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"Multinational Firms, Global Value Chains and the Organization of Technology Transfer"

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Multinational firms, global value chains and the organization of technology transfer

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Abstract

This paper combines insights from different streams of literature to develop a more comprehensive framework for the analysis of technology transfer via value chain relationships. We integrate the existing literature in three ways. First, we consider value chain relationships as a multi-facet process of interaction between buyers and suppliers, involving different degrees of knowledge transmission and development. Second, we assess whether and to what extent value chain relationships are associated with the presence of multinationals and with their embeddedness in the host economy. Third, we take into account the capabilities of local firms to handle the technology as a factor influencing knowledge transfer through value chain relationships. Using data on 1385 firms active in Thailand in 2001-2003, we apply a multinomial logit model to test how the nature and intensity of multinational presence and the competencies of local firms affect the organisation of international technology transfer. We find that knowledge intensive relationships, which are characterized by a significant transmission of technology along the value chains, are positively associated with the presence of global buyers in the local market, with the efforts of MNCs to adapt technology to local contexts, and with the technical capabilities of domestic firms. By contrast, the age of subsidiaries and the share of inputs purchased locally appear to increase the likelihood of value chain relationships with a lower technological profile.

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Multinational firms, global value chains and the organization of technology transfer

1. Introduction

Multinational firms are widely considered as crucial actors in technology transfer to local firms, especially when Less Developed Countries are considered as recipient economies. Relationships with suppliers are key channels in this perspective. Using a jargon increasingly adopted in the literature, we shall identify these vertical relationships with the term "value chain relationships" (or "Value chain governance modes"), through which production processes are organized on a global scale (Sturgeon 2001). The development of such organizational arrangements goes hand in hand with significant knowledge flows. Some knowledge transfer occurs involuntarily through imitation of the technological and managerial practices of global buyers. Important knowledge assets are also transferred voluntarily by multinationals in their efforts to increase the efficiency of their local suppliers (and to obtain access to local competencies on a reciprocity basis). However, not all value chain relationships are equally conducive to knowledge transfer. In this paper we analyze under which circumstances local firms get involved in knowledge intensive value chain relationships.

Different streams of literature provide complementary insights on factors enhancing technology transfer through global value chain relationships. Among other strands of contributions, international production literature has emphasized a number of characteristics of both foreign and domestic firms which may favor vertical linkages, technology transfer and productivity spillovers. On the one hand, several features of foreign firms have been highlighted, including the intensity of their presence in a given market and their degree of embeddedness in local contexts. On the other hand, local skill endowment and ability to handle knowledge is also stressed as a fundamental condition making it advantageous for foreign firms to engage in technology transfer, and for domestic firms to gain access to foreign knowledge. While this stream of literature highlights the importance of linkage creation in the transfer of technology, the main focus remains on the international organization of production taking place within the boundaries of multinational firms. As a result, most of these contributions largely disregard the extreme variety of value chain relationships in which multinationals are involved.

From a different perspective and with a lesser focus on multinational enterprises, recent developments in the "Global value chain" literature have drawn attention to the variety of value chain relationships wherein global buyers interact with local suppliers in different countries. Alternative relationships (governance modes) will emerge in the presence of different degrees of standardization of products and processes, and of different competencies of suppliers. As we shall highlight in reviewing this literature, the mode of governance is essential for understanding whether and how firms in developing countries can gain access to global markets, and benefit from them. However, this line of research places no particular emphasis on the characteristics of buyers, apart from their being global in nature. As opposed to works on the economics of international production, and quite symmetrically, global value chain literature has the merit of exploring the heterogeneity of governance modes but it neglects structural and behavioral differences across global buyers.

Combining insights from these two streams of literature, we develop a more comprehensive analytical framework to evaluate the choice of alternative modes of organizing technology transfer from global buyers to local suppliers. We shall follow five steps. First, we shall identify a

wider range of value chain agreements than is usually the case in contributions on multinational firms and international production. Second, we shall allow for a greater heterogeneity of global buyers than is commonly done in the global value chain literature. Third, we shall take account of competencies of local firms as emphasized by both streams of research. Fourth, we shall argue that the characteristics of both foreign and domestic firms affect the choice of value chain governance modes. Fifth, and finally, we shall apply this more comprehensive analytical framework to the case of value chain arrangements in Thailand, using data from the "Productivity and the Investment Climate Private Enterprise Survey" (PICS), conducted by the World Bank on a representative (stratified) sample of 1,385 Thai firms from 2001 to 2003.

The paper is structured as follows. Section 2 overviews the background literature. Section 3 develops an integrated approach to the analysis of global value chain relationships and presents the main hypotheses. Section 4 illustrates the data and measures used for our empirical tests. Section 5 presents the empirical model and discusses the results of our econometric exercises. Section 6 concludes.

2. Previous literature

A plethora of contributions have focused on vertical relationships as a channel through which multinational firms, or more generally "global actors", transfer technology to local companies. For the purpose of the present paper, it is worth recalling some, largely complementary, developments which have emerged from two main streams of literature whose convergence would in our view generate useful synergies. On the one hand, important insights stem from a rather consolidated, albeit variegated, strand of contributions focusing on the economics and management of the multinational corporation (MNC) and its key role in the international organization of production. We shall refer to this as International Production literature (see Ietto-Gillies 1992, Cantwell 2000 for extensive reviews of the different schools of thought which can be made fall under this heading). On the other hand, recent developments in the Global Value Chain literature have focused on more specific types of linkages, namely relationships through which global buyers organize their transactions along the value chains on a global scale (See Kaplinski and Morris 2001 for a review) and on the importance of these linkages for local suppliers' performance.

With no pretension of an exhaustive survey of the views on linkage creation and technology transfer in the very broad international production literature, one can easily single out three main approaches which are directly relevant to the scope of this paper.

First, the issue has been tackled in the rather extensive literature on the changing nature of multinationals enterprises and their growing involvement in international collaborative ventures. While empirical studies on international joint venturing have been proliferating since the mid 1980's (see Mowery 1988 for a comprehensive overview of the phenomenon in different industries), one may consider the works by Cantwell (1989) and Dunning (1993 and 1995) as some of the earliest and most path-breaking in this respect. From a historical perspective Dunning (1995) theorized the emergence of what he called "Alliance capitalism", as a result of the globalization of markets and of the changing nature of technology in a number of sectors. These forces are considered as fundamental pressures leading to a changing organization of MNCs, which increasingly have to resort to linkages with foreign counterparts endowed with complementary competencies. Building on these insights and earlier empirical work, several studies have explored different aspects of this changing nature of multinationals. These aspects range from the role of international alliances in the process of technological diversification and

asset seeking strategies of multinational enterprises (Granstrand et al.1993, Cantwell and Piscitello 2000, Narula 2003); to the complementarities between internal networks of subsidiaries and external networks of cooperation with local firms and institutions (Zanfei 2000, Castellani and Zanfei 2004); to the choice of alternative market entry strategies, including joint ventures and contractual agreements with local counterparts (Gomes-Casserses 1989, Hennart and Larimo 1998, Nisbet et al 2003); to the use of international networks to increase bargaining power of multinationals *vis à vis* national governments, labor forces and other stakeholders (Cowling and Sugden 1978, Ietto-Gillies 2002). Although with different emphasis on technology transfer issues, these strands of research share the concern about the fact that the boundaries of MNCs are changing and getting fuzzier, and this can give rise to increasing voluntary and involuntary knowledge flows across countries.

