The Impact of Licenses on a "Late-Starter" LDC: Chile in the 1990s

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Abstract

The acquistion of technology through licenses is a potentially important means of accelerating productivity growth, especially in "late starter" developing countries in the throes of "catch up". Yet the literature has tended to focus on the potential benefits to the seller, overlooking those to the purchaser (our own concern). We find that expenditures on licensing showed exceptionally high rates of return, of the order of twice those in investment in physical capital, significantly improving firms' performance and productivity in Chilean industry during the 1990s. We conclude that licensing can be an important instrument for speeding catch up in LDCs.

KEYWORDS: Development, technology, licenses, catch-up, Latin America and Chile

1. INTRODUCTION

It is a well known fact that technology is the principal source of strong and systematic growth in productivity and so, ultimately, of improved living standards. Unfortunately, technology is still much of a "black box" for economists, notwithstanding the theoretical advances of recent years in the "economics of knowledge" - whether along the lines of endogenous growth models, such as Paul Romer's (Romer 1990, for example), or in the spirit of the more microeconomically based models of evolutionary theory, such as Richard Nelson's (Nelson and Winter, 1982, for example)[i]. To be sure, all agree that the acquisition of knowledge is not effortless; it requires resources. Investment in human capital is central; so too is R&D; as well, probably, as the institutional interplay of firms, capital markets, research institutes and the educational system, or what has come to be called the national system of innovation (Nelson, 1993). But for all the progress, we have been unable to come up with much that is new in terms of policy recommendations, which would have surprised any economist from Adam Smith on to Schumpeter, indeed which might come as something of a surprise to the average man on the street. Given the importance of technology in explaining total factor productivity this is, indeed, a disappointing situation.

Moreover, precisely because the burgeoning literature has emphasized that technological growth does not fall like manna from the sky, but rather is endogenous, the result of conscious effort and investment, R&D has stolen much of the limelight. This emphasis on R&D has received added impetus from the fact that such expenditures are measurable[ii], and so, readily amenable to our powerful econometric tools.

Whatever the merits or demerits of this emphasis in developed countries, this is definitely a distortion of priorities for developing countries. For one thing that we do know is that "catch up" is critical for LDCs, - indeed, the possibility of skipping stages or technological generations is the singlemost important, and possibly sole, advantage of being a "late starter". Yet the emphasis on R&D in the literature, reflecting its importance in developed countries, but not in LDCs, has oftentimes led to a focus on R&D, even in LDCs, when it is in all likelihood of secondary importance in LDCs' *current stage of development.* As a case in point, and just to illustrate, not to be unduly harsh, the first Science and Technology Policy Review prepared by the OECD (1994) once Mexico became a member dealt almost exclusively with R&D, and had virtually

nothing to say about the *transfer of technology*. Small wonder then that LDCs so frequently focus technology policy on raising the proportion of R&D expenditures from their current 0.5-0.7% of GNP to fractions closer to those of developed countries (of the order of 2% pf GNP). Few ask themselves whether a more appropriate reference might not be what developed countries were spending on R&D when they were still at a catch up stage. A look at Japan or the Tigers in the 1950s and not the 1990s, would have shown that R&D was less than 1% of GNP - a fact that did not keep them from growing at heretofore unprecedented rates.

More importantly, few ask themselves what it was that "late starters" in fact did do, if not R&D, to speed catch up. The stories that abound are about mass imitation, learning by visiting, reverse engineering, licensing. This latter mechanism, licensing, is the focus of this paper, for we believe that licensing, though important in the development of many of today's developed countries, is largely overlooked in today's literature. Indeed, it is often looked down upon as an inferior form of learning, rather than as a short cut.

In section I we consider the potential benefits and costs which licensing may entail and then, in section II, we review the empirical evidence on the importance of licensing in developed countries as well as some "late starter" economies. The main part of the paper, however, is empirical, section III. It attempts to detemine the impact of licensing on firm performance and productivity in Chile in the 1990s. It concludes that expenditures in licensing have had exceptionally high rates of return in Chile in this period, possibly twice as high as those in investment in physical capital; hence, that licensing can be important in speeding catch up, if intelligently exploited. Moreover, precisely because a licensor sees little to fear in licensing to a firm from an LDC, the amount of licensing, whether massive, as in several successful emergent economies, or slight, as at present in most Latin American countries, is up to LDCs to determine, and so is amenable to domestic policies.

2. THE ECONOMIC LOGIC BEHIND LICENSING

The potential benefits of licensing - here understood in its broadest sense, both of a process as well as to a trademark or to a franchise - are for both parties to the license. For the licensee it provides: 1) the use of a proven technology (or a reputable quality as well as name brand) along with its associated know-how, permitting the licensee to move rapidly towards the frontier of best practise; 2) it saves time and costs on product development (or in acquiring reputation); 3) it establishes the possibility of a long term alliance with a known and reputable producer (the licensor); and 4) it avoids the possibility of long costly legal disputes (a point less relevant the smaller the LDC market). A problem for licensees is that oftentimes they are not sure of what they are buying, nor of its true worth to them. This problem of asymmetric information can make the bargaining and negotiations of licenses quite tricky, and in the limit, could actually impede such a transaction. A risk for licensees is that it could induce dependency and lethargy, utlimately slowing rather than speeding their productivity growth. Yet, as suggested by evidence in developed countries, more often than not licensing complements rather than substitutes own innovation, for the value of licenses is a function both of the firm's "scanning" capacity as well as of its "absorptive" capacity, which requires recipients to cultivate an in-house technological capability[iii].

The benefits to the licensor are also manifold. It provides: 1) a more rapid return on his investment in R&D; 2) access to new markets and integration into existing distribution channels 3) savings on capital investment; 4) enhances his technology as an industry standard; and 5) a way overcome tariff or tax barriers to export or foreign direct investment. The downside for licensors is that it can convert a licensee into a serious competitive threat in the future (reason for which, there is evidence that licensing arrangements in developed countries are more frequently made with firms in other countries than in one's own). Hence, the slower the rate of technological growth in a sector, the riskier licensing can be for the licensor, and so, the higher the fee he is apt to charge, if he licenses at all. LDC firms are probably well placed in this regard inasmuch as most developed country firms are apt to see such firms as so far behind the technological frontier that there is little risk that a licensee will become a future competitive threat. More relevant possibly in LDCs is the fear, especially in the case of

trademarks or franchises, that poor use by the licensee could tarnish the licensor firm's reputation, thereby requiring a minimal local competence before the license be sold.

