DOES TRADE IN DISEMBODIED KNOWLEDGE PROMOTE TRADE IN GOODS?

- SOME EMPIRICAL EVIDENCE FOR MIDDLE-INCOME COUNTRIES AFTER THE TRIPS AGREEMENT

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ABSTRACT

Many studies have theoretically and empirically investigated the impact of Intellectual Property Rights ("IPR") strengthening on high-tech exports from developed to developing countries. However, little empirical research has addressed the question of the impact of IPR reform on export promotion notably in middle-income countries. This paper tries to fill that gap. It examines the empirical link between IPR strengthening, disembodied knowledge demand, and export promotion by estimating a simultaneous equation model ("SEM"). The results obtained confirm the significant impact of IPR reform in middle-income countries on their demand of disembodied knowledge measured by payments for Intellectual Property ("IP") use. These results also illustrate the positive impact of IP use on export promotion in these countries despite complex mechanisms underlying access to the international market for technology.

Keywords: Disembodied Knowledge, Intellectual Property Rights, Licensing, and North-South Trade.

JEL Codes: F14, O33, O34

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I. INTRODUCTION

The TRIPS Agreement has defined the minimum standards of regulation of IP that all developing countries are called to comply with. Despite constraints and costs imposed by stronger IPR regulation, several studies have proposed to evaluate its contribution in terms of innovation, economic growth and development for these countries.[1] However, while benefits of IPR strengthening in developing countries are expected in the long run, medium-term impact on technological capabilities of these countries is nonetheless to be proven.[2]

On the other hand, it is often considered that international diffusion of technology can play a role in improving technological capabilities of developing countries provided that IPRs are strengthened. Knowledge dissemination channels that are assumed to have a positive effect on technological capabilities are mainly international trade, foreign direct investment ("FDI") inflows and use of IP.

Wide empirical literature offers converging estimates of the positive impact of IPRs on trade. Under the assumption that the market expansion effect dominates the monopoly power effect,[3] international dissemination of knowledge can be achieved through technology embodied in tradable goods. In this regard, several studies confirm the impact of IPRs strengthening on knowledge intensive exports to developing countries.[4]

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[1] David M.Gould & William C. Gruben, *The Role of Intellectual Property Rights In Economic Growth*, 48, JOURNAL OF DEVELOPMENT ECONOMICS, 323-350 (1996); Yongmin Chen & Thitima Puttitanun, *Intellectual Property Rights and Innovation in Developing Countries*, 78, JOURNAL OF DEVELOPMENT ECONOMICS, 474-493 (2005); Rod Falvey et al, *Intellectual Property Rights and Economic Growth*, 10(4), REVIEW OF DEVELOPMENT ECONOMICS (The University of Nottingham Research Paper Series, research paper no. 2004/12 ,2006); Yee K. Kim et al, *Appropriate Intellectual Property Protection and Economic Growth in Countries at Different Levels Of Development*, 41, RESEARCH POLICY, 358-375 (2012).

[2] Sanjaya Lall, Indicators of the relative importance of IPRs in developing countries, 32(9), RESEARCH POLICY,
1657-1680 (2003); John Hudson & Alexandru Minea, Innovation, Intellectual Property Rights, and Economic Development: A Unified Empirical Investigation, 46, WORLD DEVELOPMENT, 66-78 (2013); Cassandra M. Sweet & Dalibor S. Maggio Do Stronger Intellectual Property Rights Increase Innovation?, 66, WORLD DEVELOPMENT, 665-677(2015).

[3] Helpman and Krugman (1985) distinguished two effects of IPRs on trade: the first one is a monopoly power effect explained by restrictions on export supply due to the risk of imitation. The second one is a market expansion effect. This effect is explained by innovative firms willingness to increase their exports to countries where IPRs strengthening reduces imitation. Deardorff (1992) argued that the market expansion effect is more likely when IPRs are strengthened. Indeed, stronger IPRs stimulate innovation in Northern countries that meet the specific needs of consumers in the South. This favours export flows to southern countries.

[4] Keith E. Maskus & Mohan Penubarti, How trade-related are intellectual property rights?, 39, Journal OF INTERNATIONAL ECONOMICS, 227-248 (1995); Pamela J. Smith, Are Weak Patent Rights a Barrier to U.S Exports?, 48, JOURNAL OF INTERNATIONAL ECONOMICS, 151-177 (1999); Mohammed Rafiquzzaman, The Impact of Patent Rights on International Trade: Evidence From Canada, 35(2), THE CANADIAN JOURNAL OF ECONOMICS, 307-330 (2002); Carsten Fink & Carlos P. Braga, How Stronger Protection Of Intellectual Property Rights Affects International Trade Flows? (In Intellectual Property and Development, World Bank and Oxford University Press, 2005); Olena Ivus, Do Stronger Patent Rights Raise High-Tech

However, empirical researches on the impact of IPRs strengthening on exports originating from developing countries are comparatively few.[5] To conclude, IPRs do not have direct effects on developing countries' exports. However, they suggest that IPRs could have an indirect effect on exports when innovation capabilities of these countries improve. Shin and al. are more explicit about the influence of IPRs on developing countries' exports.[6] The authors show that the IPR gap between developed and developing countries affects exports from the latter to the former. Indeed, exports from developing countries would be even smaller when the IPR gap between these countries and developed importing countries is large. Hence, the IPR gap would become a "regulatory" barrier to trade.

Dissemination of technological knowledge through FDI has been also examined in several studies within the IPR framework. Mansfield considers that weak IPRs protection limits the transfer of sophisticated technologies by multinational firms.[7] For transition countries, Javorcik shows that multinational firms choose between producing in those countries and simply distributing goods according to the strengthening of IPR.[8] McCalman proposes to examine how the IP system can lead to a trade-off between arm's length licensing and FDI.[9] By highlighting a non-monolithic relationship between IPRs and FDI, McCalman concludes that the choice of subsidiary creation is predominant when intellectual property regimes are either strong or weak. Licensing is the alternative chosen only when a moderate protection of intellectual property is observable.

Based on a North-South model, Branstetter and al. assume that IPR reforms in Southern countries induce production transfer from the North to the South through FDI.[10] This

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Exports to Developing Countries?, 81, JOURNAL OF INTERNATIONAL ECONOMICS, 38-47 (2010); Kristie Briggs, Does Patent Harmonization Impact the Decision and Volume of High Technology Trade?, 25, INTERNATIONAL REVIEW OF ECONOMICS AND FINANCE, 35-51 (2013).

[5] Walter G. Park & Douglas Lippoldt, *The Impact Of Trade-Related Intellectual Property Rights On Trade And Foreign Direct Investment In Developing Countries*, TD/TC/WP(2002)42/ Final, OECD.

[6] Wonkyu Shin et al, When an Importer's Protection of IPR Interacts with an Exporter's Level of Technology: Comparing the Impacts of the Exports of the North and South, 39(6), THE WORLD ECONOMY, 772-802 (2016).

[7] Edwin Mansfield, INTELLECTUAL PROPERTY PROTECTION, FOREIGN DIRECT INVESTMENT, AND TECHNOLOGY TRANSFER (1994).

[8] Beata S. Javorcik, *The Composition of Foreign Direct Investment and Protection of Intellectual Property Rights: Evidence From Transition Economies*, 48, EUROPEAN ECONOMIC REVIEW, 39-62 (2004).