Second, the issue of linkages and knowledge transfer has been at center stage in the rather extensive literature on the embeddedness of MNCs. Even though there is a variety of ways in which this notion has been conceptualized in the literature (Dacin et al. 1999), there seems to be some convergence on the idea that at least three aspects are topical. One of these corresponds to the idea that firms may take advantages from "taking roots" in a given context. This can be assimilated to a learning process and requires time to take place, hence it is correlated to the length of establishment of multinationals in local contexts. A lengthy experience of local contexts is expected to favor acquaintance with local norms and codes of conduct, something which may help create mutual trust and make transactions more effective (Vaccà 1996, Burchell and Wilkisson 1997). A second aspect emphasized in this literature is that firms become embedded by means of extensive webs of transactions with local counterparts, and this will increase access to local competencies and eventually evolve into "thicker" relationships involving knowledge exchanges (Andersson and Forsgren 1996). A third aspect is adaptation. By adapting to local practices, e.g. in the area of human resource management, and by modifying products and processes to local requirements, MNCs are able to achieve better performances at the plant level and to increase local market penetration (Rosenzweig and Nohria 1994, Andersson et al. 2005). Adaptive efforts require knowledge of local contexts, and this is likely to be attained by means of (technical) linkages with local firms and institutions.

Third, linkages with local firms are one of the key channels through which MNCs may generate knowledge (and pecuniary) spillovers to the host economy. This issue has a long tradition of studies dating back to Hirschman (1958) and Lall (1978) and recently revived by Rodriguez-Clare (1996), Markusen and Venables (1999) and Jarvocik-Smarzynska (2004). Multinational firms may enter into a foreign country by setting up plants in upstream industries, where intermediate inputs are produced, or in downstream industries, mainly producing final goods. In both cases they tend to crowd out domestic competitors, but they are also likely to induce forward (in the former case) and backward (in the latter case) linkages, with positive effects on local firms. These effects may hinge upon the expansion of demand for local inputs, inducing higher efficiency; and on voluntary and involuntary technology transfer from multinationals to local suppliers and customers (see Castellani and Zanfei 2006 for a review of the theoretical and empirical literature on this issue). While an improvement of supplier performances has been observed in many developing countries as a result of linkage creation processes (Unctad 2001), recent studies report some evidence that there can be positive effects for local firms also when multinationals source in advanced countries (Potter, Moore and Spires, 2003, Crone and Roper, 2001, Veuglers and Cassiman 2004). Some works have stressed the importance of local firms' competencies and absorptive capacity as a necessary condition for spillovers to accrue to the host economies (Cantwell 1989, Kokko 1994). Other studies have emphasized that positive spillovers are more likely to occur when high local competencies combine with the presence of foreign firms that are as close as possible to the technological frontier (Castellani and Zanfei 2006).

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As anticipated earlier in this section, a number of scholars have more recently considered the issue of linkage creation and international transmission of knowledge from the "Global value chain" (GVC) perspective. The focus in these studies is on how firms active in international markets organize the transfer and coordination of complex and strategic information along the value chains (Baldwin and Clark 2000; Sturgeon, 2000, 2002; Takeishi and Fujimoto, 2001; Langlois, 2003; Sturgeon and Lee, 2005).

With a lesser focus on MNCs, GVC approach analyzes the activities taking place outside the firm, and in particular the strategic role of the relationships with key external actors and their implications for development.

Drawing from the transaction cost literature, Gereffi et al. (1990) developed a pioneer framework that tied the concept of the value-added chain directly to the global organization of industries. He thereafter introduced the notion of "governance" of the Value Chains, defined as "authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain" (Gereffi, 1994) This concept is now central in the literature. However, recent developments have placed much more emphasis than original contributions on non-hierarchical governance modes. Among others, Gereffi et. al (2005) have stressed the role of inter-firm relationships and of institutional mechanisms through which non-market co-ordination of activities in the chain is achieved.

A set of strategic parameters can be highlighted as characterizing governance modes: what is to be produced, how it is to be produced, when it is to be produced and how much is to be produced. By focusing explicitly on the governance of disintegrated chains, the Global Value Chains approach drew attention to the first two critical parameters for value chain governance: what is to be produced, and how it is to be produced

Humphrey and Schmitz (2000) argue that two distinct types of governance should be distinguished according to these parameters. On the one hand, there are relationships that bring together firms with complementary competences which will jointly set the key parameters. They refer to these as "networks", as the term is frequently used to denote some form of co-operation between "equals". On the other hand, there are relationships characterized by a marked asymmetry of competence and power between the lead firm and subordinate firms within the chain. The lead firm often specifies what is to be produced, how it is to be produced and how the performance of firms in the chain is to be monitored. Humphrey and Schmitz refer to this form of governance as "quasi-hierarchy".

Global Buyers most often play as "lead firms", setting these governance parameters in quasi-hierarchic relationships, especially when they source inputs from developing countries. The form and the level of detail at which the buyers specify the parameters may vary substantially across countries and sectors. As an example, buyers can provide suppliers with a particular design for the producer to work on, they can get involved in their suppliers' quality systems, or even help them to introduce particular production processes, effective routines, or monitoring procedures.

Referring to this phenomenon, Gereffi earlier introduced a distinction between producer-driven and buyer-driven global value chains (Gereffi 1994). In the former, the parameters setting is undertaken by the producers, defined as the firm which control key product and process technologies; while in the latter the key parameters are set by retailers and brand-name firms which do not necessarily involve in production facilities. More recently Gereffi (1999b) has also pointed out that each of these different types of value chain is associated with different types of production systems. However the idea that there may be heterogeneity in the behaviors of actors involved in global value chains, implying different governance modes, has not been fully

developed in subsequent literature, particularly when the role of buyers is at stake.[1] Much greater attention is given to other aspects affecting the choice of governance modes, including the nature of technology and the competencies of suppliers.

