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The Drivers of National Innovative Capacity: Implications for Spain and Latin America

Michael E. Porter
Jeffrey L. Furman
Scott Stern

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Michael E. Porter, Harvard Business School

Jeffrey L. Furman, MIT Sloan School

Scott Stern, MIT Sloan School & NBER

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A. Introduction

In the past decade, both academic scholars and policymakers have focused increasing attention on the central role that technological innovation plays in economic growth. There are at least two distinct reasons for this increased interest. First, though economists have long recognized the centrality of technological innovation in microeconomic and macroeconomic processes (Schumpeter, 1950; Solow, 1956; Abramovitz, 1956), leading models and frameworks for understanding economic growth and national competitiveness did not directly incorporate the economic drivers of the innovation process until the late 1980s and early 1990s (Romer, 1990; Porter, 1990; Nelson, 1993). At the same time, the dramatic political changes wrought by the end of the Cold War and the globalization of economic activity have increased the salience of productivity growth as a principal goal of policymakers across the OECD. In turning their attention to the sources and consequences of technological innovation, the academic and policy communities confront a striking empirical puzzle: while R&D activity is relatively dispersed around the world, "new-to-the-world" innovation tends to be concentrated in a few countries at a given point in time. For example, during the 1970s and the early 1980s, only Switzerland, a relatively small but very technology-intensive country, achieved a per capita "international" patenting rate comparable to the rate achieved by U.S. inventors.

Motivated by the geographic concentration of "new-to-the-world" innovation, researchers and policymakers are attempting to understand the drivers of R&D productivity differences across countries.[1] In this short paper, we review our prior research on the drivers of national R&D productivity differences (highlighting our findings for Spain, in particular).[2] We also extend this work to consider the historical experience and contemporary challenges for the countries of Latin

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[1] In the past decade, there has been a dramatic rise in the number of comparative international studies of innovation and relative productivity. From a policy perspective, there have been several influential "benchmarking" studies which have attempted to provide a more thorough account of international differences in industrial and R&D productivity (Dertouzos, et al (1989); Porter and Stern (1999b)). At the same time, scholars in the economics of technological change became interested in documenting the existence and characteristics of national innovation "systems" (Nelson, 1993), mostly drawing upon rich, qualitative and institutional evidence. Finally, there has been an upsurge in the use of quantitative methods, particularly those relying on the use of patent data, beginning with Griliches (1984).

[2] See Porter and Stern (1999); Stern, Porter, and Furman (1999); and Stern and Porter (2000).

America. While Latin America firms have improved their competitiveness in international markets, they continue to produce very little new-to-the-world technology: for example, several countries in Latin America are awarded less than ten U.S. patents per year. Our research helps to identify sources of this low rate of innovation performance as well as highlighting emerging areas of increased strength in terms of producing world-class technological innovation.

B. Determinants of National Innovative Capacity

Our analysis is organized around a novel framework based on the concept of *national innovative capacity*.[3] National innovative capacity is the ability of a country – as both a political and economic entity – to produce and commercialize a flow of innovative technology over the long term. Innovative capacity depends on an interrelated set of investments, policies, and resource commitments that underpin the production of new-to-the-world technologies. National innovative capacity is not simply the realized level of innovative output; rather, it is reflected in the presence of fundamental conditions, investments, and policies that determine the extent and success of innovative effort in a country (e.g., high levels of science and technology resources, policies that encourage innovative investment and activity, and innovation-oriented domestic industrial clusters).

National innovative capacity depends in part on the technological sophistication and labor force in a given economy, but also reflects the investments and policies of the government and private sector that affect the incentives for and the productivity of a country's research and development activities. As well, national innovative capacity is distinct from both the purely scientific or technical achievements of an economy, which do not *necessarily* involve the economic application of new technology, and national industrial competitive advantage, which

[3] We develop the national innovative capacity framework by drawing on three distinct areas of prior research: ideas-driven endogenous growth theory (Romer, 1990), cluster-based theory of national industrial competitive advantage (Porter, 1990), and the literature on national innovation systems (Nelson, 1993). Each of these perspectives identifies specific factors which may determine the aggregate flow of innovation produced in a given national environment. See Stern, Porter, and Furman (1999) for a complete exposition of this framework and its relationship to prior research in this area.

results from myriad factors in addition to the development and application of innovative technologies (Porter, 1990).