3. LICENSES AND GROWTH

(a) In developed countries

Since it is typically assumed that developed countries will be the licensors and developing countries the licensees, it may come as a surprise to note, for example, that the developed economies of Europe spend 0.28% of their GNP on licenses, a figure 2 1/2 to 3 times as large as that of Chile or Brazil (Agosin and Saavedra, 1999). Moreover, this figure, is not what these economies paid in the heyday of catch up, -for figures on the 50s are not readily available, - but what they spend on licenses today, when they are on, or close to, the technological frontier itself. Reflection, however, suggests that this is not so surprising after all. For most firms in developed countries are not themselves so much technological innovators as "strategic followers". Hence, they are much in need of licenses, and, if intelligently purchased, can help them maintain themselves competitive and close to the frontier without incurring in the far larger and riskier investment that R&D entails.

Indeed, a cursory glance at the literature shows that the purchase of licenses is quite common and an important part of technological transfer. For example, a recent study of Belgian manufacturing firms reveals that at least 20% of them acquired technology through licensing in the previous two years. Of possibly even more relevance to LDCs is the fact that the purchase of licenses is frequent even among small firms: at least 15% of Belgian manufacturing firms with less than 50 employees acquired technology through licenses in the previous two years (Cassiman and Veugelers, 2000). To be sure, the authors point out that the bulk of the firms that buy technology through licenses do some in house R&D (over 80% in this study, though other studies suggest half that figure[iv]). This suggests that an in house capacity to research is required in order to be able to scan available technologies intelligently and so acquire the most relevant ones, and to be able to absorb and adapt them rapidly into the productive process. Hence, licenses and own R&D seem to be complements rather than substitutes.

Studies in the US also bear out that licensing is widespread. For example, a sample of 334 manufacturing firms in a major western state (though a sample biased towards sectors were licensing was thought to be more frequent) showed that 45% were

involved in licensing in 1993/94, 20% as licensors and 25% as licensees (Fu and Perkins, 1995). Though significant, these figures were one quarter lower than those found in a similar study in 1965, when 60% of firms were found to be involved in licensing, either as licensors or licensees. Such a decline would be consistent with the view that as productivity differentials narrow, licensing becomes less attractive to licensors. Finally, this study corroborated that the larger a firm the more likely it is to buy a license, possibly suggesting that the purchase of licenses depends on the absorptive capacity and accumulated skills of the firm (since age and size are positively correlated).

Nevertheless, for the most part the emphasis in the literature in developed countries has been on the optimum pricing strategy from the point of view of the licensor, far more than on the potential benefit licenses can signify for the licensee.

(b) In less developed countries

Since the potential gains from licenses should be particularly great for licensee firms the further away these be from the technological frontier, and the potential threat of a licensee becoming a rival competitor should be less the further away the licensee firm is from the technological frontier, licensing should be especially great between developed country licensors and developing country licensees. As a matter of fact this does not seem to be the case, at least not for the most part in Latin America. As noted before, Brazil spends of the order of 0.08% of GNP on royalties and Chile's 0.1% as compared to the average of the order of 0.25% for Europe (See Table 1). Moreover, the statistics available understate the differences. For the data refer to payments on licenses *overseas*. Since developed countries are far more apt to pay licenses to firms within their own country than is the case with developing countries, such statistics understate the true extent of the use of licensing by developed countries[v]

More importantly, expenditures on licenses as a proportion of GNP in Latin America are normally well below those of two emerging economies of the OECD, Spain and Portugal, which spend 0.4% and 0.5% of GNP respectively on royalties each year (See Table 1) as well as below those of Korea where royalty payments averaged 0.5% in 1987-89 (latest figures readily at hand). Interestingly enough, though Spain and Portugal have among the lowest fractions of GNP spent on R&D in the OECD, less than 1%, their expenditures on licensing are high, as might befit countries in the catch up phase of growth. This suggests that in this early stage of development licensing substitutes for

R&D, whereas as the economy matures, licensing slows and R&D picks up, though both grow strongly, suggesting that once on the technological frontier licenses and R&D are complements more than substitutes. What stands out in the case of Latin America (exception made of Argentina in recent years) is that *both* licensing and R&D are low by international comparisons, suggesting underinvestment in each, and most especially, in licensing.

Table 1

Spending on Licenses as a Percentage of GNP, OECD and Emergent Economies

Country (year)	Royalties/GNP	Business R&D/GNP	Total R&D/GNP
A. LDCs			
Latin America			
Mexico	0.12(1996)	0.1 (1995)	0.3 (1995)
Brazil	0.08		0.9 (1987)
Chile	0.1	0.2 (1998)	0.7 (1998)
Argentina	0.34 (of manufacturing sales)	<0.1est. (1996)	0.3
B. Emergent Economies			
Korea	0.5 (1987-89)	2.1 (1997)	2.9 (1997)
Portugal	0.6 (1997)	0.15 (1997)	0.65 (1997)
Spain	0.4 (1992)	0.4 (1998)	0.9 (1998)
C. Developed Economies			
Europe	0.28 (1990)	1.5% (1997)	2.2% (1997)
Japan	0.2 (1970-83)	2.1 (1997)	2.9 (1997)
Canada	0.2 (1995)	0.7 (1997)	1.6 (1998)
Australia	.09 (1996)	0.8 (1996)	1.7 (1996)

Sources: OECD (1999). Latin american data are from Agosin and Saavedra (1998). Data on royalties for Argentina come from Argentina's INDEC (1998); and the data for Korea come from Kim and Dahlman (1992).

The question naturally arises as to why the Latin American figures are so low. Three factors would seem to be at play. First, in the 60s and 70s many Latin American countries enacted highly restrictive regulations on the importation of technology by licenses and the amount of royalty payments that could be paid. These limitations grew out of a concern that obsolescent technology was being transferred and that royalty payments might be too high . More concretely, because of the problem of asymmetric information to which we earlier alluded, the bargaining situation between the licensor and the licensee was considered to be lopsided in favor of the licensor[vi]. To redress this, much legislation was enacted to "protect" the licensee from undue exploitation by the developed country licensor. Hence, emphasis in this period was on limiting royalty payments (by capping the percentage of sales which could be paid in royalties) as well as "assuring that the technology was of benefit to the importing country". Such overemphasis on the price paid neglected the potential benefits that such capping would forego, if technological diffusion was thereby slowed.

This one-sided emphasis on the risks of technological imports far more than on its potential benefits was also a reflection of the dependency theory and anti foreign capitalist spirit characteristic of those times. Two quotations of the period bring out the temper of the times. The first comes from the Andean Pact's Board in 1976 (Junta de Acuerdo de Cartagena, 1976). "The use of imported knowledge has several effects. In the first place, it frequently ignores the internal factors of production and resources available locally. The increases in production achieved with inappropriate technology - inappropriate means to inappropriate products - tend to conflict with certain basic development objectives, such as the level of employment. Likewise, the export of products manufactured with imported technology (essential to integrating the national economies with the rest of the world is severely restricted by the terms under which technology is made available. Moreover, the need to import essential knowledge from abroad (without having adequate legislation on foreign investment), when added to the present patents system, leads to economic and political power being concentrated in foreign centresd, whose objectives and interests do not coincide with those of the recipient countries." Note the total absence of mention of the potential benefits of technological diffusion. It is all risk, no gain. This is not from some marxist reserach center, but it is a report of an official agency, representing the governments of

Venezuela, Colombia, Ecuador, Peru, Bolivia and Chile. Such were the temper of the times.