The nature of technology is at centre stage in several GVC studies on the electronics sector. Focusing on Value Chains and Production Networks, Sturgeon (2002) and Sturgeon and Lee (2001) emphasize the complexity of information exchanged between firms and the degree of asset specificity in production equipment. They highlight three types of value chain relationships, based on the degree of standardization of product and process: (1) the "commodity supplier" that provides standard products through arm's length market relationships, (2) the "captive supplier" that makes non standard products using machinery dedicated to the buyer's needs, and (3) the "turn-key supplier" that produces customized products for buyers, and uses flexible machinery to pool capacity for different customers. Hence technical change, affecting the nature and the degree of standardization of products and processes, has a significant impact on, and is influenced by, the evolution of governance modes in time. [2]

Gereffi, Humphrey and Sturgeon (2004) go deeper into the analysis of factors affecting alternative governance modes. They put forward the idea that there are three key determinants of value chain relationships: the complexity of information and knowledge transfer required to sustain a particular transaction, especially with respect to product and process specifications; the extent to which this information and knowledge can be codified and, therefore, transmitted efficiently and without transaction-specific investment between the parties involved in the transaction; the capabilities of actual and potential suppliers in relation to the requirements of the transaction.

The competencies of suppliers play a key role in the development of governance modes as they affect both the ability of local firms to contribute to technical change, and their bargaining power *vis à vis* global buyers. However, the causal relation also goes the other way around, from governance modes to firms' competencies. There is consensus among GVC scholars that the governance of the value chain importantly affects the generation, transfer and diffusion of knowledge (Humphrey and Schmitz, 2000). The link between enterprise upgrading and GVC governance has also been made more explicit recently; in a GVC context, upgrading is defined as innovating to increase value added (Giuliani, et, al., 2005, Pietrobelli and Rabellotti 2006).

The GVC perspective is useful for various reasons. First, because the focus moves from manufacturing only to the other activities involved in the value chains of goods and services, including distribution and marketing. These activities account for increasing shares of GDP worldwide. Second, GVC emphasizes the nature of the relationships among the various actors involved in the chain, and their implications for development. Moving beyond firm-specific analysis and concentrating on inter-firm linkages, it allows to better capture dynamic flows of

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[1] We shall reconsider this insight in section 3 of this paper.

[2] The concept of governance in the GVC literature is by and large dynamic. Humphrey and Schmitz (2002b) underline three factors which may affect the stability and evolution of governance mode: a) power relationships may evolve when existing producers, or their spin-offs, acquire new capabilities; b) establishing and maintaining quasi-hierarchical governance is costly for the lead firm and induces organizational rigidity because of transaction specific investments and c) firms and clusters often do not operate only in one chain but rather simultaneously in several types of chains, therefore they may apply competencies learned in one chain to value other chains

economic and organizational activities between producers within different sectors even on a global scale.[3]

Finally, for the purposes of the present paper, it is important to stress a further advantage of adopting this perspective. GVC studies identify distinct types of relationships characterized by a different level of involvement of suppliers in knowledge intensive activities. As a result, they help explore under which circumstances value chain agreements can lead to technology dissemination and absorption, hence favoring the development of local suppliers. This suggests it may be particularly useful to integrate the view of international technology transfer emerged from international production literature, as recalled earlier in this section, with the analysis of value chain relationships developed in GVC studies.

3. An integrated framework for the analysis of value chains and technology transfer

In this section we integrate and build on the existing literature in three ways. First, we consider value chain relationships as a multi-facet process of interaction between buyers and suppliers, involving different forms of knowledge transmission and development. Second, we assess whether and to what extent value chain governance is affected by the presence of multinationals and by their embeddedness in the host economy. Third, we take into account the capabilities of suppliers to handle the technology as a factor influencing technology transfer through value chain relationships.

As regards the first analytical step, we assume that value chain relationships can be classified according to the way suppliers are involved in the adoption, use and co-development of technology. On the one hand, this involvement will vary with the nature of technologies and with the capabilities of actors (Von Hippel 1988, Robertson and Langlois 1995). On the other hand, the role of suppliers in technology development reflects strategic decisions (the so called "parameter setting") concerning what is to be produced and on how it is to be produced (Gereffi 1994; Humphrey and Schmitz 2000).

While all value chain relationships do imply some transmission of information between the parties, the extent to which knowledge is actually created, transferred and adopted along the value chains varies dramatically. From this perspective, one can characterize at least three different types of value chain agreements. The first is characterized by the transfer of a product specification from the purchasing firm to the supplier, and implies that the latter will execute a number of tasks on her own which will eventually lead to the provision of the required good (or service), following the directions given by the buyer. Under this circumstance, knowledge transferred is kept to a minimum, will be mostly codified, and it will flow in one direction only (from the buyer to the supplier). A second form of knowledge development and transmission takes place when the buyer provides details of the product design and defines precise quality standards to be followed in the production process. Knowledge transfer is here much more intensive; it might require some knowledge feed-backs from the supplier to ensure that procedures are being followed correctly and standards are being met; and part of the knowledge needed in this interaction might be tacit in nature. A third typology of value chain relationship can be observed when the buyer disseminates specialized competencies, and involves the supplier in R&D and technology development. In this case the amount of knowledge transfer is highest,

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[3] For example, scrap metal collectors in South Africa are inextricably linked to a global export trade. They bring scrap metal in old trolleys directly to shipping agents who pay them London spot prices and transfer the scrap immediately to ships for export to iron and steel furnaces across the globe (Kaplinsky and Morris 2001).

hence we shall refer to these as "knowledge intensive relationships". One should notice it is not only a matter of "quantity" of technology flowing between firms: a substantial part of the transfer takes place through the mobility of personnel and the knowledge involved is thus tacit in nature, and flows in both directions, although not necessarily in a balanced way.

These typologies of value chain relationships thus correspond to different modes of organizing (international) technology transfer and diffusion. The analysis of the actual impact of value chain relationships on the host economy is well beyond the scope of the present paper. However, one may suggest that as one proceeds from the first to the third typology illustrated above, value chain relationships will be characterized by more and more significant knowledge exchanges between global buyers and local suppliers. In the case of LDCs as recipient countries, one may expect that the latter governance modes will be associated with a higher degree of technology transfer towards local firms..

The second analytical step anticipated earlier in this section consists in singling out the characteristics of global buyers which can be associated with the choice of value chain relationships. As argued earlier in this paper, this aspect has been largely disregarded in GVC literature. The only feature of buyers considered in these studies is their "global" nature as this implies a greater ability to switch to alternative suppliers in different countries and hence accumulate a greater bargaining power. We here argue that other characteristics of global buyers do matter, particularly whether and to what extent they are present in the market where suppliers are active; and their degree of embeddedness in local contexts. Let us briefly discuss both of these factors.