[9] Philip McCalman, Foreign Direct Investment and Intellectual Property Rights: Evidence From Hollywood's Global Distribution of Movies and Videos, 62, JOURNAL OF INTERNATIONAL ECONOMICS, 107-123 (2004).

[10] Lee Branstetter, et al, Intellectual Property Rights, Imitation, and Foreign Direct Investment: Theory and Evidence. (National Bureau of Economic Research, Cambridge MA, working paper no.13033, 2007).

transfer leads to a reallocation of resources towards research and development ("R&D") and innovation activities in the North. At the same time, a "production shifting" takes place. Some productive activities cease in Northern countries and begin to develop in the South.

Southern countries then end up exporting goods that are no longer produced in the North. For the authors, gains from inward FDI following IPR reform in the South do more than offset losses due to the decrease of imitation opportunities in these countries.[11]

This paper supports the idea that IPR reform and enforcement increase possibilities of access to disembodied knowledge. Unlike technological knowledge embodied in tradable goods, disembodied knowledge is defined by blueprints, patents, collaborative R&D services and other technical services, which are not directly incorporated into goods. These forms of disembodied knowledge are tradable on the market for technology. Licensing agreements correspond to a particular form of disembodied knowledge traded on this market. The definition adopted in this work is therefore consistent with the one proposed by Arora and al.[12]

The idea supported in this research also relies on statistical evidence. Indeed, access to disembodied knowledge has become widespread after the TRIPS agreement as evidenced by the increase of payments for IP use. These payments grew by an average of 12% over the 1995-2015 periods, rising from 99.3 to 961.2 billion of U.S dollars.

However, while access of middle-income countries to disembodied knowledge has grown since the TRIPS agreement, this access remains limited as shown in *Table 1*. A larger access of these countries is conditional on further IPR reforms to be undertaken, particularly with regard to patent rights. Moreover, middle-income countries would be able to bridge their technological gap through IP use to the extent that IPRs are enforced.

[11] In the absence of any IPRs reform in Southern countries, these countries would rely mainly on imitation to produce goods that they could not export especially to Northern countries due to IP infringement. However, as Southern countries reform their IP systems, they could attract more FDI and their production could be legally exported to the North.

[12] The definition proposed by the authors is closed to the definition of market for technology proposed by the U.S Department of Justice in the Antitrust Guidelines for the Licensing of Intellectual Property. See, Ashish Arora, Andrea Fosfuri, & Thomas Roende, Managing Licensing in a Market for Technology (National Bureau of Economic Research, Cambridge MA, working paper no. 18203, 2012).

Table 1: Patent Right Index (PRI) and payments for IP use before and after the TRIPS agreement: classification by income groups (121 countries).

PRI index* (mean)					Use of IP ** (payments share, %)			
Income groups* **	1975	1990	1995	2010	1975	1990	1995	2010
High income	2.33	2.84	3.63	4.23	89.2	93.9	91.84	90.2
Upper middle income	1.56	1.65	2.38	3.29	10.1	5.22	6.72	7.4
Lower middle income	1.16	1.41	1.85	2.86	0.66	0.84	1.41	2.38
Low income	1.41	1.66	1.83	2.58	0.004	0.04	0.03	0.02

*Source: author's calculations * Ginarte and Park index ** IMF (BoP) *** World Bank classification*

This paper also suggests that use of IP by these countries would increase their exports, which would place them on a higher growth path. Far from recommending a disengagement from R&D and local innovation activities, use of IP and notably licensing contracts would be an appropriate choice if it avoids waste of R&D resources on technological fields where it is difficult to invent around. Moreover, to the extent that strengthening of IPRs is unavoidable in the context of free trade agreements, use of IP offers an opportunity to reduce technological asymmetry vis-à-vis developed trading partners. Finally, use of IP could be a solution to the middle-income trap,[13] that some middle-income countries are experiencing in recent periods.

Before examining the viability of IP use for development purposes, it is firstly important to deepen mechanisms underpinning the functioning of the market for technology. Theoretical foundations to the relationship between IPRs, use of IP, and export promotion will be then exposed *(Section 1)*. Starting from empirically estimable forms, econometric investigations will be realized as part of an econometric protocol adapted

[13] Two major studies have focused on the middle-income trap problem in recent periods This research refers to the definition proposed by Paus (2017). According to the author, The middle income trap captures "a situation where a middle income country can no longer compete internationally in standardized labour-intensive goods because wages are relatively too high, but it can also not compete in higher value added activities on a broad enough scale because productivity is relatively too low. The result is slow growth and less potential for rising living standards for more people"]. See, Indermit S. Gill & Homi Kharas, H. The Middle-Income Trap Turns Ten (World Bank Group, Policy Research Working Paper no. 7403, 2015). See also, Eva Paus, Escaping The Middle-Income Trap: Innovate or Perish (ADBI Working Paper Series no. 685, 2017).

to the estimation of simultaneous equations *(Section 2)*. Thereafter, conclusions will follow.

II. SECTION 1: THE MARKET FOR TECHNOLOGY AND THE PROMOTION OF INTERNATIONAL TRADE IN GOODS: THEORETICAL LITERATURE.

Despite the increase in value of transactions on international market for technology ("MfT"), statistics relating to these transactions must be interpreted with some caution. Indeed, these statistics often provide an aggregated estimate of disembodied knowledge. This concerns, notably, those available in the *World Development Indicators* ("WDI") database where fees and royalties paid or received relate indiscriminately to licensing contracts, trademark, copyright, industrial processes, etc.[14] Moreover, as an important component of disembodied knowledge traded on MfT, licensing transactions deserve a careful interpretation. In fact, even if an overall evaluation of these transactions is available, such an evaluation gives no idea about individual prices of licenses, number of licensing agreements concluded, and conditions under which these licenses have been negotiated. Yet, such details are crucial for at least two reasons. First, they allow us to better appreciate the possibilities of access to licenses. Second, they can mostly provide relevant insights on the functioning and efficiency of the market for licenses (1). It would be also useful to identify factors that determine supply and demand of licenses (*1.*2). Finally, with respect to the interest of this work, it is to see whether use of IP and particularly licensing agreements promote export in developing countries (*1.*3). To analyze these different points, a review of related theoretical literature is necessary.

1.1 The functioning of the market for licenses: theoretical observations.

In a broader context, K. Arrow provided main reasons of the imperfection of markets dealing with exchange of information.[15] These reasons essentially revolve around the collective good character of information. However, Caves argued that the institutional approach initiated by Williamson proposes more decisive explanations for understanding the limits of contractual relationships when it comes to licensing

[14] Without a distributional key, it is difficult to have accurate information on the value of transactions specific to licensing contracts. Note also that even if other databases allow to get disaggregated data, they are often limited to disembodied knowledge traded between developed countries (OECD's Technology Balance of Payments; Survey of Current Business, U.S Department of Commerce) and large companies (Thomson Financial SDC Platinum database).

[15] Kenneth Arrow, IN THE RATE AND DIRECTION OF ECONOMIC ACTIVITY: ECONOMIC AND SOCIAL FACTORS,
Welfare and the allocation of resources for inventions (1962).

contracts.[16] The basic idea that stems from this approach is to highlight the difficulty of contractual relations between agents likely to adopt opportunistic behaviors. When such behaviours are predominant, agents organize their activities in the context of contractual relations in order to avoid transaction costs. This situation reflects in itself a problem of market imperfections.