Our framework for organizing the determinants of national innovative capacity consists of elements from two broad categories: (1) a *common* pool of institutions, resource commitments, and policies that support innovation and (2) the *particular* innovation orientation of groups of interconnected industrial clusters. Figure A illustrates our framework. The left-hand side represents the cross-cutting factors that support innovation throughout many if not all industries, referred to as the *common innovation infrastructure*. These include such elements as the current level of technological sophistication in the economy, the supply of technically oriented workers, the extent of investments in basic research and education, and policies that affect the incentives for innovation in any industry. The diamonds on the right side signify the innovative environment in individual national industrial clusters.[4] Driven by the forces highlighted by Porter in his studies of national industrial competitive advantage (Porter, 1990), individual industrial clusters must compete and evolve on the basis of sustained innovation in order to contribute to a nation's innovative capacity. Finally, linkages between the common innovation infrastructure and the individual industrial clusters contribute to an economy's ability to mobilize resources associated with the infrastructure towards innovation opportunities in specific industrial sectors.

Common Innovation Infrastructure. Although the innovative performance of an economy ultimately rests with the behavior of individual firms and industrial clusters, some of the most critical investments that support innovative activity operate across all innovation-oriented sectors in an economy. We describe such elements as an economy's *common innovation infrastructure*. Figure B illustrates three specific categories associated with the common innovation infrastructure. First, as a country becomes more technologically sophisticated, the average cost of generating a specific amount of innovation may decline, as innovators are able to draw on a more varied set of approaches and potential solutions when pursuing R&D activities.

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[4] We focus on clusters (e.g., information technology) rather than individual industries (e.g., printers) because there are powerful spillovers and externalities that connect the competitiveness and rate of innovation of clusters as a whole (Porter, 1990). As well, previous research has suggested that the scope of industrial clusters is often quite local in nature, operating at the regional or even city level (see, e.g. Porter, 1998).

As such, our framework suggests that a country's R&D productivity will depend upon the stock of knowledge it may draw upon in the context of the innovation process (denoted A_t in Figure B). Second, the level of innovative activity realized by an economy will ultimately depend on the extent of available scientific and technical talent who may be dedicated to the production of new technologies (denoted $H_{A,t}$ in Figure B).[5] In addition to the size of a country's knowledge stock and talent pool, R&D productivity will also depend on national investments and policy choices, such as spending on higher education, intellectual property protection, and openness to international competition, which will have a cross-cutting impact on innovativeness across economic sectors. (These factors are denoted together as X^{INF} in Figure B).[6]

Cluster-Specific Innovation Environment. While the common innovation infrastructure determines the general pool of innovation-supporting resources available an economy, it is ultimately firms that introduce and commercialize innovations. In thinking about the overall innovative performance of an economy, then, one must examine the extent to which innovation is supported by the competitive environment in a country's industrial clusters.[7] To do this, we apply the framework introduced by Porter (1990), highlighting how four key elements of the microeconomic environment -- the presence of high-quality and specialized inputs; a context that encourages investment and intense local rivalry; pressure and insight gleaned from sophisticated local demand; and the presence of a cluster of related and supporting industries -- influence the rate of innovation in a country's industrial clusters (see Figure C).[8] Incorporating cluster-level dynamics into the national innovative capacity framework allows us to integrate results and

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[5] Our model builds on the seminal growth model of Romer (1990), which derives equilibrium growth based on the endogenous allocation of labor to the "ideas" sector of the economy (see Jones (1995; 1998) for a useful introduction and review and Porter and Stern (1999a) for further discussion of the empirical properties of the national "ideas" production function).

[6] Across countries, the salience and specific manifestation of these additional factors may vary greatly. For example, in the United States, the dominant performers of basic research are members of the university system who compete with each other for federal funding, mostly through peer-reviewed grant processes. In contrast, basic research in Germany is performed by a more diversified set of organizations, including a substantial share by several non-university-based research institutes, such as the Helmholtz research centers, the Max Planck institutes, and the "Blue List" institutes. While this heterogeneity is of independent research interest (see, for example, the careful comparative studies in Nelson (1993)), our focus here is on the ultimate consequences of such institutions in terms of observed R&D productivity.

[7] Following Porter (1990, 1998), these industrial clusters are the sources of the geographic and cross-industry spillovers which serve to shape and reinforce national industrial competitive advantage.