As far as *multinational presence* is concerned, we expect that global buyers with an extensive web of subsidiaries in a given country and sector will have a higher propensity to set up knowledge intensive value chain agreements in that country and sector. Hence linkages of the third type described earlier will be more likely. In fact, acquaintance with the technical jargon, local norms and codes of conduct that are used in a specific context will reduce the uncertainty concerning the behavior of potential partners involved in a given transaction. This will eventually pave the way for a greater involvement of local counterparts in collaborative activities.[4] Moreover, the availability of extensive webs of subsidiaries located in a given market is likely to enable MNCs to better monitor alternative suppliers that are active locally. On the one hand, this will increase the outside options available to the MNC locally, hence reducing the risk that their counterparts behave opportunistically. On the other hand, there will be a greater possibility of selecting effective and reliable partners, thus increasing the expected payoff from technology transfer. This line of argument can be summarized in the following hypothesis.

H1: Global buyers with a significant presence in the local market are more likely to set up knowledge intensive value chain arrangements.

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[4] One may observe that multinational presence will also reduce the "external uncertainty" concerning factors that are at least partially beyond the control of individual companies, such as the characteristics of local demand, institutions and business environment. As foreign firms increase their presence in a host economy and gather more information on these factors (hence reducing their uncertainty) they can be expected to be more prone to commit directly to local activities, possibly substituting for local suppliers. While this argument certainly applies when (static) transaction cost minimisation is at stake, it seems to be much less the case of technology transfer operations, wherein dynamic efficiency considerations are at centre stage. See Castellani and Zanfei (2004) for a discussion of this issue.

However, by emphasizing the importance of an extensive multinational presence we can capture only part of the story. The quality of multinational presence also matters. An important qualitative aspect of multinational presence is the degree of *embeddedness* of affiliates. As recalled in section 2, there is still some variety in the way the notion of embeddedness is being conceptualized and operationalized in the literature (Dacin 1999). Nevertheless, most writings recognize that at least three aspects are involved. The first aspect to be considered is that taking roots in the host economy is by and large a function of time. This aspect was clearly illustrated by Dunning (1958) in his seminal study on US multinational penetration in the UK after WWII. From this perspective, the age of subsidiaries since establishment is a good predictor of acquaintance with local contexts, and may be expected to further reduce the behavioral uncertainty we have already referred to when talking about mere multinational presence. This would thus lead us to conclude that the longer the time since establishment, the greater will be a subsidiary's propensity to get involved in knowledge intensive activities:

H2: The age of subsidiaries since their establishment increases the likelihood of knowledge intensive value chain agreements

The second aspect characterizing the concept of embeddedness is the intensity of local sourcing of inputs for production. MNCs buying their inputs locally are likely to do so as part of more comprehensive value chain agreements with indigenous firms (Andersson and Forsgren 1996). However, this will not necessarily guarantee that significant amounts of technology be transferred within these value chain relationships. When inputs are sourced in LDCs, a high share of purchases carried out locally may signal that MNCs are more concerned with cost saving than with quality and technology content. Hence we expect that high shares of inputs bought locally be associated with value chain relationships at the lower bound in the knowledge intensity scale:

H3: The higher the share of inputs bought in a context characterized by low level of industrial development, the greater the likelihood of arrangements aimed at purchasing low cost goods, and the lower the transfer of technology

The third feature of embeddedness is adaptation of MNCs to local practices and demand conditions (Lane and Lubatkin 1998). Foreign firms may increase their local embeddedness by adapting to local procedures, norms of conduct and habits, especially in the field of human resource management (Rosenzweig and Nohria 1994). They can also adapt a wider range of practices, including their product and process technology and their standard operating procedures, as illustrated by Andersson et al. (2005) with reference to about 160 subsidiaries US and European multinationals. To the extent that subsidiaries pursue strategies of technology adaptation to local demands, one may expect they will set up comprehensive value chain arrangements through which they will exchange substantial amounts of knowledge. That is, subsidiaries will be ready to transfer technology in order to have access to adaptation and application abilities on a reciprocity basis. Hence our fourth hypothesis:

H4: The higher the efforts to adapt products and processes, the higher the recourse to knowledge intensive value chain relationships

A final step in our analytical framework concerns the competencies of local suppliers and how these can be associated with different governance modes. This aspect is emphasized in different

streams of literature, including the GVC approach. Here we shall follow more closely the technological accumulation tradition within the international production literature (Cantwell 1989, Kogut and Zander 1993) wherein the importance of absorptive capacity is stressed as a key condition favoring interaction between MNCs and local contexts. Following Cohen and Levinthal (1989), the idea is that domestic firms will need some competencies not only to handle the knowledge they are already endowed with, but also as a means to gain access to external sources of technology, including multinationals. From this perspective, value chain agreements are all the more likely to be an effective vehicle of knowledge transfer and adoption the greater the technical competencies of local suppliers. This for at least two sets of reasons. First, MNCs themselves are more likely to be willing to transfer technology to partners that are able to use it effectively within the value chain arrangements, especially when appropriability regimes are well defined (Teece 1992) and/or technology is modular enough to allow an effective division of labor along the value chains (Gereffi et al 2004).[5] Moreover, dealing with skilled suppliers reduces the risk that "residual incompatibilities" arise between the overall product design and the components manufactured by local suppliers (Puga and Trefler 2005). Second, the more suppliers are endowed with some technical skills, the more they will be interested in entering knowledge intensive value chain agreements, because the payoff they can expect to obtain from access to external sources of technology will be higher (Cohen and Levinthal 1989).[6] To summarise, a final hypothesis can be put forth here:

H5: The higher the technical capabilities of local suppliers the greater the likelihood that value chain arrangement are knowledge intensive.

4. Data and variable specification

4.1 Sample and sources
This paper uses new firm level data from Thailand to test the five hypotheses presented above. The data come from the "Productivity and the Investment Climate Private Enterprise Survey" (PICS), conducted by the World Bank on a sample of 1,385 Thai firms in 2004. Surveyed firms are active in the following industries: Food Processing, Textile and Clothing, Wooden Furniture and Product, Auto parts, Electronics, Rubber and Plastic, Machinery and Equipment. These industries account together for more than half of the entire manufacturing value added and of manufacturing exports. The regions covered are six: North, North East, Central, Bangkok and Vicinity, East and South.
The Enterprise Surveys sample the universe of registered businesses and follow a stratified random sampling methodology.[7] The unit of analysis was the plant and the enumerators personally gathered the information. The survey questionnaire called for a variety of qualitative and quantitative information. The qualitative section covered issues related to ownership structure, technology acquisition, views on the business environment, and relationships with banks and other financial institutions. The quantitative section included questions on production, financial accounts and human resources.