The second comes from an article in 1975 (our translation) on technology transfer in Latin America by one of the region's experts in the field (Correa, 1975). "The importation of technology and of trademarks proved to be a mechanism of virtual control on the part of licensors, which often gave them complete domination over licensee firms; it revealed the imperfections of the "market for technology" and the myriad costs which these can impose on recipient economies, without sufficently compensating benefits. ... This is the context which explains the regulations enacted or perfected in recent years in Latin America, aiming to control the purchase of technologies and the use of foreign licenses."

Small wonder, given such controls, that licensing may have long been overlooked in the region. Nevertheless, this is not a sufficient reason to explain the relatively low use of licensing today, 15 years after the resurgence of pro-market reforms throughout the region, and 11 after the fall of the Berlin Wall and the end of communism. Hence, for more recent times two additional explanations are in order

Second, it seems to be the case that the market for licensing is quite imperfect. Given the insufficient information available to licensees as to the best or most appropriate technology available internationally, given the insufficient information available to potential licensors of the capabilities and needs of would be licensees, transaction costs can be quite high - despite the potential benefits to both parties. Who then should incur the cost of finding his nate, the potential licensor or the potential licensee? It turns out that even in the United States, most licenses are marketed "informally": 49% of licensing agreements were made through word of mouth and another 23% were made through personal acquaintance (Fu and Perkins, op.cit.). Hence, proximity (geographic as well as sectoral) really matters. This, naturally, puts an LDC licensee at a disadvantage with respect to licensing, for he is far from industry flows (which are north/ north, far more than north/south).

Third, at least till the recent reversal of economic strategy towards openness and liberalization, Latin American entrepreneurs had been rather laid back, income satisficers more than income maximizers. Three factors played a hand in this: 1) the region's extreme concentration of income; 2) the assured profits stemming from its past tariff walls (where, in parody of the marxist adage, "to each sector was given the tariff it

needed"); and 3) only in recent years did modern business schools come into their own and professional managers begin running the, till then, largely family run firms. Thus, in a recent seminar on development in Latin America, a Canadian expert contrasted the Latin American and Korean styles of negotiating technology licenses[vii] The Koreans come to Canada knowing what technology they most want, and what firms outside of Canada have similar technologies and what royaties these others might charge. By contrast, in most licenses with Latin American firms it was the Canadian firm that took the initiative, visiting the Latin American firm and offering it its license. It's not just that the Koreans were able to negotiate a better deal. Rather it showed that the Koreans were far more conscious of the potential licenses could signify for them in moving rapidly to the frontier of best practises at a low cost.

For all of these reasons, the use of licensing would seem to have lagged in Latin America as contrasted with the important role it played in the catch up stage of most late starters and even the important role it still plays among developed world firms, especially among "strategic followers". Thus there would seem to be a strong presumption that Latin America (exception made of Argentina in recent years) has strongly underinvested in this form of technological transfer.

4. THE IMPACT OF LICENSING ON TECHNOLOGY TRANSFER IN CHILE

Notwithstanding its relative underutilization in Latin America, licensing nevertheless does occur in Latin America. In what follows, and on the basis of an empirical analysis of manufacturing firms in the 1990s in Chile, - the region's *model reformer and stellar performer*, - we attempt to determine whether the *prima facie* case in favor of licensing is, in fact, borne out. More concretely, we first examine the importance licensing has in different dimensions - on productivity, investment, skills, wages and exports -distinguishing by size and ownership (national or foreign owned). In a second exercise we attempt to determine the impact of licensing in an initial year with the rate of growth of total factor productivity in the following years. Lastly, we deduce the rate of return to licensing, establishing that it is well above that normally associated with investments in physical capital, and not unlike the rate of return (private) of investment in R&D in developed countries.

(a) The data

The source for our analysis of licensing is the Chilean government's National Institute of Statistics (INE) annual nationwide survey of manufacturing establishments (ENIA) for the years 1990-1996, a period ending just before the onset of the Asian crisis, when the Chilean economy grew at a rate over 7% per year and labor productivity at a rate of the order of 4.5%. The survey collects information on more than 5,000 plants every year, and is representative of firms with 10 or more employees. The exclusion of very small firms and microenterprises is important as concerns employment, but it is not serious with respect to output (less than 10% of sectoral output being accounted by such firms) and obviously is of no consequence for this study, since such firms are highly unlikely to purchase licenses. The survey provides quantitative information on various indicators of firm performance - value added,sales, wages, number of employees -white and blue collar, capital stock and exports - along with the use of licensing and royalty payments.

(b) The use of licensing by firms

As can be seen in Table 2, of the 5,000 firms sampled, only 5% purchased licenses from abroad[viii] in the period in question, a fraction of the 15-30% of manufacturing firms in developed countries which use licenses. It is true that this percentage has risen from less than 5% in 1990 to just under 6% in 1996. Nevertheless, even if this trend were to continue - at a rate of 1 additional percentage point every 6 years - it would take over 50 years before 15% of Chilean firms reached the 15% which characterized small Belgian firms, and 75 years before it reached the Belgian average of 20%!

As might be expected, licensing varies by sector (See Table 3). Licensing is most prevalent in chemical and rubber products (sector 35 of the CIIU), 22% of such firms purchasing licenses in the period in question; followed by metal products (some 13%); whereas it is least frequent in the final consumer goods sectors of furniture and wooden products, clothing and textiles and food and beverages. Somewhat surprisingly, firms producing machinery and equipment make little use of licensing, though this may simply be indicative of the huge heterogeneity of the sector, for what may be little more than repair shops coexist with genuine equipment producers (especially for the mining sector - 25 % of such equipment being produced locally, and possibly with licensing). So too

only 5% of firms manufacturing paper and cellulose, where Chile has strong comparative advantage, make use of licensing. Once again this could signal the great heterogeneity of a sector which includes major firms along with a wide assortment of printers and publishers. Or it could be that much of process technology in this sector is embodied in the equipment one purchases, so that licenses are not much in use; or inversely, it could be that Chile is too close to the frontier in this sector for licensors to be willing to transfer technology to the sector.

Table 2

Chilean Manufacturing Firms with Foreign Licenses

YEAR	WITHOUT LICENSES		WITH FOREIGN LICENSES	
	No.	%	No.	%
1990	4,314	95.2	217	4.8
1991	4,457	94.6	253	5.4
1992	4,630	94.8	252	5.2
1993	4,708	94.5	276	5.5
1994	4,761	94.8	260	5.2
1995	4,770	94.6	275	5.5
1996	5,055	94.2	310	5.8

Source: ENIA (Encuesta Anual Industrial del Instituto Nacional de Estadísticas de Chile - the annual industrial survey of Chile's National Statistical Institute).