[8] The "diamond" framework has been used extensively to describe the dynamics of competition in national industrial clusters (Porter, 1990). Here we emphasize the extent to which the environment in a country's industrial clusters encourages innovation as a specific outcome of the competitive process.

insights from multiple levels of analysis for our understanding of national R&D productivity differences.

The Quality of Linkages. Finally, the relationship between industrial clusters and the common innovation infrastructure is reciprocal: conditional on the environment for innovation in any particular cluster, its innovative output will increase with the strength of the economy's common innovation infrastructure. As well, the strength of linkages *between* these two areas will determine the extent to which the potential for innovation supported by the common innovation infrastructure is translated into specific innovative outputs in a nation's industrial clusters. In the absence of strong linking mechanisms, upstream scientific and technical activity may spill over to other countries more quickly than opportunities can be exploited by domestic industries.[9] For example, consider the case of the chemical industry in the second half of the 19th century. While the underlying technology creating this industry was the result of the discoveries of the British chemist Perkins, the sector quickly developed and became a major exporting industry for Germany, not Britain. At least in part, this migration of the fruits of scientific discovery to Germany was due to that country's stronger university-industry relationships and the greater availability of capital for technology-intensive ventures (Murmann, 1998; Arora, et al, 1998).

C. Modeling National Innovative Capacity

We use the national innovative capacity framework to direct our empirical analysis of the determinants of R&D productivity. In effect, we estimate a production function for economically significant technological innovations, choosing a specification in which innovations are produced as a function of the factors underlying national innovative capacity. Letting L X be defined as the natural logarithm of X, our main specification takes the following form:[10]

[9] While there have been some attempts to understand the role played by these linking mechanisms in shaping R&D productivity , most international comparative studies have confined themselves to carefully identifying and highlighting the mechanisms associated with institutions that play such roles in particular countries (e.g., the Fraunhofer Institutes in Germany, MITI in Japan, and Cooperative Research and Development Associations (CRADAs) in the United States).

[10] More formally, we derive this model from the "ideas" production function, $\dot{A}_{j,t} = \delta_{j,t}(X^{INF}_{j,t}, Y^{CLUST}_{j,t}, Z^{LINK}_{j,t}) H^{A\,\lambda}_{j,t} A^{\phi}_{j,t}$, adapted from Romer (1990), Jones (1995), and Stern and Porter (2000).

$$L\,\dot{A}_{j,t} = \delta_{YEAR} Y_t + \delta_{COUNTRY} C_j + \delta_{INF} LX^{INF}_{j,t} + \delta_{CLUS} LY^{CLUS}_{j,t} + \delta_{LINK} LZ^{LINK}_{j,t} + \lambda LH^{A}_{j,t} + \phi LA_{j,t} + \varepsilon_{j,t}$$

$\dot{A}_{j,t}$ represents the flow of new-to-the-world technologies from country *j* in year *t*, $H^{A}_{j,t}$ is the total level of capital and labor resources devoted to the ideas sector of the economy, and $A_{j,t}$ is the total stock of knowledge held by an economy at a given point in time to drive future ideas production. In addition, X^{INF} refers to the level of cross-cutting resource commitments and policy choices which constitute the common innovation infrastructure, Y^{CLUS} refers to the particular environments for innovation in a country's industrial clusters, and Z^{LINK} captures the strength of linkages between the common infrastructure and the nation's industrial clusters.

We conduct our analysis on a panel dataset of OECD countries from 1973 to 1995 (see Table 1), using a novel dataset drawn primarily from World Bank, OECD, and World Economic Forum sources. Evaluating the equation introduced above requires that we identify observable measures for new-to-the-world innovation and each of the concepts underlying national innovative capacity. While no measure of innovation at the national level is ideal, we organize our empirical analysis around the observed number of "international patents" (PATENTS), a useful indicator of the country-specific level of realized, visible "new-to-the-world" innovation at one point in time.[11] The average number of PATENTS produced by a sample country in a given year is 3986. As can be seen in Figures D, "per capita" patenting rates (PATENTS / million persons) demonstrate substantial differences across countries. There is, however, a *convergence* in the realized level of patenting among the initial top tier countries (the United States and Switzerland) and countries in the middle and lower tiers. Most striking, Japan and Germany "join" the top group in the 1980s,

[11] In the context of our prior work, "international patents" are defined as those granted by the United States Patent & Trademark Office as well as by the home country of the inventor. Our use of international patents draws on an extensive body of prior work (building on the foundations developed in Griliches, 1984) which has established both the advantages (as well as the limitations) of using patent data relative to other measures of innovation (Evenson, 1984; Trajtenberg, 1990; Henderson and Cockburn, 1994, 1996; Eaton and Kortum, 1996; 1998). Our prior work includes a much more complete justification for the use of patents as a measure of national level innovative activity which relies primarily on the fact that international patents represent the most useful, consistent indicator of commercially relevant innovation at the world technological frontier.

while a number of Northern European economies evidence relative increases in observed innovative output over time.

