FDI decision: the influence of the host country's innovator lead users

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Abstract

Foreign investors seek to augment their competitive advantage through their exposure to the host countries' innovation experience. Among the sources of innovation of the host country is its users. Although users' innovation is not a new phenomenon, nowadays users are better empowered to innovate thanks to the new technologies. Users' innovations have proved to be concentrated among lead users. Literature on asset seeking foreign direct investment (FDI) ignores the role of lead users. The article aims to first, highlight the particularities of users as innovators in comparison with manufactures, therefore they require specific analysis. Second, through a game theoretic model, the article shows the impact of lead users' innovations on FDI decision versus exports, then on foreign investor's decision whether to develop or not lead users' innovation. All other things equal, lead users who reveal their innovation attract FDI, the higher the tacit knowledge incorporated in their innovation. To push the foreign investor to develop their innovation, lead users shall maximize its generality and its tacit component. If the multinational has high firm-specific assets, then an arrangement to privilege the foreign investor relative to his potential competitors would arise. To have a Pareto optimum equilibrium, the foreign investor shall maximize the improvements he brings to lead users' innovation and shall privilege lead users relative to other users.

Keywords: asset seeking FDI, Lead users, innovation.

Introduction

Users innovate to satisfy their needs. This is because; manufacturers usually standardize their production, while users' needs are heterogeneous. Innovation history witnesses the importance of users' contribution to innovation (Enos, 1962; Freeman, 1968; Pavitt, 1984; von Hippel, 1988; von Hippel, 2005). Nowadays, thanks to the new technologies, users are having access to design tools (von Hippel, 2005), which enable them to concretize their innovations easier and cheaper. However, literature on asset seeking FDI, aiming to access the host country's innovation and technological capabilities (Kogut and Chang, 1991; Cantwell and Santangelo, 1999; Kuemmerle, 1999; Serapio and Dalton, 1999; Frost and Zhou, 2000; Cantwell et al., 2004), ignores the identification of the role of users, unless few exceptions (Ivarsson and Jonsson, 2003; Ernst, 2005).

For a sample of majority owned foreign affiliates in Sweden, Ivarsson and Jonsson (2003) investigate the technology development activities and their use purposes. Their investigation shows that, jointly developed technology with business customers is exploited internationally by foreign affiliates; it is not limited to local adaptation of technology. Technology developed in collaboration with business customers enhances the technological capability of the foreign affiliate and of the multinational enterprise (MNE). Besides, the affiliates who cooperate with business customers have higher export intensity relative to affiliates who only collaborate with suppliers, business service firms and R&D institutions. Ivarsson and Jonsson (2003) conclude that, locations with demanding customers and advanced suppliers of materials and know how are interesting locations for MNEs who wish to establish technological linkages to augment their competitive advantages.

Ernst (2005) explains why chip design is moving to Asia, based on interviews with companies and research institutions doing leading-edge chip design in Asia. The paper shows that MNEs are attracted by supply-oriented forces, especially the lower cost of employing a chip design engineer in Asia. However, demand-oriented factors are equally important. Global firms are seeking to relocate design close to the rapidly growing and increasingly sophisticated Asian markets, to be able to interact with Asia's lead users of novel or enhanced products or services.

This article focuses on lead users among the population of innovator users. Innovation is not a characteristic of lead users but an outcome. Lead users have two characteristics (von Hippel, 1986); first, they are at the leading edge of an important market trend(s). Consequently, they experience needs in advance relative to the other users. Therefore, their innovations, benefiting from a real life experiment, often success when they are commercialized. Second, they expect high benefits from getting a solution to respond to their advanced needs. Therefore, many of them innovate. The higher this anticipated benefit, the higher the resources they employ in their innovation process (von Hippel, 1986). The accessible resources for the user and for his community impact the probability that the user will invent and the commercial usefulness of his innovation (Franke et al., 2006; Morrison et al., 2000; Lüthje et al., 2002; Franke and Shah, 2003).

In addition, since lead users' needs are situated at the leading edge of the market place, which is an uncertain small area of the market, then supply response to those needs is of low probability. That is why, at this forefront leading edge, lead users' innovation likelihood is high (Franke et al., 2006).

von Hippel (1986) explains ‘lead users’ concept’s definition referring to; first, functional fixedness literature (Duncker, 1945; Birch and Rabinowitz, 1951; Adamson, 1952), according to which users are limited by their real world experience. Users who are habituated to use a product in a certain way find it hard to imagine new functions or new ways of using it. Only users who experience advanced needs relative to other users can give such innovative insights. The second literature, explaining ‘lead users’ concept, is diffusion literature (Rogers and Shoemaker, 1971; Rogers, 1995). It explains why lead users with advanced future needs exist. According to diffusion literature, new products diffuse gradually. This is because; the decision to adopt a new product is function in the individual’s perceived benefit for the product in question. This benefit, on its turn, depends on the level of the individual’s need for this product. The time of need occurrence differs from one person to another. Consequently, lead users, who experience advanced needs relative to other users and who can conceive new applications that the market will need in the future, do exist.

The first objective of this article is to show that lead users’ innovations impact producers differently relative to competitors’ innovations; therefore, they require distinct analysis. The second objective is to formalize first, the influence of lead users’ innovation on FDI decision versus exports and second, it formalizes foreign investor’s response to a demand driven innovation whether to develop it or not.

The article is structured as follows; the first section presents lead users as a source of innovation spillover. The second section discusses the cost of accessing lead users’ innovations. The third section explains the particularities of the impact of users’ innovations on manufacturers in comparison with competitors’ innovations. Finally, the fourth section is a game theoretic model, exploring the influence of lead users’ innovations on foreign producer’s decisions.