Though the data of 30 years ago is not perfectly comparable wiith our study, for it was not taken from a survey of manufacturing firms, but simply surveyed firms registering contracts with licenses -nevertheless, it may be illustrative of broad trends. For example, it is interesting to note that there has been an important change in the distribution of licenses in the past 25 years. (See Table 4). Whereas 25 years ago chemicals (35) accounted for 38% of licenses and machinery and equipment for 27%, in the 1990s these proportions have fallen to 26% and 13% respectively. Today over half of licenses are in final consumer goods (sectors, 31,32 and 33).

Table 3

The Use of Licenses by Manufacturing Subsector in Chile 1990-1996

(Percentage of Firms in sector)

Sector	1990	1991	1992	1993	1994	1995	1996	Average 1990-96
31 Food and beverages	2.7	3.9	3.1	4.5	3.7	4.2	4.0	3.9
32 Textiles, garments and shoes	3.3	3.6	3.4	3.6	3.1	4.1	4.9	3.8
33 Wood and furniture	2.9	3.4	3.6	3.1	4.1	4.9	3.8	3.0
34 Paper, celulose, printers and editorials	4.7	4.4	5.3	4.8	4.8	6.1	5.2	5.1
35 Chemical and rubber products	20.9	20.9	24.4	23.1	21.9	20.9	19.9	21.9
36 Non metallic minerals	10.3	9.3	9.8	10.6	9.2	11.2	8.8	9.8
37 Metallic products	11.8	13.4	13.9	11.6	11.9	12.0	13.4	12.7
38Machinery and equipment	4.0	4.2	3.6	4.2	4.5	3.6	4.5	4.1

Source: ENIA

This trend towards the greater use of licenses in consumer goods probably denotes a shift from process and technology licensing as in the past to the increased use

Table 4

Shifts in the Sectoral Distribution of Licenses in Chile

SECTOR	1967-70	1990-96
31 Food and beverages	9%	23%
32 Textiles, garments and shoes	8	14
33 and 34 Wood, furniture and paper	4	12
35 Chemical and rubber products	38	26
36 Non metallic minerals	3	8
37 Metallic products	4	4
38 Machinery and equipment	27	13

Source: ENIA for 1990-96 and UNCTAD (1974)

of trademark and franchising licenses in the present, as a result of the worldwide trend towards global marketing and Chile's move from a protected to an open economy. For in order to compete, Chile's heretofore sheltered manufacturing sector has had to create market niches. One way of establishing these is by guaranteeing local consumers post-selling services as well as by offering products at international standards of quality. The reputation afforded by an international trademark or franchise has thus served as a ready

mechanism to signal and assure such quality. Hence, the trend towards trademark and franchise licensing reflects the greater value attached to these by Chilean firms as a result of the increased international competition to which domestic firms have been exposed since trade liberalization set in.

(c) Licensing and firm performance

In what follows, we apply a method taken from the work of Bernard and Jensen (1999)[ix] to test if there are any differences (statistical) in firm performance-related indicators which distinguishes firms which utilize foreign licenses from those that do not. Equation 1 below expresses a behavioral indicator over time, LnX_{it} as a function of whether a firm uses or does not use licenses in a given year, the industrial sector in which it is and the year in question with available information (1990-1996).

$$\mathbf{(1)}\ \mathbf{LnX_{it}} = \alpha + \beta\mathbf{Lic_{it}} + \delta\mathbf{Industrial\ sector} + \lambda\mathbf{Year} + \mu_{it}$$

Lic is a category variable (0 or 1) for the given industrial sector (2 digits of the CIIU) and where **i** stands for the given firm and **t** is for each given year.

Equation 2 below estimates the same expression but controlloing by plant size, where plant size is measured by the number of employees, L.

$$\mathbf{(2)}\ \mathbf{LnX_{it}} = \alpha + \beta\mathbf{Lic_{it}} + \delta\mathbf{Industrial\ sector} + \lambda\mathbf{Year} + \gamma\mathbf{LnL_{it}} + \mu_{it}$$

This estimation allows us to identify the magnitude of the performance gap between both groups of firms for a variety of attributes. The parameter β shows the average percentage difference between firms that acquire or do not acquire foreign licenses for a series of performance related characteristics, controlling by plant size and industrial sector. A significantly positive parameter β would be evidence that firms that buy licenses exhibit greater productivity, higher capital-intensity, more intensive use of human capital or tend to be larger than firms that do not buy licenses. Only the first of these, greater productivity, would be indicative of superior performance. The others are simply performance related characteristics of firms.

Although a positive value for parameter β would show that licenses are positively correlated to a firm's characteristics, it does not show the direction of causality. For a

positive β could signify that because firms purchased licenses, they had higher productivity (or were more physical or human capital intensive or were larger); or inversely, that firms with higher productivity (or more capital or human capital intensity or larger sized) tend to purchase licenses. This section will establish correlation between licenses and performance related characteristics, whereas the next section will establish the direction of causality.

The results presented in Table 5 (equation 1, not controlling by size) and Table 6 (equation 2, controlling by size) clearly show that firms that purchased licenses are correlated with "better" performance-related characteristics than those that did not. For manufacturing as a whole (column 2 in both Tables), firms with licenses show on average significantly higher value added (167% more), possess a larger capital stock (185% more)and work with a higher capital-labor ratio (79% greater) than firms without licenses. More importantly, if we take as proxies for productivity, value added per worker or sales per worker, firms with licenses exhibit significantly higher productivity (67% moire) than firms that do not. Finally, firms with licenses pay higher wages both to their white collar (48% more) as well as their blue collar workers (33% more) and are more intensive in their use of human capital (where we use the ratio of white collar to blue collar workers as an index of skill).

Table 5

Comparative Results of Firms with and without Licenses (not controlling by size)

Variable (performance indicator)	Overall Manufac-Turing	31	32	33	34	35	36	37	38
Valueadded	1,67	1,75	1,54	1,54	2,47	1,62	2,68	1,52	1,57
Employment	1,04	1,02	1,16	0,99	1,38	0,93	1,49	1,39	1,03
Capital stock	1,85	1,90	1,55	1,75	3,06	1,53	2,94	2,04	1,66
Capital/worker	0,79	0,86	0,38	0,74	1,63	0,60	1,45	0,68	0,62
Value added/worker	0,63	0,73	0,39	0,56	1,07	0,69	1,09	0,14	0,54
Sales/worker	0,55	0,67	0,25	0,53	0,99	0,51	0,95	0,09*	0,48
Average overallwage	0,46	0,50	0,33	0,49	0,50	0,57	0,65	0,32	0,32
Avg. Wage (white collar)	0,48	0,61	0,36	0,64	0,57	0,49	0,64	0,34	0,35
Avg. Wage (blue collar)	0,33	0,34	0,24	0,38	0,36	0,37	0,57	0,23	0,21
Ratio white/blue collar	0,37	0,40	0,29	0,17	0,46	0,42	0,60	0,44	0,27
Exports	5,31	9,37	1,56	4,41	25,56	-2,05*	2,18	-0,94*	3,34

* Not significant at 5%

While controlling by plant size reduces the performance differential between firms that license and those that do not, the only result which is modified in terms of significance upon controlling by plant size is the relative export performance of firms. When one does not control by size, firms with licenses export, on average, 5 percentage points more of their output than do firms without licenses. However, upon controllling by size, the fraction of output exported by firms with licenses is *less* than that of firms without licenses, and significantly so. This latter result would be consistent with the fears expressed in the '70s that licensors imposed exporting constraints on licensees. However, before making too much of it, we need explore the issue not just of the behavior of firms that license versus those that do not, but how behavior is correlated with the *extent* of licensing, that is, with the amount of royalties paid by firms and not just whether they use or do not use licenses.

