers indicate that technological support fosters the materialization of a large impact among suppliers of material inputs, whereas organizational support facilitates such an impact among providers of production services. This is in line with the earlier findings on determinants of the provision of support, which also identify differences between the two types of supplier. Importantly, the estimated effect of foreign-ownership of client firms is significant and positive. Earlier on, the analysis found that FDI firms are more supportive. The findings in table 2 indicate that suppliers of FDI firms are more likely to experience a large positive impact, even when I control for the feature that FDI firms are more supportive, by the inclusion of the variables TECHSUPPORT and ORGSUPPORT. Clearly, this finding represents strong support for the notion that type of ownership matters for the creation of positive spillover effects.

In line with the hypothesis, the estimated effect of the technology gap is positive. This indicates that suppliers with a large scope to improve are more likely to experience a large positive impact. One implication of this finding is that, in line with the finding that several indicators of the level of absorptive capacity are positively associated with the large positive impact, the positive effect of the technology gap cannot be interpreted as being directly linked with absorptive capacity. Instead, the positive effect of the technology gap can be interpreted as reflecting that a positive impact is more likely to arise when there is a large scope for suppliers to improve. The second implication is that, as the regression model controls for the level of support that a supplier receives and type of ownership of client firms, the positive effect of the technology gap is likely to be related to efforts that are made by suppliers to absorb new technologies. When there is a large scope for suppliers to improve, these firms are more likely to increase their efforts to absorb new technologies, resulting in a large positive impact. Regarding this large overall impact, there is no additional positive effect of the interaction variable between the technology gap and FDI.

Finally, table 2 presents the findings of a Wald test on the possibility that the status of a supplier is endogenous to the estimated regression model. It could be the case that a domestic firm self-selects into becoming a supplier of FDI firms, if it expects that it will benefit more from more linkages with these firms than from linkages with Mexican producer firms. In particular, this may be the case for those suppliers that have a relative high level of absorptive capacity. It so, (part of) the estimated positive effect of the FDISUPPLIER variable will capture this tendency of suppliers preferring to operate as supplier to FDI firms. To assess whether this is the case, I regress the FDISUPPLIER variable on the absorptive capacity variables. The Wald test then estimates whether there is a correlation between the errors of this instrumental variable estimation and the errors of the structural regression model. As reported in table 2, the Wald test rejects any correlation between the two sets of errors, indicating that the estimated positive effect of the FDISUPPLIER variable is not affected by a tendency among suppliers to self-select into becoming supplier to FDI firms[14].

The second part of table 2 presents the findings from estimating the regression model using a large technological impact as dependent variable. There are some important differences with the findings from the first regression model. One difference is that

[14] I also conducted the test using all control variables in the instrumental variable regression, producing a similar insignificant Wald test score. As table 2 indicates, the Wald test rejects a significant correlation between the errors of the instrumental variable estimation and the structural equation regression in all but one case, indicating that the estimated positive effect of the FDISUPPLIER variable is not biased due to a tendency among local suppliers to self-select into becoming supplier to FDI firms.

technological rather than organizational support is the type of support that favors local suppliers experiencing a large technological impact, irrespective of the type of supplier. As for absorptive capacity, all variables have coefficients with correct signs, but the size of a supplier is the main factor influencing whether a positive technological impact occurs. Another difference is that the findings show that the type of contract matters for the occurrence of a technological impact. The estimated negative effect of the variable CONTRACT indicates that suppliers that deal with client firms through "arms-length" market transactions are less likely to benefit from a large impact. This suggests that formal and informal inter-firm linkages are important, as they facilitate flows of knowledge and technologies.

Looking at the estimated effect of supplier status, the findings confirm that suppliers of FDI firms are more likely to experience a large technological impact. The technology gap also carries a significant and positive coefficient, indicating that suppliers with a large potential to improve experience a large impact. Importantly, the findings also indicate that there is an additional positive effect of the interaction variable between FDI and TECHGAP. This further supports the finding that foreign-owned firms are more likely to generate positive effects. In particular, in these regressions the estimated positive effect of the variable FDI SUPPLIER is robust to the feature that FDI firms offer more support as well as to the feature that FDI firms offer more support when the technology gap with their local suppliers is large.