1. Lead users: a potential source of innovation spillover

The relation between the MNE’s innovation capabilities and FDI is two sided. On one hand, firms need to invest in R&D in order to remain competitive and to open new markets to recoup their fixed costs before their products become redundant (Dunning and Narula, 2000). On the other hand, FDI allows the MNE exposure to diversified distinctive technological experiences. Consequently, the MNE augments its competitive advantage by making its own technological experience more complicated. This rich exposure helps reduce uncertainty for the MNE while increasing it for competitors, since it makes imitation more difficult for them (Hitt et al., 1998). Innovation is firm-specific and location-specific; the scientific and technological history, the shared experience between actors, the education system, the business practices, all those factors make each location distinctive (Nelson, 1993). Moreover, adapting the MNE’s technology to the host country’s conditions creates new ideas. Those new ideas feed back home, further developing the entire system and enhancing the MNE’s innovation capabilities (Cantwell, 1989).

The MNE is an organisation generating innovation globally (Bartlett and Ghoshal, 1990). Lead users make part of the sources of innovation in the host market. They can play a role in enhancing the MNE’s competitiveness.

1.1. Lead users: successful innovators

In Forary (2004)’s opinion, users are at the center of knowledge production. Therefore, one of the main challenges for managers is to capture the knowledge being created by users and to integrate it in the knowledge created in the laboratories. Manufacturers have the advantage of established distribution channels, brands and established producing facilities (Baldwin et al., 2006). They tend to know more about solution possibilities and most effective production technology. As for users, they tend to know more about their particular needs and their particular use environment (Franke and von Hippel, 2003).

Users' innovations are concentrated among lead users, whose innovations have proved their novelty and commercial success. Urban and von Hippel (1988) apply lead user method on computer-aided systems for the design of printed circuit boards (PC-CAD). Among respondent user-firms, 23% have developed their own in-house PC-CAD, employing substantial resources. A sample of the lead user group joined a creative group to develop improved PC-CAD. Olson and Bakke (2001) apply lead user method in Cinet company, two new products were developed, 78% and 73% respectively of the software and hardware products' developments where based on lead users' ideas. In Lilien et al. (2002), in a natural experiment at 3 M, their comparison shows that products' concepts developed based on lead users' ideas are significantly more novel and are strategically more important. Lüthje and Herstatt (2004) study HILTI, the leading manufacturer of fastening systems for the construction industry, which has begun applying lead user method since 1980s in the pipe hangers' field (water, air conditioning, sanitary) and air duct in buildings. They also apply lead user method at Johnson and Johnson (J&J) in the division of surgical hygiene products. At HILTI, an innovative concept for a fastening system was generated through the lead user workshop and was patented shortly. The new developed products have become a main production line in HILTI. The application of lead user method at J&J has helped formulate four complete and detailed concepts. Some of the new products' ideas were totally new for J&J and for competitors.

Moreover, empirical findings prove the correlation between lead users' characteristics and innovation. Morrison et al. (2000) study users' innovations in Australian libraries to computerized information search systems called Online Public Access Computerized Systems (OPAC). Morrison et al. (2000) find that 26% of users do modify OPAC in order to meet their needs, and some of users' innovations were novel. The study shows that innovator users are distinguished by their leading edge status and their high in-house technical capability related to the field. Franke and Shah (2003), studying four sports' communities, find that innovator users have lead users' characteristics which differentiate them from no-innovator users. Lüthje (2004) surveys a sample of users of outdoor-related consumer products in Germany. The results show that innovator consumers are distinguished by the benefit they expect from using their innovations and by their level of expertise of product use. Morrison et al. (2004) prove high correlation between the actual development of innovations and the two characteristics of lead users.

The question now is what distinguishes users as innovators? The following sections will be answering this question. The next section is concerned with the resources on which users rely in their innovation process.

2. The cost of accessing users' innovations

Innovators have a choice between keeping their innovation a secret, freely revealing it or licensing it. On one hand, keeping an innovation a secret is not effective, this is because, the innovation is based on an information that other innovators might have a substitute for. Consequently, the innovator who finds revealing costless or a source of gain will be revealing despite others' willingness to keep the secret (Harhoff et al., 2003). Mansfield (1985) shows that, on 100 studied American firms, information about development decisions reaches rivals between 12-18 months, and the detailed information concerning new products or process reaches them within a year. On the other hand, literature shows that license and copyrights are not effective in protecting innovations, unless some exceptions. Acquiring a patent is costly and copyrights protect the innovator but don't protect the innovation itself. For example, a software can acquire a copyright, but it can be imitated under another name with the same functionalities (Harhoff et al., 2003).

Hence, remains the option of free revealing. Harhoff et al. (2003) explain that when the innovator 'freely reveal' proprietary information, all intellectual property rights related to this information are voluntarily given up by that innovator and all parties are given equal access to it. The information becomes then a public good. For example, putting it on a website or publishing it in a journal. However, this doesn't exclude the possibility that the recipient of the information pays another cost. The recipient may pay to subscribe in the journal, to travel to access the information (to establish a foreign subsidiary, like will be the case in the model developed later) or to acquire additional costly information to be able to exploit the targeted information.