Table 6

Comparative Results of Firms with and without Licenses (controlling by size)

Variable (performance indicator)	Overall Manufac-Turing	31	32	33	34	35	36	37	38
Value added	0,37	0,36	0,14	0,33	0,52	0,54	0,72	-0,37*	0,32
Capital stock	0,45	0,32	0,13*	0,42	1,06	0,52	0,72	0,04*	0,39
Capital/worker	0,45	0,32	0,13*	0,42	1,06	0,52	0,72	0,04*	0,39
Value added/worker	0,37	0,36	0,14	0,33	0,52	0,54	0,72	-0,37*	0,31
Sales/worker	0,32	0,37	0,08*	0,34	0,45	0,44	0,70	-0,60	0,25
Average overall wage	0,23	0,29	0,07	0,28	0,12	0,37	0,30	-0,02*	0,06
Avg. wage (white collar)	0,15	0,25	0,01*	0,29	0,09*	0,25	0,18	0,04*	0,03*
Avg. wage (blue collar)	0,18	0,23	0,05*	0,22	0,06*	0,26	0,34	-0,08*	0,03*
Ratio white/blue collar	0,33	0,36	0,26	0,29	0,22	0,33	0,51	0,36	0,17
Exports	-1,03	-1,01*	-1,78	-4,21	20,10	-6,35	-0,05*	-19,3	1,67

* Not significant at 5%

Most of the results found for manufacturing generally hold as well by industrial sector. The two exceptions are textiles, garments and shoes (subsector 32) and metallic products (subsector 37), when one controls by size of firm. In these two cases no statistically significant differences emerge between the behavior of firms with licenses and those without for most of the performance indicator variables examined.

Nevertheless, on the whole as well as for most specific subsectors, the above results reveal significant differences on most performance indicators between firms that purchase licenses and those that do not. While it is certainly plausible that such a correlation indicate causality - from licenses to increased performance, that is not necessarily the case. For example, the correlation might simply indicate that the purchase of licenses is the sort of thing that successful and more productive firms or more dynamic entrepreneurs buy, but once successful, possibly as insurance against losing market share or some other such factor. To determine then whether there is indeed such causality from licenses to increased productivity, we need estimate a behavioral equation between the purchase of licenses and the amount paid in royalties, and the subsequent impact on *own* firm productivity.

(d) The impact of licensing on own firm productivity

There are two principal mechanisms whereby licenses can impact on firm productivity. First, licenses may induce faster investment in capital goods in order to take advantage of the technology being transferred. Second, over and above the effect of licenses on capital accumulation, total factor productivity may rise thanks to that part of technology not embodied in capital goods. In what follows we explore both mechanisms.

To test whether licenses lead to the faster accumulation of capital (embodied technological change) and the direction of causality, we first regressed the rate of growth of capital in each firm in the period 1991-1996, $(\Delta K/K)_{i,\Delta t}$,on the percentage of the firm's value added paid out in royalties in the base year, $Licva_{it0,}$ and other control variables, W_{it0} , as follows:

(3) $\mathbf{(\Delta K/K)_{i,\Delta t} = \beta Licva_{it0} + \delta W_{it0} + \mu_i}$

As opposed to the former correlations, where we compared firms with and without licenses, this formulation permits us to distinguish the relative importance of the license to the firm on the basis of how much (relative to its value added) it paid out in royalties; **i** represents the specific firm; **Δt** is the period *after* the license has been purchased; $\mathbf{t_0}$ is the initial year when the firm had a license; and **W** is a set of control variables: the stock of capital in the base year (to control for the possibility that the greater the initial stock of capital the slower might be the subsequent growth in capital accumulation); and the stocks of white collar and blue collar labor in the base year respectively (to control for the fact that capital accumulation might be associated with higher initial levels of skilled and/or unskilled labor).

As can be seen from Table 7, the rate of growth of capital in the period 1991-96 was significantly stronger the greater the percentage of royalty payments in the firm's value added in the base year, 1990. This effect is enhanced, once we control for the levels of factor inputs in the base year, the impact of licenses rising from 0.46 to 0.55, and its standard deviation falling. This suggests not only that the direction of causality is from licenses to productivity (and not the reverse), but that one of the mechanisms whereby licenses speed productivity growth is through inducing a faster rate of growth of capital in the period subsequent to the license.

Table 7

Test Results of Equation 3: The Impact of Licenses on Factor Accumulation

Variable	Without control variables	With Control Variables
Licva t_0	0.46	0.55
	(2.98)	(3.8)
Capital Stock t_0		-0.062
		(-29.9)
Blue Collar Workers t_0		0.040
		(11.4)
White Collar Workers t_0		0.045
		(15.0)
No. of observations	5746	5423
Adjusted R-squared	0.09	0.22
F	22.0	51.5

Secondly, a license (be it for a process technology, be it a franchise, be it a trademark) can help raise productivity by introducing technical change or better practises which are not embodied in capital goods. If this mechanism were also operative, it would reveal itself in increases in the *total factor productivity* of firms, that is increases over and above those which we should expect by the firm's increases in factor use. To analyze this issue we suppose a production function of the following form, where K is capital, L is labor and A is a variable indicating the level of technology.