Regarding licensing contracts, Arora considers that these contracts may raise a double moral hazard problem. Knowing that knowledge transferred by a licensor to a licensee relates to codified knowledge and tacit knowledge, opportunistic behaviors adopted by both agents are specific to tacit knowledge.[17] Indeed, the licensor may be tempted not to reveal all the tacit knowledge. For its part, the licensee may be tempted to downplay the importance of tacit knowledge he has received. This situation increases the complexity of contractual relationships between licensors and licensees and raises problems of licensing contract enforcement.

More recently, Gans and Stern proposed to analyse the efficiency of the MfT referring to three market efficiency criteria established by Roth.[18] These criteria are market thickness, lack of congestion and market safety. For the authors, the more complementary are innovative ideas available on MfT, the greater will be the number of potential users of these ideas. This would increase transactions on innovative ideas and contribute to the thickness of the market for ideas. However, market thickness could be compromised when hold-up problems exist or if the renewal of innovative ideas is so fast that it would prevent potential users from evaluating them at their right price.

MfT may also experience low efficiency if transactions on innovative ideas face congestion problems. These problems are essentially related to the rival use of those ideas.[19] Knowing that the value of an innovative idea depreciates if it is used by many potential users, the best choice for the seller of such an idea is to negotiate it in secret

[16] Richard E. Caves, et al, The Imperfect Market for Technology Licenses, 45(3), OXFORD BULLETIN OF ECONOMICS AND STATISTICS, 249-267 (1983); OLIVER E. WILLIAMSON, MARKETS AND HIERARCHIES: ANALYSIS AND ANTITRUST IMPLICATIONS, (The Free Press, McMillan Publishers, London,1975).

[17] Tacit knowledge is the most intangible form of knowledge which may take the form of rules of thumb, or heuristics. It may concretely consist of technical assistance or a sharing of licensor's cumulative experience on the use of a technology]. See, Ashish Arora, Contracting for Tacit Knowledge: The Provision of Technical Services in Technology Licensing Contracts, 50, JOURNAL OF DEVELOPMENT ECONOMICS, 233-256 (1996).

[18] Joshua S. Gans & Scott Stern, Is there a market for ideas?, 19(3), INDUSTRIAL AND CORPORATE CHANGE, 805-837 (2010); Alvin E. Roth, The Art of Designing Markets, 85, HARVARD BUSINESS REVIEW, 118-126 (2007).

[19] Rival use of ideas must be distinguished from non-rival access to ideas.

and with only one potential user. Therefore, congestion problems lead to restricting access to innovative ideas. For Gans and Stern, while exclusive contracts are optimal private solutions, they are, nonetheless, socially inefficient. Indeed, exclusive contracts prevent multilateral negotiation of innovative ideas that can bring their price at an optimum level.

Efficiency of MfT also depends on security of transactions involving innovative ideas. Security of transactions requires a rigorous control on ideas reproduction. If reproduction is realized at a lower cost, the supplier of an innovative idea may lose control on its future sale and use. This risk is even more likely when the supplier is not able to discern between potential buyers of its idea, i.e., those who will reproduce it and those who will not. Such a situation could also have an impact on the pricing of ideas.[20] Finally, Gans and Stern conclude that a safe MfT is only possible if institutional guarantees are offered to producers of innovative ideas. These guarantees mainly concern IPR protection.

1.2 Supply and demand of licenses.

It would be evident to consider that innovators accept to sell licenses because they are mostly motivated by the benefit of royalties. Yet, whether the innovator is himself producer or non- producer of goods incorporating his invention, sale of licenses often results from other strategic choices. Indeed, licenses supply is sometimes determined by the choice of an innovator (producer of goods) to discourage entry of new competitors on the market.[21] Licensing may also be selective as it sometimes involves only minor innovations.[22]

However, for innovators who are non-producers of final goods, offering technology licenses is almost systematic. The aim of these innovators, called technology specialists, is to avoid two types of risks: a risk of contracts established to get additional assets (such as production and marketing) and a risk of sunk costs on investments in such complementary assets.[23]

[20] Given the risk of reproduction, the supplier of the original idea is tempted to increase its price. However, with higher prices, the original idea may not be sold. The setting of a low price does not solve the problem too because it induces strong competition between users of the same idea. Ultimately, reproducing original ideas eventually compromise the existence of a market for ideas.

[21] Nancy T. Gallini, Deterrence By Market Sharing: A Strategic Incentive for Licensing, 74(5), THE AMERICAN ECONOMIC REVIEW, 931-941 (1984).

[22] Michael L. Katz & Carl Shapiro, How to Licence Intangible Property, 101(3), THE QUARTERLY JOURNAL OF ECONOMICS, 567-590 (1985).

[23] David J. Teece, Profiting from Technology Innovation: Implications for Integration, Collaboration, Licensing,

Rockett states that some innovators grant licenses to previously selected potential competitors.[24] Targeting of potential licensees is made such that once the patent expires; the innovator will find himself faced with weak competitors that he would be able to dominate. In another context, Arora and Fosfuri highlighted the limits of the innovation monopoly model.[25] For the authors, licensing is a strategic choice when several firms hold substitutable technologies.[26] Moreover, Arora considers that the supply of licenses would be the result of an arbitrage between income from royalties and income from the production of final goods.[27] According to the authors, granting of licenses would depend essentially on the choice of the innovative firm's management between centralizing and decentralizing licensing decisions.[28]

Regarding the demand for licenses, Arora and Gamberdella consider that this demand is not systematic.[29] Indeed, use of externally developed technologies may be limited by the 'not invented here' ("NIH") syndrome. Hence, a limited recourse to licenses could be explained by the firm's willingness to better manage internally the R&D, production and marketing interfaces. This is particularly the case for developed countries.

The nature of absorptive capacities is another factor determining demand for licenses. As underlined by Arora and Gamberdella, absorptive capacities could be either capacities of utilization or capacities of evaluation of technology.[30] Capacities of utilization could be defined as the firm's ability to produce through the acquired technology, whereas capacities of evaluation would refer to firm's ability to predict the contribution of the technology to be acquired. For developing countries, demand for

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and Public Policy, 15(6), RESEARCH POLICY, 285-305 (1986).

[24] Katharine Rockett, The Quality of Licensed Technology, 8, INTERNATIONAL JOURNAL OF INDUSTRIAL ORGANIZATION, 559-574 (1990).

[25] Model supported by Teece (1986).

[26] Taking into account the two effects of income and dissipation of profits related to licensing, the authors show that when the number of innovative firms is greater than two, dissipation of profits induced by licensing is collectively better internalized.

[27] Ashish Arora et al, supra Note 13.

[28] Arora et al analyzed the agency problem affecting the relationship between top management of the firm (centralized unit) and the production unit (decentralized unit). In one hand, top management of the firm is tempted to centralize licensing decision to maximize royalties. On the other hand, the production unit, which is better informed about opportunities and threats of licensing, could have an aversion for this choice. Such aversion is justified by the risk of declining income from production of final goods as a result of intensified competition. Thus, the authors conclude that decentralization of licensing decisions could reduce the supply of licenses.

[29] Ashish Arora, & Alfonso Gambardella, Ideas For Rent: An Overview of Markets for Technology, 19(3), INDUSTRIAL AND CORPORATE CHANGE, 775-803 (2010).