Free revealing can provide the innovator with many potential benefits. The innovator can gain a reputation or a higher evaluation on the labor market. He can gain from improvements and feedback from other users, increasing then his satisfaction from the innovation in question. He can gain from a producer's decision to manufacture the innovation. Consequently, the innovator will procure his innovation in perhaps better material and at lower cost. The innovator may be rewarded by the joy of creativity and/or the honor of participating into an innovation project, and/or by obtaining the developed product earlier than others (Lüthje and Herstatt, 2004). When the benefits of free revealing exceed the benefits of keeping an innovation a secret or licensing it, a profit seeking firm or individual will choose to freely reveal (Harhoff et al., 2003).

Harhoff et al. (2003) develop a game theoretic model of two potential innovator user-firms. The model assesses when voluntary free revealing to manufacturer firm would be profitable and when it is more profitable for innovator users to hide information about their proprietary innovations. The manufacturer firm shall then decide whether to improve the innovation and to supply it to both user-firms or not. The model finds that innovator user will reveal the higher the value of the improved version developed by the manufacturer relative to the original one, and the lower the cost of adoption relative to the original version's value. The manufacture on his side will develop user's innovation the higher the generality of the solution it incorporates.

Real cases show that users do freely reveal their innovations. In open source software, users reveal the code of their software and allow other users to use it. The server software Apache, its original code was posted on the web and received modifications and developments from users, nowadays it competes with Microsoft and Netscape (von Hippel, 2001). Morrison et al. (2000), in their study of OPAC, find that users share information about their modifications. In De Jong and von Hippel (2009), a survey of high technology Small and Medium Enterprises (SMEs) in the Netherlands shows that, 54% of these firms developed or modified new process equipment or software for their in-house use, baring significant private expenses. Out of those users' innovations, 25% were transferred to producer firms to be commercialised of which

48% were transferred for free, especially for the suppliers with whom innovators already had a relationship.

If lead users might freely reveal their innovations, what is the effect users' innovations generate on the manufacturer in comparison with the effect of competitors' innovations? The following section will be devoted to this question.

3. The interactions between lead users' innovations and manufacturers

Lead users' innovations can enhance welfare (von Hippel, 2005). Social welfare here concerns total income and not income distribution. This is because, having advanced needs and benefiting from a real life experiment, lead users can play a role in better adapting the supply for demand needs. Besides, they might freely reveal their innovations (Harhoff et al., 2003) and they are not competing with manufacturers in the short term (von Hippel, 2005). Moreover, the article claims that lead users can play a role in attracting asset seeking FDI, which may generate spillover effects.

The interaction between innovator users and manufacturers has its particularities. What kind of pressure users' innovations exercise on manufacturers? How their innovations become commercialized? What is the potential that producers benefit from users' innovations' spillover? This section aims to answer those questions.

3.1. Lead users' innovations magnify their market's future needs

The article highlights the pressure lead users may exercise on manufacturers to respond to local needs. Lead users' innovations concretize the future market emerging demand. This might push supply to innovate, in order to respond to those needs, materializing then lead users' innovated idea or enhancing their innovated prototype. Morrison et al. (2000), in their research on OPAC's users' innovations, find that producers incorporated lead users' ideas in their products. Interestingly, producers said that they already knew about lead users' needs and only 10-22% of lead users' innovations constituted new information. This shows that, sometimes manufacturers do know lead users' needs but don't find it profitable to develop solutions for an 'emerging need' until several years later. Observing the degree of success of lead users' innovations between other users can give manufacturers information about the potential size of the market for this innovation (von Hippel, 2005).

Users' innovations in short term are not substitutes for manufacturers' products, rather complements (von Hippel, 2005). This is because; they are at the leading edge of the market, where potential sales are small and uncertain, while manufacturers prefer to serve large more certain markets. In the long term, the market catches up the needs that motivated users' innovations and manufacturers begin to find production of similar products commercially attractive.

Consequently, the article argues that proximity to innovator users exercises a different kind of pressure on manufacturers to innovate in comparison with proximity to innovator competitors. Competitors exercise pressure by supplying potential substituting products. Lead users can exercise pressure through freely revealing their innovations, magnifying then the market future needs and opening a new segment, the higher is the generality of their innovation and the knowledge it incorporates. This is the hypothesis tested in the next section.

But, how valuable users' innovations become commercial products and what is the role of manufacturers in the process?

3.2. How users' innovations become commercial products

To understand how users' innovations become commercial products, Baldwin et al. (2006) apply to the case of Rodeo kayaking, which is both a sport and an industry. They find that users' innovations are transformed into commercial products as follow; first, one or more users recognize a new set of design possibilities and begin to innovate. Second, they join communities motivated by the increased efficiency of collective innovation. Some users begin to manufacture using high-variable/low-capital cost production methods. When innovator users make copies of their innovations and sell them to other users, they become user manufacturers. User manufacturers have the advantage of knowing users' needs and might benefit from free assistance of their users' community. With time, the nature and the size of market demand becomes clearer. If the market promises high potential, then manufacturers may enter using high-capital/low-variable cost production methods and/or user-founded firms may increase in size and capacity.

Users can develop and market their information products on the web without manufacturers' involvement (Kollock, 1999). As for physical products, while first units can be developed and diffused without manufacturers' support, mass production involves activities of significant economies of scale that requires manufacturers' intervention.

von Hippel (2005) suggests three ways by which manufacturers can play a role in user-centered innovation. First, manufacturers may produce users' innovations for general commercial sale and/or offer a custom manufacturing service to specific users. Second, manufacturers may sell kits of product design tools and/or 'product platforms' to make users' innovation process easier. Third, manufacturers may sell products or services which complement users' developed innovations.

In some cases, manufacturers might not be interested in users' innovations. However, it is worth reminding that, with recent developments in the world economy context, driven by technological progress which democratized innovation (von Hippel, 2005); users' innovations are getting increased attention. But, what is particular about spillover effects of users' innovations?