D. Empirical Findings

Our principal empirical exercise relates PATENTS to variables corresponding to various elements of national innovative capacity. Essentially, we utilize a number of observed aggregate measures (such as the number of full-time scientists and engineers and the aggregate level of R&D expenditures) as well as indicators of national policies (e.g., measures of the strength of intellectual property protection and openness to international competition) to capture the strength of the common innovation infrastructure. As well, we capture the innovation orientation of industrial clusters and the strength of linkages by *compositional* variables, including a measure of the degree to which R&D is funded by the private sector and the degree to which R&D is performed within the university sector.

Using this framework, we have performed a number of detailed empirical analyses dissecting the drivers of national innovative capacity (Stern and Porter, 1999; Stern, Porter, and Furman 1999; Porter and Stern, 2000). Our analysis allows us to evaluate which factors matter most for driving differences in historical trends in national innovative performance. In Table 2, we present the principal model that we have used to evaluate trends in national innovative capacity across the OECD.[12] Each of the measures reflecting elements associated with national innovative capacity are quantitatively and statistically significant (and indeed explain an extremely high percentage of the overall variance in innovative output among OECD countries over the last quarter century). These results imply that the extent and nature of investments in national

[12] There are a number of methodological considerations which we do not have space to discuss here but which are treated more fully in our prior work. There, we demonstrate the robustness of our results to a number of modifications, including (a) using the cumulative sum of patents as a measure of countries' knowledge stock; (b) employing alternative specifications, such as country fixed effects and time trends; (c) including additional measures of the determinants of national innovative capacity and (d) employing alternative subsets of the data, including selecting out specific geographic regions or time periods.

innovative capacity are associated with observed levels of innovative output and R&D productivity.[13]

Our analysis suggests that the level of observed national innovative output is significantly affected by factors associated with level of technological sophistication of a country (GDP per capita), the overall level of resources devoted to innovation (e.g., the employment of technical workers, and the aggregate level of R&D spending). As well, national innovative performance depends upon more nuanced elements of the common innovation infrastructure, including investments in higher education, and policy variables such as an economy's openness to international competition and the strength of its intellectual property protections. Finally, national innovative capacity is affected by the extent to which R&D is *financed* by industry and *performed* by universities. Overall, looking at the various factors which help explain the observed level of international patenting output, our analysis suggests that no single factor is sufficient to drive national innovative capacity. Thus, our results suggest that innovation leadership will tend to result from concerted strength along a number of distinct dimensions which contribute to innovative capacity.

Using these results, we are able to compute an "index" of national innovative capacity for our sample of seventeen OECD economies since 1973 (Figure E). Essentially, a country's innovative capacity is equal to its expected per capita international patenting rate, as calculated from the variables and regression coefficients from Table 2. This counterfactual analysis allow us to reach several overarching conclusions about the development of innovative capacity. First, and perhaps most importantly, innovative capacities are converging across the OECD. Although the

[13] It is important to properly interpret the coefficients on these measures. For those variables specified in log form, coefficients reflect elasticities. For example, a 10 percent increase in GDP PER CAPITA is associated with approximately as 7.8% increase in PATENTS. For the Likert scale measures, the coefficients are equal to the predicted percentage change in PATENTS which would result from a one *unit* change in that variable (e.g., a one unit change in IP (e.g., from 7 to 8) is associated with a 25 percent increase in PATENTS). Finally, coefficients on the variable expressed as a share (ED SHARE) can be interpreted as percentage increase in PATENTS resulting from a one *percentage point* increase in ED SHARE.