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[5] The reverse also applies: researchers have often highlighted that the lack of learning incentives and absorptive capacities may represent the reasons for the failure of technology transfer on the part of the transferor (Martin and Salomon, 2003)

[6] In a similar vein, Szulanski (1996) finds that lack of absorptive capacities is a major barrier to internal knowledge transfer for eight large U.S. corporations.

[7] For further information: http://www.enterprisesurveys.org/ICAs.aspx

Only registered firms were included in the population frame. The latter has been assembled by the national statistical agency with technical assistance from the World Bank, and it was then used to randomly choose the sample of small, medium and large establishments to be interviewed.[8]

4.2 Why Thailand

There are several reasons why it is worth using data on Thailand to examine the role of multinationals, FDIs and global value chains.

First, throughout the past decades, Thailand has experienced a rapid growth in private investment, both by local firms and by foreign multinationals through FDIs. This country has been a major FDI recipient in South-East Asia over the past two decades (Brimble and Sherman, 1999; Mephokee, 2002). As a matter of fact, in 2004, the Global Investment Prospects Assessment (GIPA) of UNCTAD (United Nations Conference on Trade and Development) designed to analyze "future patterns of FDI flows at global, regional, national, and industry levels", has ranked Thailand as one of the four "top hot spots for FDI" in the world over the next four years, preceded only by China, India, and the United States. Thailand is ranked as the "Top 3" most attractive country for FDI flows in two separate categories - "Asia" and "Developing Economies" - listed only behind only China and India.

Second, until the late 1970s, FDI was dominant in import-substitution industries such as textiles, automobiles, and chemicals. From then on, an increasing share of FDI was directed to more export-oriented activities. Export-oriented FDI initially came to light in manufacturing industries such as clothing, textiles, footwear and toys. More recently, labor intensive assembly activities in electronics and electrical goods industries have been the main attraction to foreign investors. The shift in the composition of FDI from domestic-market oriented production to export oriented production has closely mirrored the shift in the domestic trade policy regime and the very favorable approach of the Thai government towards FDI

Third, Thailand has experienced impressively high rates of real GDP growth over most of the past 40 years. These positive achievements may partly be attributed to the successful transformation of the economic structure from agriculture to manufacturing. The share of agriculture in gross domestic product (GDP) declined from about 40 per cent in the 1960s to about 10 per cent in the 1990s, even though the contribution of agriculture to the economy grew steadily by more than 2.5 per cent annually between 1965 and 1996. However, the rapid expansion of the manufacturing sector overshadowed the growth in agriculture (Intarakumnerd et al., 2002). Manufacturing in Thailand has grown in importance over the last 25 years, and its share in GDP has grown also in the investment slump phase that hit Asian economies in more recent years. The sector is now approaching two fifths of GDP, compared to one third of GDP before the Asian crisis and just over one fifths of GDP in the early 1980s. In spite of this high growth of manufacturing activities, Thailand still exhibits a relatively low technological profile[9], which makes it particularly important for its firms to get involved in knowledge intensive relationships with foreign firms.

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8 We performed various tests to check missing values, zero sales, zero employment, and observations failing to satisfy other basic error checks.

9 Thai firms' USPTO patenting has been almost null between 1980 and 1996 and has thereafter grown very gradually to reach an average level of approximately 20 patents per year in the subsequent decade. In the same period China and India have experienced a gradual growth of inventive activity until the mid 90's and thereafter the number of patents with at least one inventor resident in one of the two countries has accelerated dramatically and exhibited an average increase of up to 75% per year (Puga and Trefler 2005) .

4.3 Variable Description

As this paper focuses on value chain relationships occurring between buyers and local suppliers, we consider two categories of firms: foreign owned firms (FOR) and domestic firms (DOM). The former category includes firms in which the share of subscribed capital owned by foreign investors is equal to at least 30 percent [10] and the main shareholder is represented by a Multinational Company, while the latter refers to firms which are national owned.[11] About 24 percent of firms in the sample meets the former definition (FOR), whereas more than 50 percent (717 active firms) meets the latter (DOM)[12]. FOR firms buy their inputs in the local market and export the most of their production abroad, and DOM firms sell more than 50% of their output in the domestic market.

The distribution of firms is quite uneven across industries in our sample. The presence of FOR firms is concentrated in Electronics and Automotive parts, characterized by high levels of research and development, and a large share of professional and technical workers, and in Textile and Clothing. DOM firms are concentrated heavily in Textile and Clothing too and in Rubber and Plastics industry FOR firms are generally larger than domestic firms. See Appendix 1 for descriptive statistics on these categories of firms.

The next step is to build our measure of value chain governance which will represent the dependent variable in our econometric exercise. To this aim, we take into account the theoretical framework developed in Section 3, on the one hand, and peculiarities of the Thai production system, on the other hand. We define a measure of value chain governance based on the following variables:

a) percentage of sales made by suppliers exclusively to suit buyer's specification;
b) whether the buyer provided information on Design/Quality (i.e. product characteristics) and imposed product quality standards;
c) whether the buyer engaged the supplier in process or product R&D type of activities;
d) whether the buyer sent employees to (or organized personnel exchanges with) suppliers as a means to disseminate and diffuse new technologies into the local firms' production facilities.

Consistent with our discussion in section 3, we identify three basic types of value chain governance characterized by different combinations of the key variables above(Table 1). GOV0 reflects a situation where less than 30 percent of total sales are made to meet the client's unique specification, and suppliers do not receive further inputs from the buyers; GOV1 type reflects a situation where the buyer is responsible for more than 30% of the supplier's total sales, and the client not only transfers a product specification but also provides details on the product design and intervenes to ensure that quality standards are met; finally GOV2 occurs when captive sales are higher than 30% and together with product specification, design and quality standards, the buyer disseminates technology and R&D activities.

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[10] OECD and UNCTAD use a benchmark of 10% as threshold level. Other benchmarks taken by other researches include Sjoholm (1997) who considers a 15% threshold of equity owned by foreigners, Haddad and Harrison (1993) considered foreign firms as those with at least 5 % equity owned by foreigners, Djankov and Hoekman (1998) had a benchmark of 20%, while Castellani and Zanfei (2006) considered foreign firms as those with at least 50 % equity owned by foreigners

[11] Using information about firms' ownership, whether firms have affiliates and/or separate operating facilities outside Thailand, and whether they have holdings or operations in other countries, we can reasonably state that the sample of domestic firms (DOM) does not contain any Thai (domestic) multinationals.

[12] To avoid ambiguity in the analysis, we do not consider firms which are national owned and export more than 50% of their output. These firms represent about 25 percent of firms in the sample.