(4) $Y = AF(K,L)$

Equation 4 can be expressed in terms of rates of growth as in equation 5 below:

(5) $\Delta Y/Y = \Delta A/A + \alpha_K \Delta K/K + \alpha_L \Delta L/L$

For the specific case of firms, the object of analysis of this paper, we assume that total factor productivity growth (Δ **A/A**) depends on licenses (**Licva**) and other control variables (**Z**) as follows:

(6) $(\Delta A/A)_{i,\Delta t} = \alpha_0 + \beta Licva_{it0} + \delta Z_{it0} + \mu_i$

So the equation is estimated as follows:

(7) $(\Delta VA/VA)_{i,\Delta t} = \alpha_0 + \alpha_K (\Delta K/K)_{i,\Delta t} + \alpha_L (\Delta L/L)_{i,\Delta t} + \beta Licva_{it0} + \delta Z_{it0} + \mu_i$

where **Licva**, **i**, **Δt**, and $\mathbf{t_0}$ are defined as before; and **Z** is a new set of control variables: i) export orientation, that is, the ratio of exports to total sales (to control for the possibility that a greater export orientation might lead to faster productivity growth); ii) the participation of foreign capital in ownership of the firm (to control for the possibility that greater foreign ownership might lead to higher productivity growth); iii) an index of human capital employed, using as a proxy for this the ratio of white collar to blue collar workers (to control for the possibility that greater human capital might be associated with faster productivity growth); and iv) the size of the firm, where size is measured by the number of workers employed (to control for the possibility that larger firms might have higher productivity growth). Inasmuch as the stock of capital by firm is not measured directly by the manufacturing survey, we have estimated it indirectly using the method of perpetual inventory.[x] On the other hand, since the survey does distinguish between blue collar workers and white collar employees, we have separated the labor component of equation 7 in these two groups.

The logic of the equation is quite simple. It attempts to see what part of increased output of a firm is explained by licenses, *over and above what is explained by increased factor utilization*, once we control by the above noted variables. In short, if licenses are good investments - and not simply a sign that the entrepreneur is more dynamic, they should raise the total factor productivity of the firm in question, and in proportion to how much it "invests" (royalty payments) in technology transfer.

Finally, in an effort to determine whether licenses not only benefit the firm in question but whether there might be spillover effects to other firms in the same industrial subsector, we have included another variable which measures the average expenditure on licenses as a percentage of value added in the subsector in question, **Licvas** (the simple average for the sector per firm) or **Licvasp** (the average for the subsector, where each firm is weighted by employment) as the case might be, as shown by equation 6 below.

(8) $(\Delta VA/VA)_{i,\Delta t} = \alpha_0 + \alpha_K (\Delta K/K)_{i,\Delta t} + \alpha_L (\Delta L/L)_{i,\Delta t} + \beta Licva_{it0} + \eta Licvasp + \delta Z_{it0} + \mu_i$

In this way, we can not only test whether, and by how much, licenses raise the firm's output over and above what it would have had by virtue of its increased use of factors of production, if β is statistically different from zero, but also whether there are any positive externalities to the firms in the subsector deriving from the average use of licenses in the subsector.

Table 8 defines and characterizes the variables used in our sample of firms.

Table 8

Description of the Explanatory Variables

Variable	Description	Average	Standard Deviation
Licva	Expenditures on licenses as a % of firm's value added	0,13%	1,41%
Licvas	Simple average of royalties to value added for subsector	0,13%	0,12%
Licvasp	Weighted average (by firm employment) of Licva by subsector	0,19%	0,23%
Exp	Ratio of exports to sales by firm	5,46%	18,9%
FDI	Share of foreign ownership in the firm	3,3%	16,8%
Emob	Ratio of white collar to blue collar workers	39%	89%
Tam	Total employment in a firm	85,1	161,3

The results of testing equation 7 and 8 for all firms, independent of size, are presented in Table 9. Table 10 presents the results but controlling by size of firm.

Table 9

The Test Results of EquationS 7 and 8 (whole sample, independent of size)

Variable	(1)	(2)	(3)	(4)
Capital	0.12 (12,4)	0.12 (12,2)	0.12 (12,2)	0.12 (12,2)
Blue collar workers	0.34 (24.7)	0.34 (24.2)	0.34 (24.0)	0.34 (24.0)
White collar workers	0.22 (17.6)	0.23 (17.8)	0.23 (17.8)	0.23 (17.8)
Licva	0.36 (3.60)	0.33 (3.33)	0.33 (3.33)	0.33 (3.33)
Licvas	--	--	-50.00 -(1.19)	
Licvasp	--	--	--	-37.7 -(1.19)
Exports	--	0.0001 (0.01)	0.0001 (0.01)	--
FDI	--	0.0001 (1.12)	0.0001 (1.12)	0.0001 (1.12)
Emob	--	0.005 (2,13)	0.005 (2,13)	0.005 (2,13)
Size	--	0.000008 (0.84)	0.000008 (0.84)	0.000008 (0.84)
No. of observations	4857	4.808	4.808	4.808
Adjusted R-Squared	0.299	0.299	0.299	0.299
F	69.97	61.18	61.18	61.18

Table 10

The Test Results of Equation 7 controlling by Firm Size

Variable	<50 Workers	51-200 Workers	>200 Workers
Capital	0.12	0.12	0.09
	(10.3)	(5.71)	(2.94)
Blue collar workers	0.36	0.32	0.36
	(18.2)	(12.9)	(9.10)
White collar workers	0.22	0.24	0.28
	(13.3)	(2.38)	(6.99)
Licva	0.62	0.28	1.09
	(2.27)	(2.39)	(2.41)
Exports	-0.015	-0.025	0.055
	(-0.70)	(-1.76)	(2.87)
FDI	-0.0006	0.0002	0.0002
	-(2.31)	(1.50)	(0.90)
Emob	-0.007	0.015	-0.005
	(-1.61)	(4.38)	(-0.88)
No. of observations	2.691	1.540	577
Adjusted R-Squared	0.309	0.285	0.367
F	37.40	20.15	11.46

As was to be expected, for the total sample as well as by size of firm, the rate of growth of output is strongly dependent on the increase in factor utilization: the coefficients of capital and labor (in both white and blue collar form) being significantly greater than zero. More importantly for our purposes, β, the coefficient of licenses is positive, significantly different from zero. Thus, the share of a firm's value added paid out in licenses in the base year, 1990, β, significantly increased the growth of the firm's output *in the following 6 years* (1991-1996)over and above what would be explained by the firm's increased use of capital and labor. This finding is quite robust, holding true for all sizes of firm (small, medium and large) and regardless of the control variable - , export performance, extent of foreign ownership or human capital.

This confirms that the direction of causality in Table 6 runs from licenses to productivity, not the other way around. In short, independently of size, firms that purchase licenses are not only likely to have higher capital/labor ratios, use more skilled intensive labor, pay out higher wages (to both their skilled and unskilled workers) and have higher productivity, but they do this because through licenses they achieve higher growth rates thanks to their absorption of technology, both in embodied and unembodied form. Tables 9 and 10 also allow us to conclude the following. 1) There is no evidence of positive externalities to the subsector from the use of licenses in other firms of the subsector (that is to say, the coefficient of Licvas or Licvasp is not significantly different from zero). The data did not allow us to determine whether this was true because there was no spillover or because, generally speaking, sectoral use of licenses was low, and so the spillover effect was too slight. 2) Generally speaking, foreign ownership (the degree of foreign participation in firm ownership) does not significantly increase rates of growth of output (though, strangely, for small firms, there is a statistically significant negative correlation)[xi]. 3) Somewhat surprisingly given the emphasis often given to exports in the literature, better export performance is not generally associated with faster output growth, except in the case of large firms, where it does contribute positively (thus overturning the negative result found in an earlier section, where licensing was measured as a category variable - either used or not used); 4) The greater the firm's intensity in human capital, as proxied by the ratio of white collar to blue collar workers (Emob), the greater the growth of output. This result, however, seems to be true exclusively because of its importance in medium sized firms, those with 50 to 200 workers; otherwise it is not significant.