3.3. The particularity of the externalities generated by users' innovations

Some research finds that spillover effects increase with proximity. Verspagen and Schoenmakers (2000) investigate a sample of European MNEs' patents' geographical distribution. They find that, between firms and within firms, citations occur between units located relatively near each other. Geographical distance makes the transfer and the absorption of tacit knowledge difficult (Jaffe, 1989; Feldman, 1994; Caniëls, 2000).

In Rallet and Torre (2005), the authors distinguish between geographical proximity and organized proximity. Geographical proximity is concerned with the physical space between actors, while organized proximity is concerned with the belonging to the same organization, implying complicity between agents. The authors emphasize that, geographical proximity on its own is not enough to generate synergies. In order actors interact together, geographic proximity needs to be activated by organized proximity. In some cases, through organized proximity and new information and communication technologies (NICTs), the transfer of tacit knowledge can be realized without face to face interaction.

However, Rallet and Torre (2005) explain that face to face interaction, in order to share tacit knowledge, remains essential in two situations. First, when actors having different reasoning modes and different knowledge base start an innovative project; second to manage conflicts between innovators and for negotiation purposes.

FDI, implying direct interaction, is necessary in order the foreign producer benefits from users' innovations' spillover. This is because; lead users and producers have different objectives with different reasoning, different background and knowledge. Therefore, direct interaction is needed in order to access the information generated by lead users.

Another particularity concerning users' innovations in comparison with competitors' innovations is concerned with the probability of spillover occurrence. Fosfuri and Motta (1999) develop a game theoretic model, where firms might conduct 'technology acquisition' FDI in a leading firm's country. The efficient technology is represented by a lower cost of production. Even when export costs are zero and when the technological follower doesn't have an advantage in comparison with the leader, FDI may occur to benefit from technology spillovers. However, in Fosfuri and Motta (1999) model, technology spillovers are uncertain, and their occurrence is associated with a probability. In order the MNE benefits from spillover effects from the host country, there must be no barriers set by local competitors (Pugel et al., 1996). Besides, the investing firm must possess the necessary absorptive capacity (Makino et al., 2002).

It is argued here that, in case the foreign investor is seeking access to users' innovations, the probability of spillover might be higher. This is because of the expected free revealing of users' innovations, when free revealing benefits exceed its costs (Harhoff et al., 2003) as it was explained in the previous section. Besides, usually users are not competing with manufacturers. The question of barrier to entry set by the innovator user becomes a concern in case the user becomes a manufacturer user. Moreover, the knowledge generated by innovator users may be absorbed easier by manufacturer than the knowledge generated by competitors. This is because; the manufacturer firm has the advantage of specialisation and of understanding of the technology underlying the product better than users. But, Olson and Bakke (2001)'s findings point to the difficulty users encounter in translating their ideas into a language understandable by the technical staff of the firm. This difficulty may inhibit the absorption process.

Lead users are self motivated innovators, who are best positioned to predict the needs of other users and who might find it profitable to freely reveal their innovations. Investors should be hunting them, especially foreign investors who face a higher level of uncertainty in comparison with local ones. The next section models the impact of lead users' decision to reveal versus not reveal their innovation on the foreign producer's decision to conduct FDI versus to export and then, on the foreign investor's decision whether to develop or not lead users' innovation.

4. The impact of lead user's innovation on foreign producer's decisions: game theoretic model

This section presents a sequential move game of perfect and complete information. It is a finite game of two periods and then, the possibility of repetition is considered.

All things being equal, an international economy where there are two countries *M* and *H*. We are in a fast moving sector with a high rate of innovation. Like Harhoff et al. (2003), the model fits with innovator users in the copper-interconnections, clinical chemistry analyzers, and information and communication technologies (ICTs). In those fields, innovations were freely revealed by users and then were adopted by manufacturers who commercialized them, making them available for all users.

M has one firm in the industry in question (*m*) and *H* has n user-firms of the industry in question, among which *L* an innovator lead user, $n \succ 1$. The model is concerned with user-firms, although it can be applied to consumers with some modifications. The possibility that a firm from *H* operates in *M* is excluded[1]. Besides, operations of *m* in *H* don't impact its operations in *M*[2]. Consequently only profits realised in *H* will be considered.

First period, first stage, *L* does nothing, while *m* has to decide whether to export or to conduct FDI to access *H*'s market. For the time being, *m*'s decision holds for all the periods of the game. In the second stage, *m* produces θ_0. The third stage, the lead user *L* innovates θ_1, a new concept based on θ_0. Lead user's innovation ranges from an idea to a full prototype. The fourth stage, *L* shall decide whether to freely reveal or not its innovation. Users sometimes find it profitable to reveal their innovations (Harhoff et al., 2003; De Jong and von Hippel, 2009). In this model, it is supposed that the new applications innovated by the lead user are not within the set of product characteristics defined by the firm.

Consider first, the case if in the first period *m* has undertaken FDI and *L* has revealed θ_1. In this case, in the second period, *m* has two choices; whether to continue producing θ_0 or to develop θ_1 solution, which is an improved version of θ_1. It is assumed that once a producer has introduced a product to the market, he can't change it within the period[3].

If *m* decides to produce θ_1, it will support an extra fixed cost *c* in its totality, to develop a commercial product θ_1 based on θ_1. However, the firm *m* will gain a more diversified innovation experience, increasing its competitive advantage, leading to long term cost reduction. This spillover effect is reflected in an expected discounted per period profit δ, where δ is the value of lead user innovation θ_1. It is assumed that the manufacturer and the user value θ_1 similarly, according to the tacit knowledge it incorporates.