Finally, the last part of table 2 presents the findings on factors that influence local suppliers experiencing a large positive organizational impact. All three absorptive capacity variables carry significant coefficients with the correct sign. The estimated effect of the variable CONTRACT is positive. This is contrary to expectations, as it suggests that "arms length" market transactions favor the materialization of a positive organizational impact. This finding may be explained by producer firms preferring to offer organizational support to those suppliers with which they deal via pure market linkages, resulting in an estimated positive impact of the contract variable. The estimated effect of the support variables indicates that in most cases this support does not enhance the chance that a supplier experiences a positive impact. The estimated effect of the FDI variable is significant and positive, confirming the positive effect of type of ownership on the creation of a positive organizational impact among the suppliers. Finally, the technology gap and the interaction variable between FDI and the technology gap are not significantly associated with a large organizational impact, indicating that the technology gap only plays a role in processes that generate positive technological impacts.

5. Summary and Policy Implications

FDI firms can generate important technology impacts when they act as source of new knowledge and technologies to domestic firms in host economies. Having said this, the econometric evidence on FDI spillovers is heterogeneous, especially concerning intra-industry effects. An important development is that recent evidence indicates that it appears more likely that positive FDI spillovers arise between industries, in particular to local suppliers within regions of a host economy. In addition to this econometric evidence, several case studies and surveys on the dynamic impact of FDI firms present evidence on when and how FDI firms act as source of new technologies to their suppliers. Another development is that several studies look at the effect of the technology gap on FDI spillovers, attempting to identify the importance of absorptive capacity of domestic firms. The purpose of this study is to obtain new evidence on how such spillovers may arise between foreign-owned firms and local suppliers, and to investigate whether and how the technology gap influences these effects. The study incorporates the analysis of several aspects that have remained under-

explored so far, including a consistent comparison between FDI and domestic producer firms regarding their spillover creating activities and the actual impact that results from these. Also, the study analyzes the effect of the technology gap following an alternative interpretation of what this gap captures and assesses the importance of absorptive capacity for spillovers to arise between producer firms and local suppliers.

The findings of the study can be summarized as follows. First, I present detailed evidence on the scale and nature of the static and dynamic impact of FDI and domestic producer firms. Producer firms are involved in a variety of types of support and knowledge transfer activities to a substantial degree, suggesting that producer firms act as source of new technologies to their local suppliers. Importantly, the dichotomous comparisons between foreign-owned and domestic producer firms indicate that FDI firms generate a larger positive dynamic impact among suppliers. FDI firms are significantly more supportive to their suppliers. This applies especially to technological support, support with a direct positive impact on production processes of suppliers. This finding is very suggestive, especially as I find no differences between FDI firms and Mexican producer firms regarding their static impact, indicating that both types of producer firms are very similar in terms of their level of use of local and non-local suppliers. The finding that FDI firms are more supportive is confirmed by means of multivariate analysis. Furthermore, the multivariate analysis indicates that suppliers of FDI firms are more likely to experience a large positive impact, even when the analysis controls for the feature that FDI firms are more supportive and that FDI firms offer more support when there is a large technology gap with local suppliers. This latter aspect only applies to the provision of technological support to suppliers of material inputs. Importantly, I find no evidence that the estimated positive effect of having foreign-owned client firms could be (partly) caused by suppliers self-selecting into becoming suppliers of FDI firms.

Second, the study investigates the impact of the technology gap, assuming that the effect of the technology gap is positive. The common assumption that the technology gap is an inverse direct indicator of the level of absorptive capacity of domestic firms is conceptually unsound and there is substantial evidence that a large instead of a small technology gap promotes positive spillovers. Alternatively, based on the original concept of catch-up, I expect a positive effect on the technology gap on spillovers. A large technology gap represents a large potential scope of improvement among suppliers, offering incentives to the suppliers to try to absorb new technologies. The findings indicate that the technology gap plays a varied role, subject to the nature of support that is provided and the impact that is generated. Looking at the findings on the determinants of support, producer firms in general lower their support when the level of technological differences with local suppliers is large. However, FDI firms increase their support under a large technology gap. This suggests that whereas domestic firms see a large gap as an obstruction, foreign-owned firms see it as reflecting the large potential improvement that suppliers may achieve. The restriction to this is that this only applies to the provision of technological support to suppliers of material inputs. This implies that FDI firms are able to assess the potential improvements of their suppliers when it concerns their actual production processes, and only of suppliers of those inputs with which foreign-owned firms have sufficient experience themselves. As for the effect of the technology gap on the actual impact among suppliers, I find that a large gap increases the chance that a large impact materializes, in line with the alternative interpretation of what the technology gap captures. Similar to the findings on the determinants of the provision of support, the positive effect of the technology gap on the impact that FDI firms create only applies to impacts of a technological nature. Also, given that the estimations control for the level of support provided by producer firms as well as type of ownership of client firms, the estimated positive effect of the technology cap can be interpreted as indicating that local