[30] Ashish Arora, & Alfonso Gambardella, Evaluating Technological Information and Utilizing it: Scientific Knowledge, Technological Capability, and External Linkages in Biotechnology, 24(1), JOURNAL OF ECONOMIC BEHAVIOR & ORGANIZATION, 91-114 (1994).

licenses will be all the more important as their capacities of utilization (production and marketing) grows. Moreover, since capacities of evaluation in these countries are comparatively lower than those available in the developed world, this would explain their greater dependence on licensing.

1.3 Licences access and developing countries export promotion.

The above analysis shows that access to and use of licenses are mainly conditioned by the strengthening of IPRs and by absorptive capacities. In addition, there is still reluctance to grant licenses to potential competitors on the market for final goods. In this respect, Razgaitis indicates that only 25% of technologies pave the way for licenses negotiation and that conclusion of definitive agreements concerns only 3% of those technologies.[31]

Given these multiple constraints, there is reason to question conditions and opportunity for developing countries to access licenses. The first necessary condition is IPRs strengthening in these countries. For Maskus, stronger IPRs could be a vector for development, particularly through imports of high-tech goods.[32] However, the question is to what extent strengthening IPR in developing countries facilitates their access to licenses while enabling them to enhance their export capacities. Yang and Maskus offer relevant theoretical insight on this point.[33]

In a North-South model, Yang and Maskus define variables explaining innovation efforts in the North and specify factors affecting Northern countries decision for selling licenses to Southern countries. Licensing is explained by variables defined in structural form [1]:

$$n = f(L_N, L_S, a_l, a_L(\kappa, G), \delta(\kappa, C)) \qquad [1]$$

Variable n corresponds to the number of licenses granted to Southern firms. Labour factor endowments in Northern and Southern countries, respectively denoted L_N *et* L_S , play a particular role. Indeed, if L_S is high, this would imply low wages in the South, which justifies

[31] R. Razgaitis, U.S/Canadian Licensing In 2003: Survey Results, 34(4), JOURNAL OF THE LICENSING EXECUTIVE SOCIETY, 139-151 (2004).

[32] Keith E. Maskus, Intellectual Property Challenges For Developing Countries: An Economic Perspective, UNIVERSITY OF ILLINOIS LAW REVIEW, 457-474 (2001).

[33] Guifang Yang, G & Keith E. Maskus, Intellectual Property Rights and Licensing: An Econometric Investigation, 137(1), Weltwirtschaftliches Archiv, 58-79 (2001); Lei Yang & Keith E. Maskus, Intellectual Property Rights, Technology Transfer, and Exports in Developing Countries, 90, JOURNAL OF DEVELOPMENT ECONOMICS, 231-236 (2009).

the production of final goods in these countries.[34] Condition on wages is nevertheless insufficient because production in the South can only be realized if Northern firms accept the granting of licenses.

According to the authors, granting of licenses by Northern firms to Southern ones depends on the cost of innovation , the cost of licensing $a_L(\kappa, G)$ and the sharing of rents between licensors and licensees $\delta(\kappa, C)$. Moreover, cost of licensing and sharing of rents depend on

IPR protection in the South measured by parameter . These variables are further affected respectively by the cost of knowledge-transferred and the cost of imitation

However, unlike Yang and Maskus[35], the model proposed by Yang and Maskus[36] examines more explicitly the relationship between exports and licensing. Indeed, the authors assume that in order to produce and export to Northern countries, Southern firms have to choose between imitation and acquisition of licenses. Through licenses, they would be able to reduce their production costs while avoiding any blockage of their exports to Northern countries. Taking into account other alternatives, relation [2] allows a comparison of production costs between Northern and Southern firms:

$$C_S > C_N > C_S - i(a) > C_S - l(x,a) \qquad [2]$$

C_S and C_N respectively represent Southern and Northern firms marginal costs in the absence of imitation and licensing. According to (2), Southern firms marginal cost could be reduced either through imitation or licensing.[37] In both cases, absorptive capacities, denoted are decisive. However, cost reduction through licensing also depends on the level of tacit knowledge transferred by Northern firms (licensors), denoted . An equilibrium with licensing derived from the model lead to two major theoretical findings:

- Tacit knowledge transferred through licensing would be all the more important if: patent rights protection in Southern countries is reinforced, Southern and Northern markets are large, C_S is low and C_N is high post-transfer, and Southern firms absorptive capacities are important.
- Under the assumption of systematic blocking of Southern firms exports to Northern

[34] An increase of has two possible effects. If is allocated to R & D sector, it will boost innovation efforts in the North and help increase the number of licenses granted to the South. However, when feeds final goods production sector in the North, Northern countries would be more competitive to produce these goods and licensing to southern countries would cease.

[35] Yang & Keith (2001),supra Note 33.

[36] Yang & Keith (2009), supra Note 34.

[37] $i(a)$ and $l(x,a)$ respectively represent the contribution of imitation and licensing to the reduction of Southern firms marginal cost.

countries due to imitation, equilibrium with licensing depends on a minimum threshold of IPR protection in Southern countries. This minimum threshold deters imitation by making it very costly. At the same time, it gives Southern firms substantial cost advantage through sustained tacit knowledge transfer. By this way, Southern firms would be able to export to Northern countries without being legally blocked.

III. SECTION 2: EMPIRICAL ANALYSIS

The theoretical developments presented above suggest the existence of links between IPRs, access to disembodied knowledge through IP use, and export promotion. Since these links are described in the context of simultaneous relations, empirical estimates of those relations require a particular econometric protocol. Before exploring this protocol, variables and data used will be presented.

2.1 Data and description of variables

Most of the studies propose to measure strengthening of IPRs through patent rights index ("PRI") constructed by Ginarte and Park and updated by Park.[38] This index, which takes values ranging from 0 (low protection) to 5 (high protection), is based on the following dimensions: extent of patent rights coverage, membership in IP related international treaties, duration of patent protection, enforcement mechanisms and restrictions on patent rights. For the purpose of this work, use of PRI seems more appropriate compared to IPRs measures proposed by the Global Competitiveness Index, because patent rights are more directly related to the granting of licenses.[39]

Chen and Puttitanum explain strengthening of IPRs by the level of technological capabilities or country's development.[40] These criteria are approximated by Gross Domestic Product per capita[41] ("GDPC"). However, other variables should be taken into account such as innovation activity at the local level, pressures exerted by more openness to trade, education and the institutional environment specific to each country. Innovation activity at the local level is approximated by the number of patents filed by residents ("PATR"). WDI database provides data on this variable. Regarding openness to trade, studies cited in introduction have largely confirmed the relationship between IPRs and trade. Indeed, when IPRs are strengthened in developing countries, imitation

[38] Juan C. Ginarte & Walter G. Park, Determinants of Patent Rights: A Cross-National Study, 26, RESEARCH POLICY, 283-301 (1997); Walter G. Park, International patent protection: 1960-2005, 37, RESEARCH POLICY, 761-766 (2008).

[39] Lesser (2011) proposes a weighted index of patent rights (Cortez Patent Index) where the criteria of duration of protection and patent protection restrictions are removed. These criteria are replaced by patent office efficiency and the cost of patent protection. The index is however only available for the year 2009 and for a more limited sample of countries.

[40] Chen & Puttitanun (2005), supra Note 5.