If *m* decides to continue produce θ_0, in this case, it will not bear *c* and will still have access to *δ*. Once *L* reveals θ_1, all local manufacturers can benefit from the tacit knowledge it incorporates. However, since *L*'s revealed innovation opens a new segment in the market, *m* will risk a new entrant.

To account for the credibility of the threat of entry by a local competitor, let the probability of entry be $\frac{1}{F}$, where *F* is *m*'s accumulated firm-specific assets, which increase the cost of entry for its rivals, $F \geq 1$. It is assumed that players are risk neutral. If *F* is at its minimum level of 1, then the probability of entry will be at its maximum of 1. If *F* is at its maximum level of infinity, then the probability of entry will be at its minimum of zero.

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[1] Following Smith (1987) model assumption.
[2] Following Motta (1992) model assumption.
[3] Following Wesson (1999) model assumption.

The threat of entry is considered as a move by Nature after *m* decides whether to produce θ_1 or not. This makes the game an uncertain one. To transform uncertainty into a game of certainty, without changing the equilibrium, following Rasmusen (1989), Nature move will be eliminated and replaced by the payoffs, taking into consideration the probability of entry $\frac{1}{F}$ set by Nature.

The information about lead user's innovation cannot be licensed. This can be explained by the difficulties of contracting under asymmetric and incomplete information, especially when the knowledge in question is tacit in nature and difficult to codify (Wesson, 1999). This knowledge also can't be acquired through exporting to *H*. Although the exporter conducts market research in order to adapt the product to the importing country's demand patterns, market research doesn't give full information about local needs or local propositions for ultimate solutions (von Hippel, 2005). Besides, lead users and manufacturers have different knowledge base and logic of thinking, there is no organised proximity between them as defined by Rallet and Torre (2005). Therefore, geographic proximity is necessary to access the knowledge created by *L*. Only a direct interaction with the characteristics of lead user's innovation, through manufacturing subsidiary, enables accessing this tacit knowledge, due to the stickiness of this kind of information (von Hippel, 1994, 2005). Therefore, if *m* has chosen to export to *H* in t_0, it will continue produce θ_0 in the second period.

To determine *L*'s payoffs, the model refers to some of the variables of Harhoff et al. (2003) model. It is assumed that δ is the value of θ_1 in present discounted profits to the innovator lead user (in the context of consumers, δ can be thought of as the utility of θ_1). α is the intensity of competition between user-firms; when the payoff of one firm increases, the other's decreases, the higher is competition, $0 \leq \alpha \leq 1$ (in the context of consumers, α may represent the extent of the person's individualism). The degree of generality of the need for which lead user's solution was developed is γ, where $0 \leq \gamma \leq 1$. When the technology is completely specific to the innovator user, $\gamma = 0$, while when the technology is completely general and benefiting all users, $\gamma = 1$. The degree of improvement of θ_1 due to manufacturer's involvement (whether *m* or a new entrant), transforming it into θ_1, will be represented by μ, where $\mu \geq 0$. The value of θ_1 to the innovator lead user is bigger by (1+ μ) than the value of θ_1. It is assumed that the users will not pay an extra cost for θ_1.

In order to give γ a meaning within the model presented here, γ can be regarded as an increasing function in *d*, where *d* is the difference in the use environment between *M* and *H*. The higher the difference in the use environment *'d'* between the home and the host country, the higher the probability that users in *H* will have different needs relative to users in *M*, implying a probability of product misspecification by the foreign producer. Therefore, the higher is *d*, the more the user will be incited to innovate to compensate for this misspecification. User's innovation then would be incorporating a solution to a general local particular need lacking in θ_0. If the use environment of both countries is close, then user's innovation is expected to respond to specific needs of the innovator. *d* is exogenously given in the model and common knowledge for all players, $0 \prec d \prec 1$.

m on its turn is seeking to maximize its profits. Export costs are incurred in every period. In case *m* exports it will bear an export cost *T*.

FDI costs are also incurred in every period, because of the costs of operating a foreign subsidiary and the difficulty of reversing FDI decisions (Wesson, 1999). In case *m* chooses to FDI and to produce θ_0, it will bear a cost *G*; a fixed cost of establishing a foreign affiliate which incorporates the cost of plant set up and the cost of applying lead user method. Besides, a constant marginal and variable cost taken as zero without loss of generality (Motta, 1992). In case *m* chooses to FDI and to produce θ_1, it will bear an extra cost *c* to develop the new product θ_1.

Price per unit for all products is equal one, without loss of generality. When there are two producers supplying the same product, sales are divided between them. In the first period, demand for θ_0 is $D_0 = \nu n$. In the second period, first, demand for θ_1 is $D_1 = \gamma n$. Second, demand for θ_0 in case θ_1 is not supplied by a competitor is $D_0 = \nu n$. If a potential local entrant decides to enter the market and produces θ_1, demand for θ_0 in this case will be $D_{01} = \nu n - \gamma \nu n = \nu n(1-\gamma)$. This is because, the more the need concretised by lead user's innovation is general within θ_0 users, the less the adopters of θ_0 in the second period.

Both players aim to maximise their expected discounted profits. Following Wesson (1999) assumptions, it is assumed that there is no discounting of future cash flows.

Let;

M_{EN} : *m* profit when *m* exports, produces θ_0, under no reveal from *L*.

L_{NE} : *L* payoff when *m* exports, produces θ_0, under no reveal from *L*.