United States and Switzerland appear at the top of the “index” of national innovative capacity across three decades, the relative advantage of the leader countries has declined over time. Over this time period, there have been substantial differences across countries in the extent to which they have invested in factors contributing to national innovative capacity. In particular, despite an economic slowdown in the 1990s, Japan has dramatically improved its innovative capacity since the early 1970s and evidences little sign of weakening its pace of investment. Further, the Scandinavian economies of Denmark and Finland have made major gains in innovative capacity since the mid-1980s, joining Sweden in establishing a region of world class innovation. In contrast, several Western European countries, including the United Kingdom, France, and Italy, have maintained constant (or perhaps declining) innovative capacity levels over the past quarter century.[14]

The Spanish experience presents a mixed record. Relative to other countries in our analysis, Spain has sustained a low level of national innovative capacity (and so is ranked lower throughout the sample). In part, this record reflects the isolated political and economic circumstances of Spain until the late 1970s. However, over the past twenty years, Spain has experienced a substantial increase in its national innovative capacity: indeed, on a percentage basis, Spain has registered among the fastest rates of growth in national innovative capacity among OECD countries (consistent with the convergence phenomena identified earlier.) While Spain has not enjoyed the transformation of countries such as South Korea, Singapore, or Israel, there is evidence of a consistent and maintained effort to commit to policies and investments which have increased the ability of Spanish companies to develop and commercialize world-class innovation.

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[14] Related analysis suggests that new centers of innovative activity are emerging outside of the OECD. Singapore, Taiwan, South Korea, and Israel have made substantial investments and upgraded their innovative capacity over the past decade. Ireland has also established the infrastructure and industrial clusters consistent with strong innovative activity. In contrast, several countries that have drawn much attention as potential economic powers—India, China, and Malaysia—are not yet generating a meaningful level of patentable innovative output on an absolute or relative basis. None of these countries is investing rapidly enough to be considered to possess high per capita levels of national innovative capacity.

E. National Innovative Capacity in Latin America

In this section we extend our prior analyses by applying the national innovative capacity framework to Latin America. First, we contrast the innovation profile of these economies with those of leading innovator countries in the OECD; second, we undertake a more nuanced comparison of the differences in innovative capacity among the economies of Latin America and in comparison with other emerging rgions.

As is the case for the OECD, the ability of Latin American countries to develop new-to-the-world technologies is rooted in their historical investments in national innovation infrastructures and the presence of innovation-oriented competition in national industrial clusters. At least until recently, the countries of the Spanish-speaking world have faced barriers that have limited progress in these areas, with severe consequences for the production of new-to-the-world innovation. For example, in 1997, while many Latin American countries have per capita incomes that are greater than one-fifth of those of Western Europe, the per capita rates of international patenting in most Latin American economies are less than *one-fiftieth* of the rates in most Western European countries. In other words, Latin American firms and individuals are 50 times less likely to patent a world-class innovation than their Western European counterparts. Indeed, Latin American inventors receive *extremely* few patents from the United States in absolute terms; even large countries such as Columbia have been assigned only a handful of patents over the past quarter century (see Table 3).

The lower level of overall national productivity in these countries plays an important role in understanding this innovation shortfall. However, the gap between national innovative capacity in the OECD and Latin America is also the result of several factors more specific to the process of technological innovation. For example, prior research (see, e.g., Nelson, 1993, as well as our own efforts) emphasizes the special role played by the university system. In many leading innovator economies, the university system provides the training necessary for a technically skilled labor force and undertakes the "basic" research that provides a foundation for a country's industrial clusters. Throughout the Spanish-speaking world, however, universities have historically played a limited role in the innovation process. Rather than participating in a dynamic interaction with industry, as occurs in countries such as the United States and Sweden, Latin American higher education has often remained isolated from industry and only loosely involved in national science and technology policy. Similarly, whereas openness to international competition encourages innovation by fostering knowledge spillovers and competitive pressures, the largely closed history of Latin American economies has impeded the development of national innovative capacity.