Table 1 – Classification of Value Chain Governance

Types of Value Chain Governance	% of sales made according to buyers' unique specification	Design/quality and product quality standards	Technology dissemination and process and product R&D
GOV0	Less than 30%	No	No
GOV1	More than 30%	Yes	No
GOV2	More than 30%	Yes	Yes

Hence, our dependent variable GOVij takes value equal to 0 (GOV0) if captive sales of local firm *i* active in sector *j* represent a relatively low share of its total sales, no transfer of information occurs concerning design and quality standards, and there is no involvement in technology and R&D activities; equal to 1 (GOV1) if there is a high share of captive sales, a transfer of design and quality standards, but no involvement in technology and R&D; and equal to 2 (GOV2) if there is a high share of captive sales, a transfer of design and quality standards, and a direct involvement in technology and R&D activities. It is worth noting that the three governance types are characterized inter alia by a different involvement of suppliers in technology development, and by distinct degrees of knowledge transfer from multinationals to local firms. We shall accordingly refer to GOV2 as "knowledge intensive" value chain relationships to emphasize this aspect. See Appendix 1 for descriptive statistics on the distribution of these governance types across industries and firms.

We focus on a set of sector and firm specific characteristics which can be expected to be associated with these governance types. GOVij will be regressed on different measures of multinational presence, of the degree of embeddedness of foreign buyers in the host economy (Thailand), and (firm level) measures of the competencies of local suppliers. A vector Z of controls for firm size, year, region and macro-sector[13] is also introduced in all regressions. The equation to be estimated will thus be of the following type:

GOVij=f(SUBj, AGEj, LSUPj, ADAPTj, DOMTECHij, DOMPATij, Zij)

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[13] According to World Bank's ICA (Investment Climate Assessment) criteria based on OECD classification by technological intensity,we aggregated our 7 industries into four macro-sectors: High tech: electronics; Medium high tech: machinery; automotive parts; Medium low tech: rubber and plastics; Low tech: textile and clothing; food processing, wood

The functional form used for the empirical test will be discussed in section 5 below. Independent variables are defined as follows:

- Multinational presence
We computed two measures of the presence of multinationals. The foreign presence ratio (SUBj) as the share of foreign subsidiaries out of the total number of firms active in sector *j; the subsidiaries workers ratio (SUBwks*j) as the share of subsidiaries workers out of the total number of workers in sector *j*. As discussed in section 3, we expect the extent of foreign presence in the market to reduce behavioral uncertainty of MNCs and to increase the likelihood that effective suppliers are eventually selected, hence facilitating the recourse to GOV2. (see H1 in section 3).

- Multinational embeddedness
As discussed in section 3, multinational embeddedness is a multi-facet concept which can be captured by different variables. We suggest to use the following proxies.
AGE*j*: this is calculated as a weighted sum of subsidiaries, where the weights are given by the years that each subsidiary has been active in sector j in Thailand. A similar measure has been used also in Padmanabhan and Cho (1999) and Castellani and Zanfei (2004), and takes into account the length of time that foreign firms has been operating in a given market. This is expected to reinforce the impact of multinational presence and to affect positively the choice of GOV2 (see H2 in section 3).
LSUP*j*: this indicates the log of the amount of inputs bought locally by multinational subsidiaries in sector *j*. LSUP captures how extensive are the market relationships of MNCs subsidiaries with local firms, as an indicator of embeddedness. The existing literature emphasises that MNCs can obtain significant performance advantages from an extension of their relationships with local firms (Andersson 2005). For the purposes of the present analysis we suggest that, especially in the case of relationships with suppliers in LDCs, a mere increase in the share of inputs purchased locally is likely to indicate mainly an effort to obtain cost savings through value relationships. We thus expect this measure to impact positively on GOV0 and negatively on GOV2 (see H3 in section 3).
ADAPT*j*: this measure identifies whether product and process technology are adapted by MNCs active in sector *j* to local requirements. For this purpose, we use a dummy variable which takes value one when foreign firms adapt their technology to suit local conditions, and zero otherwise. As discussed in section 3, we expect this indicator to be associated with intensive exchanges of knowledge between MNCs, which value design, R&D and skills, and suppliers which co-develop the technology helping to adapt it to the local context. Hence we expect this variable to impact positively on GOV2 (see H4 in section 3).

- Domestic firms' capacity "to handle the technology"
This capacity is proxied by two variables referred to domestic (Thai) firms only. DOMPAT*ij* is a dummy variables which takes value 1 if the the domestic supplier *i* active in sector *j* has filed a patent in the last 3 years and 0 otherwise; while DOMTECH *ij* takes value 1 if domestic firm *i* active in sector *j* develops the technology within the establishment locally and 0 otherwise. These measures capture domestic firms' absorptive capacity and can be expected to be positively correlated to GOV2 (see H5 in section3).

5. Empirical analysis

5.1 Empirical model

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We use a multinomial logit model approach to investigate the correlation between value chain governance modes and the characteristics of firms and sectors in Thailand. Since GOV0, GOV2 and GOV3 represent qualitatively different modes of organizing technology transfer, which may each be influenced by different combinations of explanatory variables, a **multinomial logit** model is the most suitable for this analysis. We estimated the multinomial logit model by maximum likelihood method.

We consider a vector of explanatory variablesto examine the relationship between these variables and the y-th alternative in terms of governance levels. The vector contains the set of independent variables defined in section 4 above: the ratio of foreign subsidiaries of MNCs to total firms active in sector j (SUBj)[14], the average age of subsidiariesin sector j (AGE j), the share of inputs they buy locally (LSUPj), whether they adapt the technology to suit local conditions (ADAPTj); and the technological capabilities of domestic firms involved in the relationship (DOMTECHij and DOMPATij).[15] As mentioned earlier, controls for year, industry, region and size are also included in this vector.

Following Greene (1997), we define a multi-category variable (y) as dependent variable. Let x be the vector of explanatory variables, the multinomial logit model response probability takes the following form:

$$P_r(y_n = k) = P_{nk} = \exp(x\beta_k)/[1+\sum_{k=0}^{K} \exp(x\beta_k)] \qquad \text{for } k=0, 1, \ldots K$$

(1.1)

where Pnk is the probability that the dependent variable (Yn) takes value k at nth observation, with k ranging from 0 to K. In our case k will take values 0, 1 or 2 to identify three different governance modes: GOV0 ($k = 0$), GOV1 ($k = 1$) and GOV2 ($k = 2$).

It should be mentioned that the point estimates of a multinomial logit tell us, for each choice k, the change in probability of the outcome k, relative to the baseline outcome ($k = 0$), induced by a unit change in the explanatory variables. In a multinomial framework, this does not assure that the absolute probability of outcome k will increase or decrease, but that k will be more or less likely relative to baseline outcome. As we are interested in the change in absolute probability of the outcome k induced by the regressors, we shall calculate the marginal effect:

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[14] We show only the results with foreign presence ratio expressed in terms of the number of foreign firms as a share of the total number of firms in sector j. We also tested the alternative measure expressed in terms of the number of workers, both separately and jointly with the other explanatory variables, with no significant diversities in results. The outcomse of regressions using alternative specifications are available from the authors upon request.