Moreover, inasmuch as our specification has shown that causality does indeed run from licenses to productivity, - so that licensing is, indeed, an investment, this implies that the coefficient of the fraction of value added spent on licenses can be interpreted as the marginal product of a dollar spent on licenses. For given our production function, $\mathbf{Y = AF(K,L)}$ (equation 4), by simple growth accounting:

(9) $\mathbf{\Delta Y = MP_A \,.\, \Delta A + MP_K.\, \Delta K + MP_L \,.\, \Delta L}$ or

(10) $\mathbf{\Delta Y/Y = MP_A \,.\, \Delta A/Y + MP_K.\, \Delta K/Y + MP_L \,.\, \Delta L/Y}$ or

multiplying the K and L terms by K/K and L/L respectively yields:

(11) $\Delta Y/Y = MP_A \,.\, \Delta A/Y + (MP_K.\, K)/Y.\, \Delta K/K + (MP_L \,.\, L)/Y.\, \Delta L/L$

Equation 11 is the same expression as equation 8, where$(MP_K.\, K)/Y = \alpha_K$, where $(MP_L \,.\, L)/Y = \alpha_L$, where **Licva** $= \Delta A/Y$ by definition, and so where $\beta = MP_A$ and so where β multiplied by the percentage of value added invested in licenses in 1990(Licvas) measures the amount by which output grew over the period 1991-1996 thanks to the investment in licenses in 1990. Hence, the coefficient β (62% for small, 28% for mediumand 109% for large firms) can be converted into a rate of return to investment in licensing. Under reasonable assumptions of the time profiles of income flows and their persistence[xii], this implies that the rate of return to licenses *accruing from unembodied technological change alone*[xiii] runs from a low of the order of the rate of return on physical capital, some 17% per year for medium sized firms, to rates of return similar to those for I&D in developed countries, of the order of 35% per year for small sized firms and over 50% per year for large firms. This corroborates our initial presumption that Chile along with most Latin American countries is seriously underinvesting in technology transfer via licenses.

Finally, Table 11 presents the results of testing equation 7 by subsector. Given the far fewer observations of licensees in each subsector (only two subsectors, food and beverages and chemical products having more than 35 observations of firms with licenses), in only two subsectors are statistically significant results obtained, that for food and beverages, implying a rate of return of 39% for the 6 year period (or of the order of 20% on an annual basis) and that for non metallic minerals with a rate of return of 242% for the 6 year period (or of the order of 100% on an annual basis), but then again, with a bare 20 observations of licensees.

Table 11

The Test Results of Equation 7 by Subsector

Sector	Rate of returns To Licenses	No. of Observations Total (with licenses)	R^2 adjusted
31 Food and beverages	0,39 (2,96)	1,403(56)	0,14
32 Textiles, garments and shoes	0,24 (0,53)	856(34)	0,25
33 Wooden products and furniture	1,45 (0,23)	483(14)	0,42
34 Paper, celulose, printers and editorials	-1.10 (-0.76)	292(15)	0,16
35 Chemical products	0,72 (1,01)	319(65)	0,17
36 Non metallic minerals	2,42 (1,81)	206(20)	0,51
37 Metallic products	-2,86 (-1,14)	69(9)	0,48
38 Machinery and equipment	-0.12 (-0,39)	831(33)	0,28

(e) Licensing and productivity elsewhere

One final point. We observed earlier that Argentina stood out as an exception among Latin American countries with an unusually high annual expenditure on licenses, 2 1/2 times greater than Chile, at least as of the 1990s after it began its program of stabilization and liberalization. How then can we explain the fact that Chile has done so much better despite the fact that it spent so much less on licenses? An answer to such a question would require a detailed analysis of the Argentinian data (which is not available to us) and, of course, another paper. Nevertheless, two points can readily be made. First, and most obviously, licenses are not the sole, or even principal source of growth in an economy. They are but one of the mechanisms available to firms to raise productivity, one, which, we have argued, has generally been severely underutilized in Latin America. Secondly, though Chile has done better than Argentina on the whole, in point of fact, Argentina's manufacturing sector showed a growth in productivity (labor) twice that of Chile's manufacturing sector in the 90s: close to 10% per year (1992-96). Thus, its far better productivity results would, in fact, be consistent with its greater expenditures in licensing over this period.

5. CONCLUSION

In almost all models of economic growth, technological progress is the main source of strong and systematic growth in productivity. However, other than by investing in R and D, there is little evidence of what countries can actually do to improve their technology. This is all the more relevant for a developing country such as Chile, where investment in R and D should be relatively unimportant, given its late starter status. In this paper we argue that the acquisition of foreign licenses is a potentially fruitful way to absorb technology in a late starter developing economy. Notwithstanding the potential importance of licensing for the acquisition of technology by LDCs, we have found few empirical studies of the subject, and none of a quantitative nature. For this reason, we have attempted to determine if licensing had a positive and significant impact on Chilean manufacturing industry in the 1990s, a period of very rapid growth for the economy as a whole.

Our results indicate that licenses have been a significant factor in raising capital and human capital to labor ratios among manufacturing firms, in raising productivity and wages and in speeding growth. Licenses were found to impact on productivity in two ways. First, licenses sped embodied technological change by raising the growth of capital accumulation in a firm. Secondly, they raised total factor productivity growth, that is, technological change not embodied in capital goods.Yet there is evidence of considerable underinvestment in licenses. First, a mere 6% of firms purchase licenses in Chile compared to figures of the order of 20% in developed countries. Second, royalty payments in relation to value added are 1/3 those paid in developed countries and 1/5 those paid by successful, late starter countries (Korea, Portugal and Spain). Third, rates of return to licensing are exceptionally high, especially in small and large firms, where they exceed 35% per year (and this just for the unembodied effect). However, we found no evidence of significant technological spillover from firms with licenses to other firms in the sector. Moroever, we found that neither foreign ownership nor export performance, two variables thought to be important to growth, raised growth rates beyond what could be accounted for by factor accumulation and licensing.