To understand the differences *among* Latin American countries themselves, we compute and then dissect an index of national innovative capacity for a sample of seven Latin America countries for which consistent and reliable data are available (see Table 1).[15] Overall, there is a tight relationship between the rankings according to index (which is based on the model we used to evaluate national innovative capacity within the OECD) and realized levels of per capita international patenting by Latin American countries. In other words, innovation performance by Latin American economies seems to be driven by the same fundamental factors we found in our earlier research on OECD economies.[16]

Relative to all other countries in the sample, Argentina is estimated to have the highest level of national innovative capacity (see Table 4). However, Argentina's level is still substantially lower than that of OECD countries (e.g., while the leading countries have index values in excess of 100 and Spain registers a level of between 15 and 20, the Argentina index value is only slightly above 2). Following Argentina is a second tier composed of Chile and Brazil, each estimated to have similar levels of national innovative capacity (with values just above 1). Costa Rica in fact ranks fourth in terms of national innovative capacity, though Venezuela is the only country in the sample poorer than Costa Rica. This result highlights the

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[15] The index is calculated using the weights provided by the regression coefficients from Table 2 and can be interpreted as the *predicted* number of international patents per million persons in each country based on that country's fundamental investments in the elements of national innovative capacity. Because of data limitations, we were unable to calculate a reliable index for other leading patentors, including Panama and Jamaica.

[16] Venezuela constitutes an interesting anomaly in this regard, as its actual rate of patenting greatly exceeds the rate achieved by other countries, despite its having a low measured index of national innovative capacity. Closer investigation reveals, however, that more than 95% of the patenting in Venezuela is attributable in most years to a *single* company (Intevep) which, while a world-class innovator itself, does not seem to be closely connected with other institutions or clusters of firms in Venezuelan. Indeed, the Venezuelan experience accentuates a key aspect of our model of national innovative capacity. The long-term ability to translate national innovative capacity into widespread international competitiveness relies on strength in multiple areas: a single area of expertise is unlikely to yield long-term *national* competitive advantage.

degree to which national innovative capacity is more than simply a measure of economywide wealth but reflects specific investments and policies related to an economy's ability to produce and commercialize new-to-the-world innovation, a finding in our prior research on OECD economies. Finally, the remaining countries are estimated to have much lower levels of national innovative capacity (all below 0.4): even though countries such as Columbia, Mexico and Venezuela have achieved similar levels of GDP per capita as Chile and Brazil in the late 1990s, our estimates suggest that these countries have invested less intensively in becoming world-class innovator economies.

Table 5 highlights some of the specific factors which contribute to the different estimated levels of national innovative capacity across Latin America. With respect to each of these dimensions, Argentina is among the leaders; in particular, it possesses a substantial advantage with respect to the number of scientists and engineers employed per capita. Each of the top four countries according the index (Argentina, Chile, Brazil and Costa Rica) displays at least some areas of strength. For example, Chile employs a relatively large number of scientists and engineers (per capita) and exposes its firms to the pressures of international competition. Though its GDP per capita is relatively low, Costa Rica has achieved strength across several dimensions of national innovative capacity by increasing its R&D expenditures, strengthening its intellectual property institutions, increasing the openness of its economy to international competition, and increasing the share of R&D funded by the private sector (Porter and Kettelhohn, 2000; Hill, 2000).[17]

Finally, though several countries in Latin America are in the process of improving their national innovative capacity, there remains an important gap between the experience of this region and other emerging regions throughout the world. In prior research, we document the exponential increase in national innovative capacity realized by several emerging economies over the past quarter century, particularly the Asian NICs (Porter and Stern, 1999). By contrast, the Latin American experience is characterized by, at best, modest improvements in national innovative

[17] However, some countries display a more uneven national innovative capacity profile: for example, though Brazil has increased R&D expenditures over the past decade (Hill, 2000), Brazil still offers relatively weak intellectual property protection, still raises barriers to international competition, and devotes a relatively small share of its overall workforce to technological innovation.

capacity. Because of data limitations, we are unable to document the changes over the past several decades in each contributor to national innovative capacity for each of our sample countries. However, looking at innovation performance (i.e., international patenting), we are able to provide at least some insight into the differences across emerging regions. During the late 1970s, the seven Latin American countries in our sample actually realized a higher level of international patenting than a comparison group of seven emerging Asian economies; in sharp contrast, by the second half of the 1990, patenting in the Asian economies dwarfs the Latin American output (see Table 6 and Figure F). This difference in performance reflects, at least in part, the high rate of investments in national innovative capacity by the emerging Asian economies compared to the more modest upgrades realized by Latin American nations.