M_{ER} : *m* profit when *m* exports, produces θ_0, while *L* reveals.

L_{RE} : *L* payoff when *m* exports, produces θ_0, while *L* reveals.

M_{MN} : *m* profit when *m* conducts FDI, produces θ_0, under no reveal from *L*.

L_{NM} : *L* payoff when *m* conducts FDI, produces θ_0, under no reveal from *L*.

M_{MR0} : *m* profit when *m* conducts FDI, produces θ_0, while *L* reveals.

L_{RM0} : *L* payoff when *m* conducts FDI, produces θ_0, while *L* reveals.

M_{MR1} : *m* profit when *m* conducts FDI, produces θ_1, while *L* reveals.

L_{RM1} : *L* payoff when *m* conducts FDI, produces θ_1, while *L* reveals.

The strategic form of the game yields the following payoffs' table, where *m* is the row player and *L* is the column player:

Payoffs:

L / *m*	Reveal	No reveal
FDI/ θ_1	$(\frac{1}{2}\left[vn+\gamma n-\frac{\gamma n}{2F}+2\delta-2G-c\right],$ $\frac{1}{2}\delta[2-2\alpha\gamma+\mu-\alpha\gamma\mu])$	Excluded possibility
FDI/ θ_0	$(\frac{1}{2}\left[vn(2-\frac{\gamma}{F})+2\delta-2G\right],\ \frac{1}{2}\delta\left[2-2\alpha\gamma+\frac{\mu}{F}-\frac{\alpha\gamma\mu}{F}\right])$	$(vn-G,\delta)$
Export/ θ_0	$(\frac{1}{2}\left[vn(2-\frac{\gamma}{F})-2T\right],\ \frac{1}{2}\delta\left[2-2\alpha\gamma+\frac{\mu}{F}-\frac{\alpha\gamma\mu}{F}\right])$	$(vn-T,\delta)$

<u>Solving for equilibrium by moving backward</u>:

<u>*m is the last mover:*</u>

First, consider if $G \prec T$,

Whatever is *L* decision, FDI will strictly dominate export. Under reveal scenario, FDI/ θ_1 will strictly dominate FDI/ θ_0 if $M_{MR1} \succ M_{MR0}$:

$$\frac{1}{2}\left[vn+\gamma n-\frac{\gamma n}{2F}+2\delta-2G-c\right] \succ \frac{1}{2}\left[vn(2-\frac{\gamma}{F})+2\delta-2G\right]$$
$$\Leftrightarrow \frac{1}{F} \prec \frac{\gamma n-vn-c}{\gamma n(0.5-v)}$$

Therefore, if $G \prec T$, FDI is strictly dominating, while under reveal scenario FDI/θ_1 is a strictly dominant strategy if $\frac{1}{F} \prec \frac{\gamma n - \nu n - c}{\gamma n(0.5-\nu)}$.

Second, if $G \succ T$,

There are two possibilities:

1- The first is that $G - \delta \succ T$.

2- The second is $G - \delta \prec T$.

1- If $G - \delta \succ T$, Export/θ_0 will strictly dominate FDI/θ_0.

In order FDI/θ_1 strictly dominates Export/θ_0 in case of reveal, there must be:

$$M_{MR1} \succ M_{ER}$$
$$\frac{1}{2}\left[\nu n + \gamma n - \frac{\gamma n}{2F} + 2\delta - 2G - c\right] \succ \frac{1}{2}\left[\nu n(2 - \frac{\gamma}{F}) - 2T\right]$$
$$\Leftrightarrow \frac{1}{F} \prec \frac{\gamma n - \nu n - 2G - c + 2T + 2\delta}{\gamma n(0.5-\nu)}$$

Otherwise, (if $\frac{1}{F} \succ \frac{\gamma n - \nu n - 2G - c + 2T + 2\delta}{\gamma n(0.5-\nu)}$), Export/$\theta_0$ will strictly dominate.

2- If $G - \delta \prec T$

Under no reveal scenario, Export/θ_0 will strictly dominate FDI/θ_0, while under reveal scenario, FDI/θ_0 will strictly dominate Export/θ_0. FDI/θ_1 will strictly dominate FDI/θ_0 in case of reveal if $\frac{1}{F} \prec \frac{\gamma n - \nu n - c}{\gamma n(0.5-\nu)}$.

<u>*The next mover backward is L,*</u> *L is aware of m's payoffs:*

Whatever is *m* decision, if $\gamma > \frac{\mu}{\alpha(2+\mu)}$, *L* will not reveal.

If $\gamma \prec \frac{\mu}{\alpha(2F+\mu)}$, then *L* will reveal whatever is *m* decision.

If $\frac{\mu}{\alpha(2F+\mu)} \prec \gamma \prec \frac{\mu}{\alpha(2+\mu)}$, *L* will reveal only if *m* chooses to FDI/θ_1.

At $\gamma = \frac{\mu}{\alpha(2+\mu)}$, the maximum level of γ at which *L* would reveal; where *L* is sure, in case it reveals, *m* will develop and supply θ_1.