[41] GDP per capita constant 2010 U.S dollars$ is considered.

of imported products decreases in these countries. This encourages exports by firms located in developed countries. Data from *UNCTAD Trade Statistical Year Book* are used to measure imports from high-income countries ("IHIC").

Measures related to education and institutional environment are compiled from data coming from WDI and the EFW dataset available on the Fraser Institute's website. Education is approximated by gross enrolment ratio in tertiary education ("ERT"). Approximation of the Institutional environment variable is based on the Economic Freedom Ranking Index ("EFI") which takes values between 0 and 10. This index is defined with respect to five criteria size of government, legal system and property rights, sound money, freedom to trade internationally and regulation.[42]

Factors determining use of IP are inspired by Maskus, [43] and Yang and Maskus.[44] IPRs are one of those factors. However, other factors are to be considered such as market size approximated by population ("POP") and GDPC. These variables allow control for demand characteristics. When use of IP relates to acquisition of licenses, specific variables should be taken into account. Assuming that licenses are used for production of intermediate or final goods, real production measured by real Gross Domestic Product,[45] (GDP) is considered.

Theoretical explanations also suggest that as a form of IP use, licensing agreements require enhanced absorptive capacities. These capacities could be associated with the presence of high- level skills. For a reliable measure of high skills, ILO classification seems to be the most appropriate. However, as this classification has been performed since 2004, skills will be approximated by gross enrolment ratio in tertiary education defined above. Finally, as a form of trade in disembodied knowledge, granting of licenses would be sensitive to the institutional context specific to each country. Considering this assumption, Economic Freedom Index ("EFI") variable is again incorporated as a factor that could potentially influence licensing agreements.

This research also addresses the relationship between use of IP measured by fees and royalty payments ("FRPAY") and developing countries' exports of high-tech goods. Starting from theoretical state of the art, there would be two types of trade-off operated

[42] Other relevant variables, such as government effectiveness or control of corruption, would have helped to further define the institutional environment. However, data on these variables provided by the WGI dataset start in 1996.
[43] Supra Note 33.
[44] Supra Note 34.
[45] GDP constant 2010 U.S dollars$ is considered.

by patent holders located in developed countries. The first one is whether to opt for direct exports of manufactured goods or granting of licenses].[46] The second one is whether to opt for FDI or granting of licences.[47]

If granting of licences happens, it is supposed that the licensee does not necessarily sell its products only on its local market but may export part or all of its production to the licensor's market or to tiers markets. It is further assumed that licensee's export sales may relate to intermediate or final high-tech goods. Data on high-tech exports ("THE") is provided by WDI database,[48] and UNCTAD Trade Statistical Year Book. The impact of foreign direct investment in high-tech exports is also taken into account by considering net FDI inflows (FDI) statistics available on IMF's Balance of Payments database. *Table 2* provides a complete description of the variables to be used in the estimations.

[46] Kristie Briggs & Walter G. Park, There Will Be Exports and Licensing: The Effects of Patent Rights and Innovation and Firm Sales, 23(8), JOURNAL OF INTERNATIONAL TRADE AND ECONOMIC DEVELOPMENT, 1112- 1144 (2014).

[47] James R. Markusen, Contracts, Intellectual Property Rights, and Multinational Investment in Developing Countries, 53, JOURNAL OF INTERNATIONAL ECONOMICS, 189-204 (2001); Thitima Puttitanum, Intellectual Property Rights and Multinational Firms' Mode of Entry, 11, JOURNAL OF INTELLECTUAL PROPERTY RIGHTS, 269-273 (2006); Lee Branstetter, et al, Intellectual Property Rights, Imitation, and Foreign Direct Investment: Theory and Evidence. (National Bureau of Economic Research, Cambridge MA, working paper no.13033, 2007); Lei Yang & Keith E. Maskus, Intellectual Property Rights, Technology Transfer, and Exports in Developing Countries, 90, JOURNAL OF DEVELOPMENT ECONOMICS, 231-236 (2009); Lee Branstetter, et al, Does Intellectual Property Rights Reform Spur Industrial Development?, 83, JOURNAL OF INTERNATIONAL ECONOMICS, 27-36 (2011).

[48] According to WDI database, exports of high-tech goods concern R & D-intensive goods (aerospace, computers, pharmaceuticals, scientific instruments, electrical machinery). This classification is fairly close to UNCTAD's classification based on 3-digit level SITC Rev. 3 product codes. It should be noted that data on high-tech exports provided by WDI database are available only as a percentage of manufactured exports. Calculations make it possible to transform percentages to values expressed in U.S dollars.

Table 2: Descriptive statistics

Variable	No. of Observations	Mean	Std. Dev.	Min	Max
PRI	124	3.618	0.888	1.233	4.875
FRPAY*	124	2790,000	5800,000	1432,5	3280,000
HTE*	124	24700,000	42000,000	336,4	197000,000
PATR	124	12571.69	37935.07	7	241977
GDP*	124	1010000,000	2370000,000	12300,000	15000000,000
GDPC	124	19296.49	19621.76	622.303	88494.36
IHIC*	124	120 000, 000	189 000,000	957,000	967 000,000
EFI	124	6.948	0.871	3.834	9.053
ERT (%)	98	45.5	23.4	4.9	99.7
FDI*	124	26 000,000	56 700,000	72 600	350 000,000
POP**	124	84900	196,000	2537440	1230,000

** Thousands of U.S dollars* ***Thousands of people*

Given constraints on data availability, our empirical analysis is based on a sample of 31 countries including 17 high-income countries and 14 middle-income countries.[49] All the variables listed in *Table 2* have been observed for the years 1995, 2000, 2005 and 2010. As shown in this table, there are missing values for ERT variable. Regarding PRI, it was possible to get data until 2010.[50]

I. 2.2 Econometric Method

The relationships between IPRs, payments for IP use and exports of high-tech goods could be described by the following functional forms:

$$PRI = f(PATR, GDPC, MHIC, EFI, ERT) \quad [3]$$

$$FRPAY = g(PRI, POP, GDP, EFI, ERT) \quad [4]$$

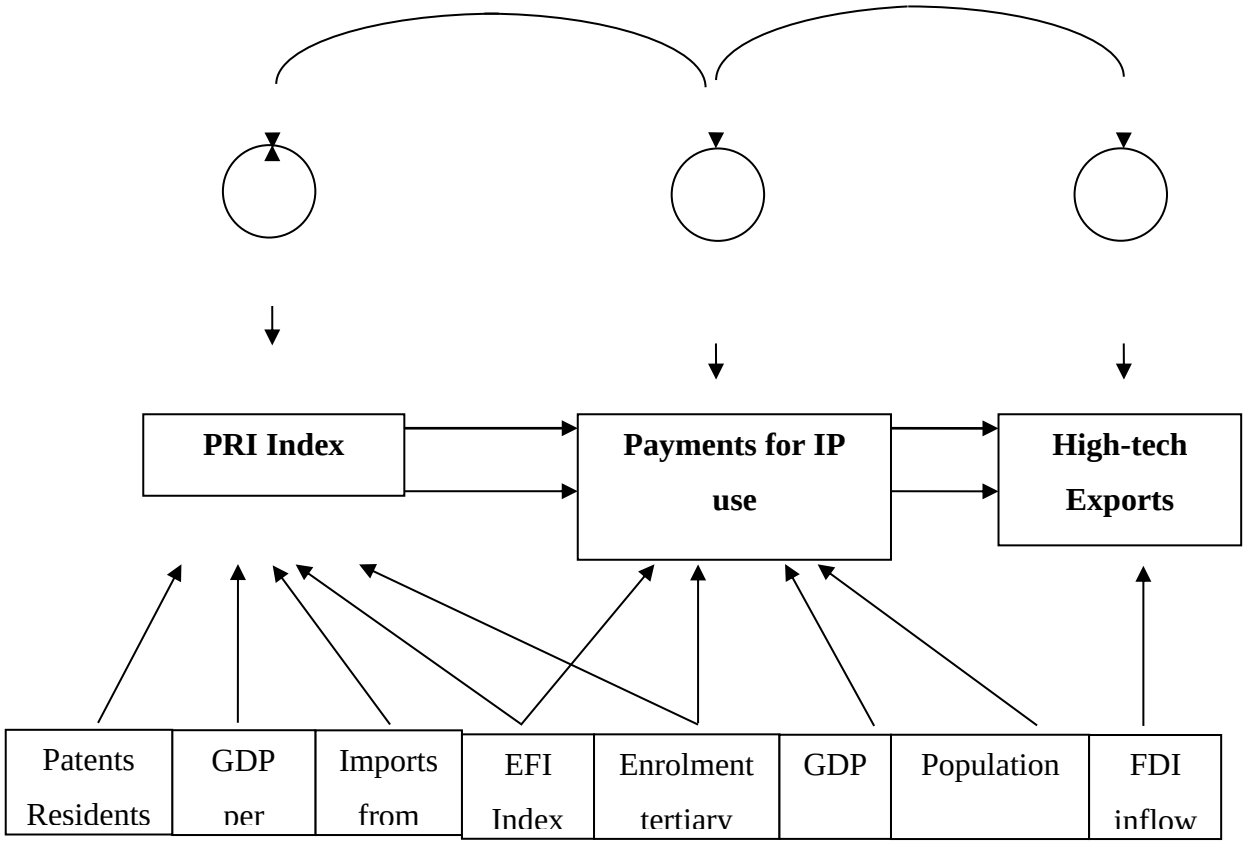
$$HTE = h(FRPAY, FDI) \quad [5]$$

To estimate the Structural Equation Model (SEM) based on the functional forms (equations) [3], [4] and [5], a particular econometric approach is needed. Indeed, the model assumes dependencies between observed response (endogenous) variables PRI, FRPAY and HTE. Therefore, it is a structural model having paths between response variables. It should also be noted that all exogenous variables (PATR, GDPC, IHIC, EFI,

[49] The list of countries and the correlation covariance matrix of all variables are available in annex.
[50] I would like to thank Professor Walter G. Park for providing me with updated data on patent rights index.

ERT, GDP, POP, FDI) included are observed. Moreover, the model does not rule out the hypothesis that error terms $\varepsilon_i, (i = 1,2,3)$ specific to each equation are correlated (*Figure 1*).

Figure 1: Path diagram

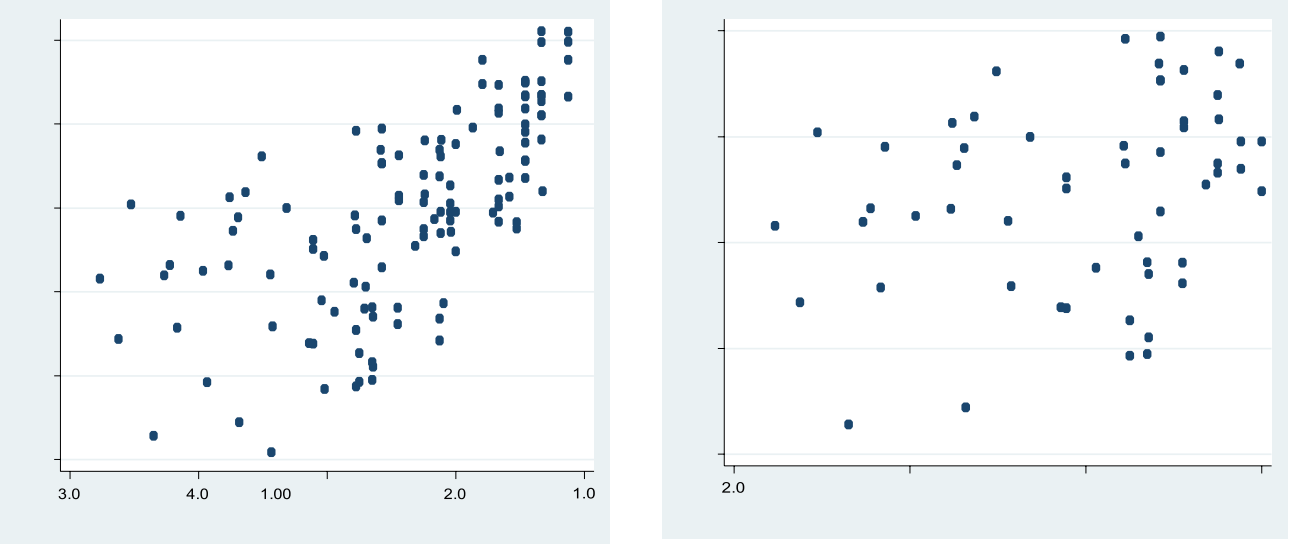


In addition, the structural equation model corresponding to *Figure* 1 is recursive and over- identified.[51] Therefore, the model to be estimated is stable by definition. However, because of the possibility of errors correlation, full information maximum likelihood ("FIML") method is recommended for coefficients estimation. SEM also allows for a decomposition of direct and indirect effects, which makes it possible to analyze mutual influences exerted by each variable on the others.[52]

[51] Over-identification is based on a checking for rank and order conditions.
[52] D.F. Alwin & R.M. Hauser, The Decomposition of Effects in Path Analysis, 40(1), AMERICAN SOCIOLOGICAL REVIEW, 37-47 (1975); Kenneth A. Bollen, Total, Direct and Indirect Effects in Structural Equation Models, 17, SOCIOLOGICAL METHODOLOGY, 37-69 (1987).

Before presenting the empirical results, it would be useful to observe graphs relative to direct links between endogenous variables specified in the model. The graphical analysis covers both the full sample (31 countries) and the reduced sample of middle-income countries (14 countries). *Graph 1* and *Graph 2* respectively plot the relationship between payments for IP use (in log values) and patent rights index and the relationship between high-tech exports and payments for IP use.

Graph 1: Payments for IP use and Patent Rights Index



All Sample **Middle Income Countries**

Graph 22: High tech Exports and payments for IP use

These graphs suggest that the relationship between endogenous variables seems rather linear when it comes to the full sample. In contrast, linear adjustment seems less obvious for middle-income countries. At first glance, increase in patent rights index is associated to a greater use of IP. At the same time, a greater use of IP would stimulate high-tech exports. However, these findings remain more evident for the full sample and seem less obvious for the reduced sample.