suppliers are making efforts to absorb new technologies when the potential to obtain benefits from doing so is large.

Third, the study analyzes the importance of the level of absorptive capacity of domestic firms for the materialization of positive spillovers. The alternative interpretation of what the technology gap stands for rejects any link between this gap and the level of absorptive capacity of domestic firms. This does not mean that absorptive capacity is not important, however. Considering the underlying concept of catch up, a sufficient level of absorptive capacity and large technological differences are both required for meaningful effects to occur. Therefore, I introduce several alternative indicators of the level of absorptive capacity of domestic suppliers. The findings confirm that absorptive capacity of local suppliers is important, as these indicators are positively associated with the impact that suppliers experience from their business dealings with their client firms. This indicates that it is important to include separate controls for the technology gap and absorptive capacity, as both concepts can have independent effects on the materialization of positive spillover effects.

Finally, the findings carry several policy implications. First of all, at a general level, findings from the producer and suppliers surveys show that producer firms are involved in a variety of knowledge transfer activities and that suppliers experience positive technological and organizational impacts. This confirms the notion that FDI firms can be linked to positive spillover effects, suggesting that government policies to attract foreign-owned firms to foster economic and technological development have merit. Furthermore, the findings of the present study identify inter-firm linkages between FDI firms and their local suppliers as an important channel that transfers knowledge and technologies to these domestic firms. This indicates that, in extension of merely attracting FDI firms, there is a clear scope for host economy governments to design policies that can influence positive FDI spillovers. Of course, the findings from the present study only apply to one region in a developing host economy setting and the exact nature of the technology impact is likely to vary between regions and host economies. However, the findings confirm the notion that FDI firms can be engaged in a variety of supportive behavior towards their local suppliers, supporting the general policy of FDI-driven economic and technological development in developing host economies.

Second, the findings show that FDI firms are more supportive than domestic producer firms and that suppliers of FDI firms are more likely to experience large positive impacts. This indicates that policies that attract FDI firms to promote technological development of domestic firms may be successful, given that these firms are creating more technology flows to local suppliers. Having said this, the findings also indicate that domestic firms are also involved in knowledge transfer activities and act as source of new technologies to their suppliers. As such, policies designed to promote regional economic and technological development can be successful when focusing on technology flows that arise from FDI firms, but these policies may also include the further promotion of domestic producer firms that generate such flows. In any case, host economy governments will benefit greatly from obtaining detailed information on whether and how technology flows occur between foreign-owned and domestic producer firms and local suppliers and whether and how there may be differences in the regional impacts that different types of producer firm create.

Third, the findings indicate that a large technology gap between FDI firms and local suppliers fosters the occurrence of positive spillover effects. The original interpretation of the technology gap as direct inverse indicator of absorptive capacity of domestic firms suggest that, to facilitate FDI spillovers, host economy governments should attract FDI firms that are technologically not too different from domestic firms. In contrast, the present findings indicate that FDI firms need to be attracted that are technologically substantially more advanced, in order to allow meaningful effects to arise. This finding is especially relevant given the Mexican context where the economy is trying to move away from low skilled labor

intensive industries towards technology and skilled-labor intensive manufacturing activities. Furthermore, the study finds that FDI firms provide more technological support when the technology gap is large, indicating that FDI firms can generate larger spillovers when they are able to assess whether domestic firms will be able to achieve the necessary improvements. This suggests that regional host economies may foster FDI-induced technology flows by designing policies that improve the FDI firms' familiarity and understanding of the local supplier base. If foreign-owned firms and the local supplier base work together in e.g. local industry associations and regional development agencies, it may be that FDI firms will improve their capacity to judge which local suppliers may be able to improve, resulting in an increase in the number of local suppliers that will receive support.