Searching for Nash equilibrium in pure strategies:

First, in the area where $\gamma \prec \frac{\mu}{\alpha(2F+\mu)}$, *L* will reveal whatever is *m* decision. Aware of *L* dominant strategy, *m*'s best response at this level of γ, i.e. Nash equilibrium, will be according to the relation between *G*, *T* and δ:

- If $G \prec T$ or if $G \succ T$ and $G-\delta \prec T$, there will be (FDI/θ_1, reveal) at equilibrium in the area $\frac{1}{F} \prec \frac{\gamma n - \nu n - c}{\gamma n(0.5-\nu)}$, while there will be (FDI/θ_0, reveal) in the area $\frac{1}{F} \succ \frac{\gamma n - \nu n - c}{\gamma n(0.5-\nu)}$.
- If $G \succ T$ and $G-\delta \succ T$, there will be (FDI/θ_1, reveal) at equilibrium in the area $\frac{1}{F} \prec \frac{\gamma n - \nu n - 2G - c + 2T + 2\delta}{\gamma n(0.5-\nu)}$, while there will be (Export/θ_0, reveal) in the area $\frac{1}{F} \succ \frac{\gamma n - \nu n - 2G - c + 2T + 2\delta}{\gamma n(0.5-\nu)}$.

Second, in the area where $\frac{\mu}{\alpha(2F+\mu)} \prec \gamma \prec \frac{\mu}{\alpha(2+\mu)}$, *L* will reveal only if *m* chooses to FDI/θ_1. It is the area where the highest level of γ at which *L* would reveal. Then, from *m* solving, the following conditions must hold:

- If $G \prec T$ or if $G \succ T$ and $G-\delta \prec T$, there will be (FDI/θ_1, reveal) at equilibrium if $\frac{1}{F} \prec \frac{\gamma n - \nu n - c}{\gamma n(0.5-\nu)}$.
- If $G \succ T$ and $G-\delta \succ T$, there will be (FDI/θ_1, reveal) at equilibrium if $\frac{1}{F} \prec \frac{\gamma n - \nu n - 2G - c + 2T + 2\delta}{\gamma n(0.5-\nu)}$.

Third, if $\gamma > \frac{\mu}{\alpha(2+\mu)}$, whatever is *m* decision *L* will not reveal. Aware of *L* dominant strategy, *m*'s best response concerning its mode of supplying θ_0 at this level of γ will be according to FDI costs relative to export costs:

- If $G < T$, (FDI/θ_0, no reveal) will be a Nash equilibrium strategy.
- If $G > T$, (Export/θ_1, no reveal) will be a Nash equilibrium.

There are several possible equilibriums, depending on variables' values. To sum up, under no reveal scenario, the foreign producer *m* will conduct FDI, if FDI costs (*G*) are less than export costs (*T*). The lead user *L* will reveal the innovation, the lower is the expected loss in profits ($\gamma\alpha$), due to the innovation's generality and to competition between users, relative to the expected increase in profits due to manufacturer's improvements (μ). *L* will be more inclined to reveal, when it expects that the foreign investor will find it profitable to develop the innovation. Under reveal scenario, FDI appears at equilibrium, the lower are FDI costs (*G*) relative to export costs (*T*) and to the value of the tacit knowledge incorporated in lead user *L's* innovation (δ). The foreign investor will develop *L's* innovation in order to be commercialised, the less the probability of entry by a competitor ($\frac{1}{F}$) and the higher the market share of *L's* innovation (γ) relative to the cost of developing it (*c*) and to the other product's market share (ν).

<u>What if the game is repeated?</u>

Suppose that, in the following periods, *L* will continue innovating new concepts. Concerning *L*, the choice whether to reveal or not reveal remains open each period. As for *m*, while it can switch from an export to a FDI strategy, it can not reverse its decision to FDI. 'FDI' induce high fixed costs; therefore, it is considered as an irreversible decision (Smith, 1987). As for 'export' it is possibly reversible and revocable decision in the third period. However, in case of FDI, if *L* reveals, *m* will have to decide whether to develop *L*'s innovation or not.

Consider the third period for example, *L* will not reveal whatever is *m* decision, as long as $\gamma \succ \frac{2\mu}{\alpha(3+2\mu)}$. If *m*'s choice so far was to export, it will switch to FDI strategy in the third period, if export costs increase relative to FDI costs, such that $G \prec T$.

If $\gamma \prec \frac{2\mu}{\alpha(3F+2\mu)}$, *L* will reveal whatever is *m* decision. If *m* strategy so far in the game was to export, *m* will switch to FDI strategy in the third period, if $G \prec T$ or if $G \succ T$ and $G-\delta \prec T$. Therefore, all other things equal, when the lead user *L* reveals its innovation, it can attract FDI through increasing the tacit knowledge incorporated in the innovation. What about *m* decision whether to develop *L*'s innovation or not?

If the profile of strategy of the second period was (FDI/θ_1, reveal), we can expect that *L* observing that *m* did develop its innovation in the second period, will be more inclined to reveal in the period after, as long as $\gamma \prec \frac{2\mu}{\alpha(3+2\mu)}$, which is the condition under which the scenario (FDI/θ_1, reveal) is profitable for *L*. However, *L* is aware that *m* will continue developing its innovations only if it is responding to a general need, where $\gamma \succ \frac{3G+2c-\nu n-3\delta}{n(2-\frac{1}{F})}$, which is the condition under which *m* profit under (FDI/θ_1, reveal) scenario is positive. Therefore, *L* is expected to develop an innovation at the maximum level of generality at which *L* would reveal and the minimum level of generality at which *m* will produce.