2.3 Econometric results

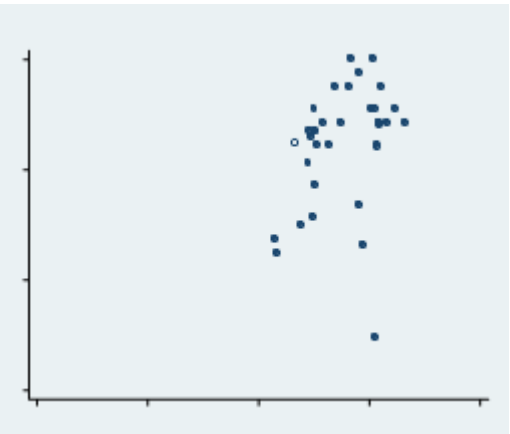
Econometric results are shown in *Table 3*. All coefficients are estimated equation by equation.[53] *Model 1* and *Model 4* provide estimates without the variable representing absorptive capacity as measured by enrolment rate in tertiary education. *Model 2* and *Model 5* include estimated coefficients for all variables selected. *Model 3* and *Model 6* allows a comparison with the state of the art on the determinants of IP use. *Table 3*

[53] Stata 12.0 is used for econometric results.

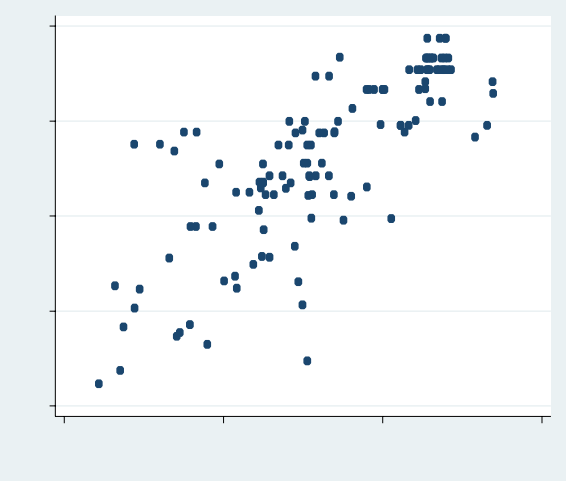
presents estimations for the entire sample and for the reduced sample of middle-income countries. Before commenting on the results, it is necessary to check for model goodness of fit. A Likelihood Ratio ("LR") test is applied for this purpose. Results of this test are shown in the last row of *Table 3*. Chi2 statistic provides acceptable values at conventional thresholds. In what follows, econometric estimations will be interpreted equation by equation.

Thus, *equation 3* shows that local innovation activity measured by residents' patents does not explain strengthening of IPRs. It would seem, therefore, that causality between innovation activity and IPRs only works in one direction as it was evidenced empirically by Chen and Puttitanum.[54] However, development measured by GDPC has a significant impact on IPRs strengthening as it is confirmed by *Model* 2 and *Model* 3 for the full sample and by *Model* 5 and *Model* 6 for middle-income countries. A linear relationship characterizing the link between these two variables is rather evidenced.[55] This linearity seems at least more evident for observations made since the TRIPS agreement as it is shown in *Graph 3*.

Chen & Puttitanun (2005), Supra Note 5. Graph 3: Patent Rights Index and GDP per capita



All Samples



Middle Income Countries

Regarding trade, IHIC's coefficient confirms theoretical predictions. Indeed, imports from high-income countries are clearly correlated to IPRs in all countries. This positive

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[55] Surprisingly, the sign and significance of the coefficients associated to GDPC and GDPCSQ (GDPC squared) do not confirm the U-shaped form characterizing the relationship between development and PRI index as shown in Chen and Puttitanum (2005).), supra Note 5.

correlation has a lesser effect in the case of middle-income countries, although it remains significant (*Models 5* and *Model 6*). EFI and ERT variables are also significant in *Model 1* through *Model 3*, which confirms predictions about the importance of institutional environment and education for IPRs strengthening. In middle-income countries, however, the effect of EFI does not seem to be strong except in *Model 4*. In addition, ERT does not have significant effects on IPRs strengthening as reflected by *Model 5*. This result would mean that education level improvement in middle-income countries does not necessarily increase the incentive for IPRs promotion.

Estimates for *equation 4* are also conclusive for both the full and reduced sample of middle- income countries. The relationship between the use of IP and PRI index appears to be rather monolithic.[56] With the exception of *Model 4*, it seems that strengthening of IPRs allows more broad benefit from use of IP and probably in part from licensing contracts.

The sign of coefficients relating to EFI are however counterintuitive. This result is not really surprising since EFI index does not take into account an important criterion, namely the effectiveness of regulation on contracts enforcement. The same applies to real GDP variable, which is statistically significant while it takes an unexpected sign. The negative coefficient associated to this variable can be explained by the fact that real GDP measures real production at the macro level. As such, it may be of less relevance compared to firms' production capacities or firms' sales that could have more direct influence on IP use.

However, market size as measured by POP has a positive and significant effect on IP use (*Model 1* through *Model 3* and *Model 6*). This result would confirm theoretical predictions about market size influence, especially on licensing demand. Finally, the negative sign and non-significance of ERT are quite surprising. This finding which contradicts theoretical predictions could be explained by an inappropriate approximation of absorptive capacities.

Regarding *Equation 5*, the coefficient associated to FRPAY is in all cases positive and statistically significant which corroborates predictions about the positive role of IP use on high-tech exports. This result is of a particular importance as it is confirmed for middle- income countries. However, coefficients associated to FDI are apparently counterintuitive in *Models 4* through *Model 6* for the reduced sample. Yet, the negative

[56] The sign of PRISQ (PRI squared) is not significant in model 3.

and significant sign of these coefficients would provide information on multinational firms' choices. In case of high- tech goods, multinational firms may prefer granting licences rather than investing directly in middle-income countries, particularly if setup costs are high. It should also be noted that available data on net FDI inflows does not distinguish between FDI intended for local production and FDI intended for exporting activities.

Table 3: Structural Equation Model (SEM) estimations with Full Information Maximum Likelihood (FIML) method

Equation n°	Full Sample (High and Middle Income countries)			Reduced Sample (Middle Income Countries)		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Equation 3 : PRI						
PATR	0.033 (0.021)	0.006 (0.021)	0.008 (0.02)	0.034 (0.035)	- 0.030 (0.028)	-0.026 (0.025)
GDPC	0.779*** (0.162)	0.567***(0.163)	0.488***(0.166)	1.330 (0.763)	1.131** (0.506)	1.188***(0.438)
GDPCSQ	- 0.338** (0.169)	- 0.169 (0.151)	-0.089 (0.151)	- 0.896 (0.776)	- 0.817* (0.483)	-0.72 (0.433)
IHIC	0.242*** (0.056)	0.232***(0.061)	0.225***(0.062)	0.164 (0.086)	0.160** (0.067)	0.145**(0.063)
EFI	0.278***(0.063)	0.190*** (0.073)	0.190***(0.073)	0.318*** (0.096)	0.106 (0.132)	0.143 (0.133)
ERT	-	0.184** (0.083)	0.185**(0.083)	-	0.249 (0.162)	-
Constant	- 6.643***(1.069)	- 4.922*** (1.17)	-4.537***(1.14)	-11.909** (5.108)	- 8.068** (3.843)	-8.90***(3.327)
Equation 4 : FRPAY						
PRI	2.705*** (0.680)	2.785*** (0.782)	3.082***(0.865)	2.271 (1.284)	2.340** (0.944)	2.602**(1.077)
PRISQ	-	-	-0.262 (0.215)	-	-	-
EFI	- 0.612** (0.292)	- 0.494* (0.287)	-0.497 (0.300)	- 0.567 (0.516)	- 0.173 (0.347)	-0.298 (0.406)
POP	1.344*** (0.482)	1.338*** (0.516)	1.365**(0.548)	1.568 (1.119)	1.519 (0.942)	0.638***(0.096)
GDP	- 1.329** (0.545)	- 1.233** (0.584)	-1.265**(0.616)	- 1.040 (1.102)	- 0.781 (0.853)	-
GDPC	-	-	-	-	-	-0.932 (0.617)
ERT	-	- 0.401 (0.29)	-0.415 (0.301)	-	- 0.359 (0.467)	0.23***(0.041)
Constant	9.466*** (2.842)	6.045** (2.715)	5.478 (2.84)	7.508 (7.508)	- 1.283 (5.294)	3.325 (6.056)
Equation 5 : HTE						
FRPAY	1.050*** (0.086)	1.106*** (0.084)	1.11***(0.079)	1.316*** (0.148)	1.599*** (0.137)	1.591***(0.136)
FDI	- 0.074 (0.089)	- 0.130 (0.090)	-1.127 (0.088)	- 0. 303** (0.142)	- 0.599*** (0.142)	-0.59***(0.142)
Constant	- 1.184** (0.604)	- 0.196 (0.694)	-0.21 (0.684)	- 2.794* (1.665)	- 0.016 (2.121)	-0.075 (2.12)
No. of Observations	124	98	98	56	41	41
LR test	32.41	30.52	315, 51	21.44	23.40	21.93
Prob. > chi2	0.0021	0.0065	0.0000	0.0647	0.0541	0.0384