Finally, in extension of the third policy implication, the study shows that the level of absorptive capacity of domestic firms is clearly important for the occurrence of positive spillovers. This is an important finding, especially considering the policy implication that governments should focus on attracting FDI firms that are technologically substantially more advanced than domestic firms. The potentially large scope of improvements that suppliers can achieve when technologically sophisticated foreign-owned firms enter a host economy will depend crucially on their capacity to learn from and absorb new technologies incorporated into the FDI firms. In conjunction with the operations and actions of FDI firms and local suppliers, regional governments have a real opportunity to increase positive spillover effects, by investing in improving the level of absorptive capacity of local suppliers.

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Table A. Characteristics Producer Firms and Local Suppliers

Characteristics producer firms	No. of firms	Characteristics local suppliers	No. of firms
Ownership		Type of product	
Mexican	32	Raw materials	10
FDI	50	Parts and components	23
		Production services	35
Foreign-owned		Machinery and parts	32
US	37		
Japan	6	Age (years)	
Other	7	0-9	24
		10-15	21
Sector		> 15	55
Chemical	20		
Electronics	19	Size (employees)	
Cars/Car engines	43	0-10	30
		11-49	44
Size (employees)		50-150	23
150-250	40		
251-500	21	Client firms	
> 500	21	Mexican	43
		FDI firms	19
Age (years)		Both types	38
0-9	24		
10-15	14	Exports	
> 15	44	No	73
		Yes	27
Exports (% sales)			
0-10	27	Sales in regional economy	
11-30	18	0-20	12
> 30	37	21-75	61
		> 75	27

Table B. Variables uses in multivariate analysis on determinants of provision of support

Name	Description	Measurement
AGE	Age of producer firm	Ln (nr years in operation)
SIZE	Size of producer firm	Ln (nr employees)
MAT	Use of material inputs	Material inputs as % total input costs
MAQUILA	First generation Maquiladora firms	Dummy variable taking value of 1 when a Maquiladora firms has been in operation in the region for 15 years or more
NEWMAQUILA	Younger generation Maquiladora firms	Dummy variable taking value of 1 when a firm is participating in the Maquiladora program
FDI	Foreign-owned producer firm	Dummy variable taking value of 1 when a firm has 10% or more foreign participation
TECHGAP	Indicator of size technology gap between producer firm and suppliers	Dummy variable taking value of 1 when producer firm indicates that large technology gap is one of the 2 most important reasons not to increase use of local suppliers
INDUSTRY	Chemical, electronics and car industries	Dummy variables for the three industries

All variables are calculated with information from the producer survey

Table C. Variables uses in multivariate analysis on determinants of large impact

Name	Description	Measurement
SIZE	Size of supplier	Ln (number of employees)
EXPERIENCE	Experience as supplier in regional economy	Ln (number of years in operation)
QUALITY	Frequency of problems with quality control systems and other technical production issues	Scale of 1-4; 1 = no problems, 4 = frequent problems
CONTRACT	Type of contract between supplier and client firms	Dummy variable taking value of 1 when supplier uses standard purchasing orders (*)
TECHSUPPORT	Level of technological support that a supplier receives from client firms	Summation of frequent support received in form of product design, use of machinery, use of advanced tools, quality control systems and development of human capital
ORGSUPPORT	Level of organizational support that a supplier receives from client firms	Summation of frequent support received in form of business organization, finances, sourcing of inputs, exporting and diversification of products
FDI	Type of ownership of a supplier's client firms	Dummy variable taking the value of 1 when a supplier's client firms are only or mainly foreign-owned
TECHGAP	Indicator of level technological differences between a supplier and its client firms	Scale of 1-4; 1 = no technology gap, 4 = large technology gap

(*) Suppliers were asked to indicate on a scale of 1 to 4, with one being standard purchasing orders and 4 representing monthly contacts between supplier and client firms, to indicate the degree to which their business relations with their client firms involve frequent contacts and coordination. Given the preference of the suppliers for either 1 or 4, this variable is transformed into a dummy variable.

All variables are calculated with information from the supplier survey