However, if *m* defects in the coming periods and doesn't develop *L*'s innovation or if the second period has resulted into (FDI/θ_0, reveal) profile, the lead user *L* may punish the foreign producer *m*. In case the probability of a competitor's entry is low i.e. *F* is high, the punishment will be through not revealing in the next period. This threat is credible, the higher is δ, inducing a loss for the investor in term of knowledge spillover in case *L* doesn't reveal. Besides, lead user can act as an opinion leader, pushing other users to punish *m* through boycotting its product. This can only be done, if the innovation is useful for other users as well i.e. if it is responding to a general need in the local market. Therefore, *L* is better off innovating at the maximum profitable level of γ, in order to encourage *m* to develop the innovation and to be capable of lobbying with other users in case *m* deviates. It is not expected that *L* will continue punish *m* through not revealing all along the game. This is because; *L* itself will incur a cost due to the loss of its innovation potential improvement. As long as the actualisation parameter is close to one (in this game it is set to one), there is no need to continue punishment to ensure cooperation.[4] Since *F* is high, a commitment may arise, according to which *m* will develop *L*'s innovation and in counterpart *m* will have a proprietary advantage over *L*'s innovation for a certain period of time.

In case the probability of entry is high; *F* is not important enough to deter competitor's entry, *L* will continue reveal its innovation. The punishment in this case will be through opening a new segment for a rival. To ensure the credibility of *L*'s threat, *L* shall maximise the tacit knowledge incorporated in its innovation δ and innovation's generality γ, in order to encourage a new entry. Therefore, at different levels of *F*, the lead user's threats would be credible the higher δ and γ.

Improving δ may be costly and increasing γ will increase the number of adopters of the new product among *L*'s competitors. Those measurements then, to ensure that *L*'s threats would be credible, will increase the profits of *L*'s competitors, while they may decrease *L*'s own profits; the higher is competition between users. Therefore, to reach a Pareto optimum equilibrium, the foreign investor, willing to encourage the lead user *L* to enhance those variables, shall on his turn enhance the improvement μ he brings to *L*'s innovation. Besides, the foreign investor shall also privilege *L* relative to other users. This can be done for example through giving the lead user a first access to the product or through adding a specific required improvement benefiting the lead user.

For simplification, it was assumed that, at the departure, the foreign producer *m* was monopolizing the market. If at the departure there was another producer, local or foreign, this wouldn't have changed results. The other producer would have faced the same choice as *m*. He would have had to decide whether to develop lead user based innovation or not. This is because; lead user's innovation is out of the well known product solution space of the supply side. Then, both producers would have faced the threat of entry by a third producer to serve the new segment lead user's innovation has opened. Consequently, having an oligopoly at the departure would yield the same result as introducing the probability of entry as a move by nature, following the foreign investor's decision. Even with multiple competitors, the advantage of accessing lead user's innovation would have persisted. However, the market would have been divided between many suppliers.

Conclusion

Lead users are a competitive advantage for nations. They can attract FDI, since geographic proximity is necessary in order to benefit from lead users' innovations' spillovers.

The article has developed a game theoretic model to detect the impact of the host country's innovator lead users' decision to reveal versus not reveal their innovation on foreign

[4] Yildizoglu (2003), p. 93.

producer's decisions. The model proposes that, all other things equal, lead users can attract FDI when they reveal their innovation, the higher the tacit knowledge it incorporates. In a repeated game, whether in a market with high entry cost or in a market characterized by low entry barrier, when lead users reveal, they would be pushing the foreign investor to develop their innovation through maximising the knowledge incorporated into the innovation as well as its generality. However, under high cost of entry for competitors, a commitment to secure the foreign investor's privileges in comparison with potential entrants may take place. Lead users' innovation will then be developed, incorporating the potential level of tacit knowledge, generating the maximum spillover effects and benefiting the maximum number of users.

In order to encourage lead users' efforts to increase the tacit knowledge of the innovation and its generality, players shall reach a Pareto optimum equilibrium. Therefore, the foreign investor shall increase the improvements he brings to lead users' innovation and shall privilege lead users relative to other users.

Those findings are consistent with literature on global diversification of innovation by the MNE, suggesting that, the MNE may globally generate innovation to adapt products to the needs of local users, which is a local for local strategy (Bartlett and Ghoshal, 1990; Archibugi and Michie, 1995, 1997a). If the host country is a lead market -its preferred design is expected to be internationally successful (Beise and Cleff, 2004)-, then the innovation process would be a local for global one.

This discussed role of lead users implies different reasoning for investors, governments and users themselves. Concerning managers, the evaluation of a country's innovation capabilities should consider lead users' activities. This also implies more important role for subsidiaries in the MNE's innovation process. Conversely, it implies more independence towards headquarter, while more integration in the host country's innovation dynamics. Subsidiaries need to establish mechanisms in the host country to interact with lead users and their innovations, searching for them deliberately to increase mutual benefits and hence social welfare.

Most governments now aim to attract FDI through costly financial incentives. Asset seeking FDI, which is a more probable source of spillover for the host country compared with other types of FDI, is looking for more than financial incentives (Dunning and Narula, 2000). Asset seeking FDI is looking to tap into the nation's competitive advantages. Among those immobile advantages are the country's lead users. Taking into consideration the value of lead users, governments can play a role in encouraging their innovations. Indeed, the American national innovation initiative highlights the role of users as partners in innovation (Innovate America, 2004) and the Danish government is focusing on user driven innovations (Nye Mal Regerings Grundlag, 2005).

Although users' innovations constitute a big percentage of total investment in innovation in a country, the majority of users' innovations are not recorded into governments' statistics (von Hippel, 2005). The contribution of users to innovation should be accounted more rigorously to highlight their role to managers and to policy makers. For example through country level survey, which includes users' innovations, like the one conducted on UK population in Flowers et al. (2010). If the other actors become aware of the role lead users can play, lead users will increasingly find it beneficial to participate in the innovation process, to innovate and to reveal their innovations. This is because; lead users will expect that the other actors will be rewarding their contributions.

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