Estimated coefficients are shown together with the standard errors in parentheses. *** Significance at 1% level, ** Significance at 5% level, * Significance at 10% level. Wald test confirms that all estimated coefficients are significantly different from zero. All variables are in log form except PRI, EFI and ERT. SEM estimates ultimately confirm the relationships between IPRs strengthening, use of IP, and exports of high-tech goods in middle-income countries. However, beside estimation of direct effects examined earlier, SEM method makes it possible to refine results by highlighting indirect effects defined in the path diagram described above.[57] In fact, *Figure 1* clearly shows that PRI variable has an indirect effect on high-tech exports ('THE'). In addition, GDP per capita ('GDPC'), IHIC, EFI and ERT are supposed to have indirect effects both on the use of IP ('FRPAY') and on high-tech exports. *Table 4* provides the most significant indirect effects deduced from estimates of *Model 5* and *Model 6* presented in *Table 3*.

Table 4 : SEM Indirect effects estimations for Middle Income Countries

	Model 5		Model 6	
Variables	Estimated Coefficients	Standard errors	Estimated Coefficients	Standard errors
FRPAY <-				
GDPC	6.678***	2.310	7.799***	2.503
IHIC	0.610***	0.121	0.616***	0.121
HTE <-				
PRI	15.743***	6.197	17.503***	7.030
GDPC	16.332***	5.659	13.294***	5.042
IHIC	1.492***	0.297	1.503***	0.295
ERT	0.061***	0.012	0.063***	0.011
POP	-		1.989***	0.379

Several observations stem from *Table 4*. First, even if it is not directly explained by absorptive capacities, middle-income countries' use of IP is significantly correlated with their level of development, the latter also having an indirect effect on high-tech exports. Second, imports from high-income countries indirectly explain disembodied knowledge demand through the impact of IPRs strengthening. In addition, IPRs also have an indirect impact on high-tech exports to the extent that these exports are not blocked by regulatory barriers. Regarding market size measured by population, its relative indirect impact on exports derives essentially from its stimulating effect on the use of IP especially through licensing agreements. Finally, the indirect role played by tertiary

[57] For technical details on indirect effects measurement in structural equation models, seeSee, Bollen, supra Note 53.

education ('ERT') on high-tech exports promotion seems evident. Thus, even if ERT variable does not seem to be a good approximation for absorptive capacities, tertiary education remains a strategic choice for export promotion in middle-income countries.

IV. CONCLUSIONS

This research proposes the opening of a debate on the contribution of disembodied knowledge and more specifically of IP use to export promotion in middle-income countries. Despite the complex mechanisms underlying the market for technology, there is evidence of a growing recourse of middle-income countries to disembodied knowledge in its different forms and presumably in the form of licensing contracts. Estimates resulting from the application of SEM method show that strengthening of IPRs in these countries increases their possibility of access to disembodied knowledge through IP use. This access also has a significant impact on their high-tech exports.

The econometric results obtained should nevertheless be interpreted with caution. First, data constraints prevented validation of results across a larger sample of middle-income countries. Second, approximation of disembodied knowledge demand by payments for IP use does not allow us to distinguish the specific contribution of licensing agreements to export promotion in middle-income countries. Traceability of licensing contracts involving these countries would certainly contribute to interesting extensions of this research. These extensions would also make it possible to take into account sector specificities and disaggregated values of exports in a bilateral trade scheme.

As policy implications, this research suggests that middle-income countries need to adopt a policy mix. The first component of this policy-mix is a credible choice of IPRs reforms and a consolidation of scientific and technical skills. These are two necessary conditions for an optimal exploitation of tradable disembodied knowledge and more specifically licensing contracts. The second component of this policy mix concerns trade-off between opportunity to invest in licenses and opportunity to invest in R&D. This trade-off involves defining a targeted innovation policy that takes into account comparative technological advantages to be identified sector by sector.

Finally, this research proposes to deepen reflections on international trade of disembodied knowledge. With regard to the imperfection of the market for licenses,

these reflections should focus on two aspects. The first one concerns FRAND access to non-compulsory licenses to the extent that these technology licenses represent an important part of trade in disembodied knowledge. The second one concerns actions to be taken against abusive licensing practices in accordance with section 8, article 40 (paragraphs 1 and 2) of the 1995 TRIPS agreement. Reflections conducted during UNCTAD (2016) conference are already important steps in deepening the debate to address the problem of unfair access to licenses and licensing market imperfections.

Annexure

List of Countries

Argentina	Jamaica	Romania
Brazil	Korea (South)	Singapore
Canada	Lithuania	South Africa
Chile	Mexico	Sweden
Colombia	Morocco	Thailand
Czech Republic	Netherlands	Tunisia
Egypt	Norway	United Kingdom
France	Pakistan	United States
Germany	Philippines	Uruguay
India	Poland	
Israel	Portugal	

Correlation matrix of all variables used

	pri	lpatr	lgdp	lgdpc	lmhic	efi	lfrpay	lpop	lfdi	lhte
pri	1.0000									
lpatr	0.5872	1.0000								
lgdp	0.5344	0.8917	1.0000							
lgdpc	0.7853	0.5360	0.4866	1.0000						
lmhic	0.6560	0.8396	0.8902	0.5785	1.0000					
efi	0.7058	0.3306	0.3282	0.6642	0.5317	1.0000				
lfrpay	0.6560	0.7971	0.8435	0.6104	0.9044	0.5885	1.0000			
lpop	-0.1065	0.4939	0.6530	-0.3438	0.4553	-0.2230	0.3776	1.0000		
lfdi	0.6766	0.7535	0.8483	0.6260	0.8612	0.5483	0.8651	0.3692	1.0000	
lhte	0.6493	0.7683	0.7787	0.5888	0.9014	0.5295	0.8156	0.3265	0.7787	1.0000