[15] We use interaction terms to econometrically capture the additional effect of the variables considered when referred to domestic firms. Moreover, we test for multicollinearity and we run separated regression for each of the variables in the vector.

$$\delta_k \frac{\partial P_{nk}}{\partial x_n}$$
$$(1.2)$$

Estimation of the multinomial logit model is based on the assumption that probabilities of the alternative choices are independent of each other. This property is called the independence from irrelevant alternatives (IIA). The validity of this assumption is checked using the test introduced by Small and Hsiao (1985) (see Appendix 2).
Outcomes are presented in terms of marginal effects (table 2). Small and Hsiao test results (Appendix 2) support the IIA assumption.

Table 2 about here

5.2 Discussion of results

- Multinational presence (SUB).

As foreshadowed by the marginal effect reported in Table 2, the estimated coefficients on the variables used to identify Multinational presence suggest that a greater presence of SUB in the market increases the likelihood of observing types of governance featured by suppliers' involvement in technology and R&D activities (GOV2).The evidence is thus broadly consistent with the hypothesis H1 (section 3) that the extent of the presence of global buyers in the local market reduces behavioral uncertainty and increases the likelihood of success in the selection of partners, both conditions favoring the development of knowledge intensive value chain agreements.

- Multinational embeddedness

The three measures of embeddedness used in this paper appear to have a different impact on the governance of value chain relationships.
As far as the length of time (AGE) is concerned, our findings reveal that an extensive and long lasting presence in the country is not significant for the three aspects of value chain governance considered in the analysis (Table 2). These results do not appear to be in line with hypothesis H2, according to which the age of subsidiaries increases the likelihood of knowledge intensive value chain agreements. This outcome might have to do with the specificity of the Thai case. A possible explanation is that MNCs which have a long experience of this market got to know more weaknesses than strengths as far as manufacturing and technology management abilities of local firms. This is broadly consistent with the evidence briefly recalled above (section 4) and produced *inter alia* by Puga and Trefler (2005), who show that Thai firms exhibited a very limited increase of the patents filed to the USPTO in 1980-2004, as opposed to other Asian countries characterized by much higher growth of inventive activity, such as China and India. Over time, MNCs active in Thailand may thus have experienced lower innovative performances than expected and this might have a negative impact on the decision to get involved in joint development of technology with local suppliers.

When we turn to another measure of embeddedness, namely the share of inputs bought locally (LSUP), we find a positive correlation with GOV0 and a negative correlation with GOV2 (Table 2). In other words, the more MNCs buy inputs locally the higher the likelihood of value chain relationships characterized by a very limited transfer of knowledge. These findings seem to support the hypothesis H3 (section 3): it is most likely that MNCs purchasing a high share of their

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inputs in Thailand will do so above all to obtain significant cost savings. This priority is exactly opposite to the one that is normally pursued when value chain relationships are used to co-develop technology with local firms. While using local purchases to reduce costs seems to be a rather general rule when MNCs source their inputs in LDCs, this could be particularly the case of Thailand, as local input manufacturers might well be less dynamic than in other Asian countries.

Finally, the efforts of MNCs to adapt products and processes (ADAPT) appear to impact positively on GOV2. In other words, when MNCs are so "embedded" in local contexts that they invest in the adaptation of products and processes, value chain relationships are more likely to be knowledge intensive. [16] Under these circumstances, the arrangements with local suppliers will not only imply high shares of captive sales, but also significant transfers of knowledge concerning product specification, design and quality standards, and a substantial dissemination of technology and R&D activities (Table 2). These results are thus consistent with hypothesis H4 as discussed in section 3.

- Domestic firms' capacity "to handle the technology"

It is apparent from table 2 that when suppliers have the capacity "to handle the technology", value chain relationships are more likely to be characterized by transfer of design, quality standards and technology (GOV2). This result is robust to changes in the measure used to capture domestic firms' technical competencies, that is both dummies used for this purpose (whether domestic firms have filed patents, DOMPAT, or develop technology intra-muros, DOMTECH) have a positive impact on GOV2. Even more important, these variables remain significant also when controlling for the presence of multinational firms (SUB), suggesting that domestic competencies have a positive impact on knowledge intensive value chain relationships for any given level of foreign presence. Consistently with hypothesis H5, it thus appears that if local suppliers have the capacity to develop the technology within their establishments, value chain arrangement will likely be knowledge intensive. This result mirrors the correlation we found between GOV2 and ADAPT. The positive impact of ADAPT on GOV2 can be interpreted as a signal that the effort of MNCs to adapt technology requires governance modes through which some knowledge exchange occurs, and hence applications abilities can be more easily supplied by local firms. Quite symmetrically, the positive impact of DOMTECH (or DOMPAT) on GOV2 suggests that global buyers may be induced to set up knowledge intensive relationships with domestic suppliers when local competencies are high enough.

6. Conclusion

In this paper we have attempted to combine insights from international production literature and from the recent "Global value chain" approach to develop a more comprehensive framework for the analysis of technology transfer via value chain relationships. It is suggested that the characteristics of both foreign and domestic firms affect the development of alternative modes of organizing value chain relationships between multinationals and local firms.
Our study has made an effort to integrate the existing literature in three ways. First, we have considered value chain relationships as a multi-facet process of interaction between buyers and suppliers, involving different degrees of knowledge transmission and development. Second, we

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[16] It is worth noting that more than 60% of SUB firms in our sample adapt their technology to suit local conditions. This helps explain why the share of GOV2 is rather high as a whole. See Appendix 1, table 2. However, the negative impact of AGE discussed in the text may signal that the share of GOV2 may be decreasing over time.

have assessed whether and to what extent value chain governance is affected by the presence of multinationals and by their embeddedness in the host economy. Third, we have taken into account the capabilities of suppliers to handle the technology as a factor influencing technology transfer through value chain relationships.