But if private rates of return are so high, why has there been underinvestment in licenses in most of Latin America? Our results rule out one potential explanation: the imperfect approbiability of technical knowledge leading to within sector spillovers from

firms that license to those that do not was *not* found present in our study[xiv]. Rather, we believe that the explanation must be looked for in two other directions. First, in the market for licensing, which, as noted earlier, is quite imperfect, for the appropriate matching of licensors and licensees is riddled with insufficient information and high transaction costs. Secondly, within firm deficiencies in LDCs in identifying that best practise technology most suitable to their needs and adapting it to local conditions, or what Cohen and Levinthal (1989) call the "two faces of R&D: innovation and learning". For successful licensing requires an *active and systematic* search on the part of firms of those current state-of-the art technologies most suitable to their needs and once adopted, an ability rapidly to achieve rated productivity standards. Successful technology transfer thus depends very much on the technical competence and skills of agents in the adopting country This point has been shown for OECD countries by Griffith, Redding and Van Reenen (2000). If true for adopting firms in the OECD, how much truer must it be for LDC firms, where levels of entrepreneurial competency are still sorely deficient (which thus makes technology transfer an issue ripe for policy concern in LDCs).

The policy implications are rather clear. Licensing can be an important mechanism to speed catching up, *if intelligently exploited*. This means recognizing it for the potential benefit it offers - thereby encouraging, not restricting, its use; helping reduce the high transactions costs which characterize this market, costs all the higher for LDC firms distant, both geographically as well as sectorally, from industry flows. Government co-financing of technology search missions by entrepreneurs can be a step in this direction. For the most appropriate technology to license may not be that of the industry leader, but of "strategic followers" (firms more akin to those of LDCs); and the more alternatives (firms and technologies) considered, the more likely that the eventual license can be acquired on more favorable terms (as suggested by the Korean example earlier alluded to).

Moreover, precisely because a licensor is apt to see little to fear in licensing to a firm from an LDC, the amount of licensing, whether slight as at present, or massive, is up to LDCs to decide, and so is amenable to domestic policies. Nevertheless, licenses also entail a risk - that of perpetual technological dependency. Thus whatever incentives be provided for licensing should be transitory, till LDC firms' use of licenses rises to rates comparable to those in today's emerging economies, and so firms come to evaluate them for the potential benefits and risks they entail. To be sure, our paper suggests that at

this particular juncture, the risks are largely one-sided; for today Latin American firms are seriously neglecting the potential benefits of licenses.

FOOTNOTES

[i] As is well known, technology is no longer taken as exogenously given. Theorists both of the endogenous growth and evolutionary schools make technological change some function of the profit-seeking investments of firms, able to keep proprietary control over some portion of the fruits of said investments. However, whereas endogenous growth theorists try to fit models into a general equilibrium framework, evolutionary theorists consider that technological change is essentially a disequilibrium process (Nelson, 1998). For they consider that investments in knowledge are riddled with "Knightian" uncertainty; the probability payoff distribution of such investment is simply not knowable. Firms are thus seen as profit-seekers, groping for knowledge (thus the evolutionary metaphor), rather than maximizers of expected profits as in the standard endogenous growth model (where the probability distribution of the outcomes is assumed to be known). Evolutionary theory thus points to path dependent technological trajectories - a conclusion which accords with reality. Yet the cost of such greater microeconomic realism is that, unlike endogeneous growth theorists, evolutionary models can not specify a unique solution.

[ii] We gloss over the well known fact that firms typically list as R&D expenditures those deriving from such Departments. This naturally understates the true R&D effort, especially of small and medium sized firms, where such specialization is not yet justified, as well as the many "minor" improvements in productivity which originate on the plant floor, and which oftentimes account for half of registered productivity gains in a firm.

[iii] This is one of the principal conclusions of the literature survey on technology transfer by Cusumano and Elenkov (1994). For example, firms who spend more than 5% of sales on R&D are twice as likely to purchase licenses in the the United States than those spending less than 5% on R&D (Fu and Perkins, 1995).

[iv] For example, a study of licenses bought by Spanish firms in 1991 showed that 40% of them also carried out in house R&D. Though half the US figures, it must be kept in mind that this was the case at a time when the Spanish private sector spent of the order of 0.5% of GNP to R&D, a third of what US firms invested). See Macho-Stadler, Martinez-Giralt and Pérez-Castrillo (1996).

[iv] The fact that informal contacts - that is, word o mouth and personal acquaintance be so important in technology licensing suggests that geographical proximity will favor licensing. On the other hand, the fear of building up a competitor could encourage looking outward. We know of one specific study with relevant data, that of the machine tool industry in the United States, Germany and the United Kingdom, which revealed that some 20% held licenses from firms within the national boundaries. See Davies (1995).

[v] No doubt the foremost exponent of this point of view was Constantine Vaitsos, whose work later with the Andean Pact would result in the (in)famous Decision 24, which set limits on royalties as well as on profit remittances from countries of the Andean region. See Vaitsos, 1970 and Vaitsos, 1975.

[vii] This was a seminar on the development of clusters held at the Unted Nation's Economic Commission for Latin America (ECLAC). The Canadian expert worked in a Canadian government agency responsible for tracking technology and technological developments internationally.

[viii] Strictly speaking some of the developed country studies referred to licenses both from national as well as foreign sources. Nevertheless, given the relatively low productivity of Chile's manufacturing sector (at least by international standards- 20% of US labor productivity, for example), it can be safely assumed that virtually all licenses in Chile are foreign. Hence, the conclusion that relatively few Chilean manufacturing firms purchase licenses stands.

[ix] Bernard and Jensen (1999) use the above method to test for differences in the behavior of U.S. firms that export and those that do not.

[x] See for greater detail Álvarez, Crespi Naschelsky and Sepúlveda (1999).

[xi] Nor was the impact of licenses on total factor productivity growth in 1991-1996 modified by the fact or extent of foreign ownership in the base year , under a variety of specifications (data not shown).

[xii] To calculate an annual rate of return we would have to know more about the exact profile of income flows for the 6 year period and beyond. For example, in the case of small firms with a $\beta = 0.62$, if we were to assume on one extreme that the registered increase in output due to licenses was zero for the first 5 years and then shot up 62% in the 6^{th} year and held steady thereafter, the annual rate of return for investments in licenses would be 30% per year (with a discount factor of 12%). Inversely, at the other extreme, if we were to assume that the full income increase due to licenses took place as of the very first year and (as Table 6 would suggest) held constant thereafter, the annual rate of return would be equal to 62%. The most reasonable assumption with the data at hand would seem to be that income flows from licenses increase linearly till the 6^{th} year and then hold steady thereafter (neither increasing nor decreasing after that), in which case the rate of return on an annualized basis would be equal to 35% per year (again discounting future income at 12% per year). Using the latter as the most reasonable set of assumptions yields the rates of return shown in the text.

[xiii] Recall that licenses also impact on firm growth by raising spending on capital goods. Thus the above rate of return is simply that due solely to unembodied technological change.

[xiv] At least this is the conclusion of not observing significant coefficients for our spillovers variables, Licvas and Licvasp, in Table 9. Although there still exist possibility of between sector spillovers associated to client-suppliers relationships. Unfortunately, the lack of information precluded testing this hypothesis.

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