Overall, our analysis suggests that, despite rapid economic growth in much of Latin America over the past ten years, the region still faces substantial challenges in developing innovative capacity at a level commensurate with those of leading countries in the OECD. However, some countries seem to moving to address this challenge. For example, the Costa Rican government is exerting political leadership encouraging the development of an information technology-based industrial cluster; these policies are in turn helping to upgrade each element of Costa Rica's national innovative capacity (Porter and Kettelhohn, 2000). Maintaining a consistent record of investments and policy choices to enhance the environment for innovation will be a key determinant of whether Latin America is able to sustain and enhance its competitiveness over the next generation.

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TABLE 1
SAMPLE COUNTRIES

A. OECD SAMPLE COUNTRIES (1973-1995)

Australia	France	Netherlands	United Kingdom
Austria	Germany*	Norway	United States
Canada	Italy	Spain	
Denmark	Japan	Sweden	
Finland	New Zealand	Switzerland	

* Prior to 1990, data for the Federal Republic of Germany include only the federal states of West Germany; beginning in 1991, data for Germany incorporate the New Federal States of the former German Democratic Republic.

B. LATIN AMERICAN SAMPLE COUNTRIES

Argentina	Brazil	Chile	Columbia
Costa Rica	Mexico	Venezuela	

TABLE 2
DETERMINANTS OF THE PRODUCTION OF NEW-TO-THE-WORLD TECHNOLOGIES

Dependent Variable = **ln(**INTERNATIONAL PATENTS**)$_{j,t+3}$**		National Innovative Capacity Model
QUALITY OF THE COMMON INNOVATION INFRASTRUCTURE		
A	L GDP PER CAPITA$_{j,t}$	**0.783 (0.096)**
H^A	L FTE SCIENTISTS & ENGINEERS$_{j,t}$ (FTE S&E)	**0.883 (0.045)**
H^A	L \$ R&D EXPENDITURES$_{j,t}$	**0.272 (0.044)**
X^{INF}	SHARE OF GDP SPENT ON HIGHER EDUCATION$_{j,t}$	**0.152 (0.016)**
X^{INF}	INTELLECTUAL PROPERTY PROTECTION$_{j,t}$ (survey scale, 1-10)	**0.221 (0.045)**
X^{INF}	OPENNESS TO INTERNATIONAL TRADE$_{j,t}$ (survey scale, 1-10)	**0.061 (0.030)**
CLUSTER-SPECIFIC INNOVATION ENVIRONMENT		
Y^{CLUS}	% R&D FUNDED BY PRIVATE SECTOR$_{j,t}$	**0.016 (0.002)**
QUALITY OF THE LINKAGES		
Z^{LINK}	% R&D PERFORMED BY UNIVERSITY SECTOR$_{j,t}$	**0.009 (0.003)**
Year fixed effects		**Significant**
Adjusted R-Squared		0.9981
Observations (17 countries x 21 years)		347

[*] The natural logarithm of a variable, X, is denoted L X.

TABLE 3
TOTAL CUMULATIVE "INTERNATIONAL" PATENTING BY SELECTED LATIN AMERICAN COUNTRIES, 1976-2000

COUNTRIES	Total Patents Awarded to Inventors by Country	Ratio of Assignee Patents to Inventor Patents	Total Inventor Patents Per Million Population
Argentina	692	0.18	19.9
Brazil	1,288	0.44	8.1
Chile	149	0.33	10.5
Colombia	162	0.14	4.2
Costa Rica	135	0.13	38.0
Dominican Republic	21	0.00	2.7
Ecuador	39	0.15	3.4
El Salvador	10	0.00	1.8
Guatemala	34	0.21	3.4
Haiti	12	0.42	1.6
Honduras	14	0.29	2.5
Jamaica	33	0.06	13.3
Mexico	1,292	0.31	14.2
Nicaragua	4	0.00	0.9
Panama	59	1.73	22.4
Paraguay	1	0.00	0.2
Peru	70	0.13	3.0
Uruguay	5	0.40	1.6
Venezuela	553	0.56	25.3

[*] Inventor Patents refer to the total number of patents granted by the USPTO to inventors in each of the countries between 1976 and May, 2000. Assignee Patents refers to the total number of patents granted by the USPTO and assigned to establishments or individuals in each of the countries between 1976 and May, 2000. Per capita patenting based on RICYT 1996 population data.

Source: US Patent and Trademark Office (www.uspto.gov), 2000.