Using data on a representative sample of 1,385 Thai firms, we have applied a multinomial logit model to test whether and to what extent governance modes are influenced by multinational presence, by the degree of embeddedness of foreign buyers in the host economy (Thailand), and by the competencies of local suppliers. The available data allow us to carry out only a cross-section analysis which highlights simple correlations and no causal links between variables. Moreover, correlations are not always straightforward in the analysis. Nevertheless, knowledge intensive governance modes, that are characterized by a greater transmission of technology along the value chains, appear to be positively associated with the presence of global buyers in the local market, with the efforts of MNCs to adapt technology to local contexts, and with the competencies of domestic suppliers. These results are consistent with a view of technology transfer as a process that requires some proximity of MNCs to suppliers, and the local availability of technical capacities. Technology transfer is also facilitated when the degree of embeddedness of MNCs is high enough to induce affiliates to modify their products and processes to local demands. By contrast, the age of subsidiaries and the share of inputs purchased locally appears to be associated with value chain relationships with a lower technological profile. A high share of inputs purchased in a Less Developed Country may reflect a cost saving approach, in contrast with a strategy based on knowledge intensive value chain relationships. The negative impact of the age of subsidiaries may reflect that foreign buyers with a long experience of the Thai market have learned that local suppliers are not competent enough to make technology transfer worthwhile.

A deeper interpretation of these results calls for further research on the evolution of market structure in the Thai economy and on the actual behavior of MNCs active in that market, and possibly comparative works on different recipient economies. It remains that the empirical results obtained in this study induce some reflections on the role of embeddedness of MNCs as a factor conducive to technology transfer and local development. In fact, it appears that it is not enough that MNCs have an extensive and lasting presence in a country to favor the creation of knowledge intensive relationships with local firms; nor is it enough that foreign firms get involved in massive market transactions with local firms, if these concern low cost and low value added goods. What seems crucial to make value chain relationships evolve and become fundamental vehicles for technology transfer is a combination of efforts by both domestic and foreign firms, aimed at increasing local competencies, on the one hand, and at adapting technology to host market conditions, on the other hand.

Table 2 **- Firms' characteristics and value chain governance**

Multinomial logit regression	GOV = 0	GOV = 1	GOV = 2
	dy/dx	dy/dx	dy/dx
SUB	-0.17	-0.28	0.39
	(-4.58)	(-2.29)	(3.79)
AGE	0.00	0.00	0.00
	(2.19)	(-1.46)	(0.076)
LSUP	0.04	0.04	-0.08
	(2.39)	(1.24)	(-2.48)
ADAPT	-0.14	0.03	0.29
	(-1.64)	(3.15)	(3.15)
dompat*	0.06	-0.12	0.09
	(2.56)	(-4.89)	(2.38)
domtech*	0.05	-0.12	0.05
	(2.87)	(-4.27)	(2.97)
Industries	included	included	included
Regions dummies	included	included	included
Size	included	included	included
Observations	717	717	717
Source PICS, authors' own computation			

APPENDIX 1 – Descriptive statistics on sample firms

A.1- Distribution of firms across industries (%)

	FOR	DOM
Textile and Clothing	17.8	26.1
Food Processing	9.1	5.4
Machinery	14.9	15.5
Electronics	30.1	7.7
Wood	3.7	10.7
Rubber and Plastics	9.0	23.1
Automotive Parts	17.1	11.6

A.2- Size distribution of firms in the sample (%)

	FOR	DOM
Small (less than 50 workers)	10.9	36.1
Medium (50 to 150 workers)	21.4	34.3
Large (more than 150 workers)	67.7	29.6
Total	100	100

Source: authors' own computation on PICS data

A.3 - Governance type distribution across industries (%)	GOV 0	GOV 1	GOV 2	Total
Textile and Clothing	9.04	48.59	42.37	100
Food Processing	10.61	34.64	54.75	100
Machinery	11.3	40.11	48.02	100
Electronics	10.84	33.13	53.61	100
Wood	15.2	48.8	35.2	100
Rubber and Plastics	9.62	41.84	47.7	100
Automotive Parts	7.59	40.69	51.03	100
Pearson chi2 (6)=	16.2409	55.1731	54.8764	
Pr=	0.013	0.000	0.000	
Source: authors' own computation on PICS data				

A.4 - *Domestic firms* Governance type distribution across industries (%)	GOV 0	GOV 1	GOV 2	Total
Textile and Clothing	13.9	47.8	38.5	100
Food Processing	12.8	41.0	46.2	100
Machinery	12.6	41.4	45.9	100
Electronics	25.4	41.8	32.7	100
Wood	22.0	49.3	28.6	100
Rubber and Plastics	13.3	38.8	47.7	100
Automotive Parts	7.2	38.5	54.2	100
ALL INDUSTRIES	14.1	42.9	42.5	100
Source: authors' own computation				

APPENDIX 2 - Small –Hsiao test to assess the Independence of Irrelevant Alternatives (IIA) Assumption

The Small-Hsiao test is a modified version of the McFadden-Train-Tye likelihood ratio test. Following Small and Hsiao (1985), we can divide the sample randomly into two subsets of about equal size. The unrestricted model is estimated for both subsets where $\hat{\beta}_u^{S1}$ refers to estimates of the unrestricted model on the first subset, and $\hat{\beta}_u^{S2}$ is its counterpart for the second subset. A weighted average of the coefficients is computed as follows:

$$\hat{\beta}_u^{S1S2} = (1/\sqrt{2})\hat{\beta}_u^{S1} + [1 - (1/\sqrt{2})]\hat{\beta}_u^{S2}$$

After this, a restricted sample is created using the second sub-sample by eliminating all outcomes with a chosen value of the dependent variable. The model is the estimated using the restricted sample with $\hat{\beta}_r^{S2}$ referring to the estimated coefficients and $L(\hat{\beta}_r^{S2})$ indicating the likelihood. Finally, the following test statistic is used which is asymptotically distributed with degrees of freedom equal to the number of independent variables plus one

$$SH = -2\{L(\hat{\beta}_u^{S1S2}) - L(\hat{\beta}_r^{S2)})\}$$

(1) Small –Hsiao test results (I specification with *SUBwks*j)

Omitted	lnL(full)	lnL(omit)	chi2	df	P>chi2	evidence
1	-1244.71	-1240.79	7.84	9	0.55	for Ho
2	-556.623	-553.439	6.367	9	0.703	for Ho
0	-545.925	-542.333	7.184	9	0.618	for Ho

(2) Small –Hsiao test results (II specification with *SUB*j)

Omitted	lnL(full)	lnL(omit)	chi2	df	P>chi2	evidence
1	-1279.46	-1277.9	3.129	9	0.959	for Ho
2	-572.716	-571.29	2.853	9	0.97	for Ho
0	-557.163	-555.939	2.448	9	0.982	for Ho

(3) Small –Hsiao test results (III specification vector SUBj;AGEj;LSUPj;ADAPTj;DOMTECHij and DOMPATij)

Omitted	lnL(full)	lnL(omit)	chi2	df	P>chi2	evidence
1	-524.465	-516.831	15.268	16	0.505	for Ho
2	-518.801	-512.755	12.093	16	0.738	for Ho
0	-1180.186	-1176.825	6.722	16	0.978	for Ho

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