TABLE 4
NATIONAL INNOVATIVE CAPCITY INDEX RANKINGS
SELECTED LATIN AMERICAN COUNTRIES, 1998

Country	**NIC Index**
Argentina	2.50
Brazil	1.12
Chile	1.08
Costa Rica	0.64
Mexico	0.37
Colombia	0.29
Venezuela	0.16

TABLE 5
SELECTED DETERMINANTS OF NATIONAL INNOVATIVE CAPCITY, SELECTED LATIN AMERICAN COUNTRIES, 1998

Country name	FTE R&D Workers per Million Pop.	R&D Expenditure ($M) per Million Pop.	Strength of Intellectual Property Protection	Openness to International Competition and Trade
Argentina	1,212.2	32.8	4.7	8.5
Brazil	433.7	35.3	3.3	5.4
Chile	639.2	32.0	6.1	8.8
Colombia	n/a	9.0	5.0	5.0
Costa Rica	557.0	32.2	6.0	6.0
Mexico	365.3	15.2	6.1	7.9

Sources: RICYT, 2000; World Competitiveness Report (various years); and author calculations.

TABLE 6
"INTERNATIONAL" PATENTING BY EMERGING LATIN AMERICAN and ASIAN ECONOMIES
1976-1980 & 1995-1999

Country	1976-1980	1995-1999	Growth Rate
Emerging Latin American Economies			
Argentina	115	228	0.98
Brazil	136	492	2.62
Chile	12	60	4.00
Colombia	28	42	0.50
Costa Rica	22	48	1.18
Mexico	124	431	2.48
Venezuela	50	182	2.64
Emerging Asian Economies			
China	3	577	191.33
Hong Kong	176	1,694	8.63
India	89	485	4.45
Malaysia	13	175	12.46
Singapore	17	725	41.65
South Korea	23	12,062	523.43
Taiwan	135	15,871	116.56

Source: US Patent and Trademark Office (www.uspto.gov), 2000.

Figure A
Measuring National Innovative Capacity

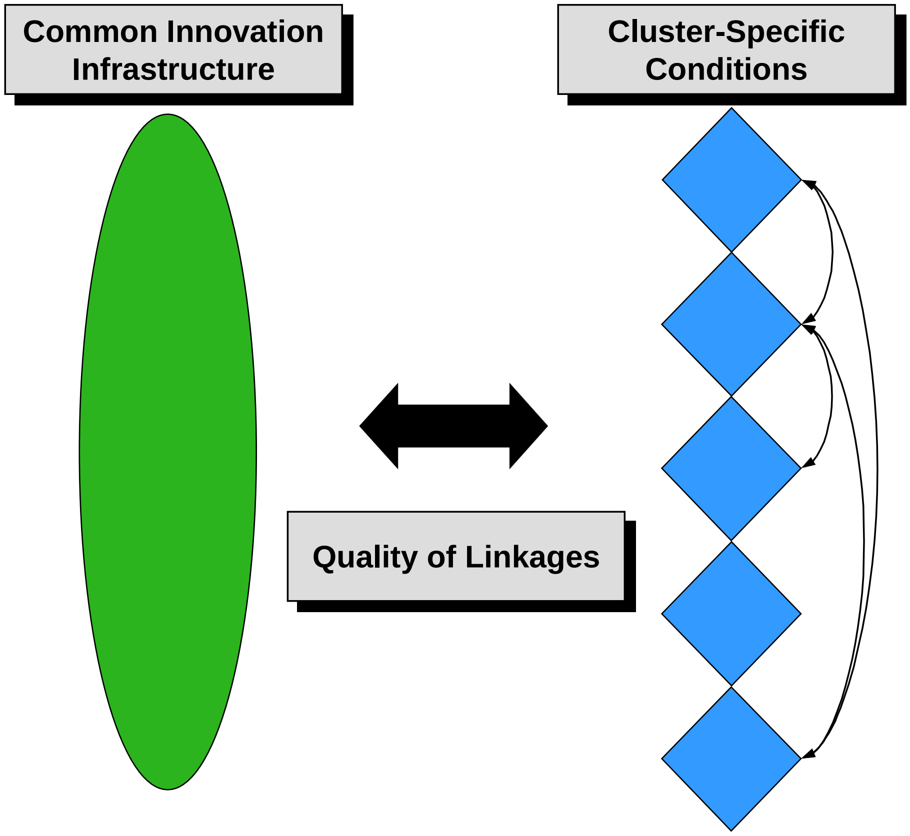


Figure B
The Common Innovation Infrastructure

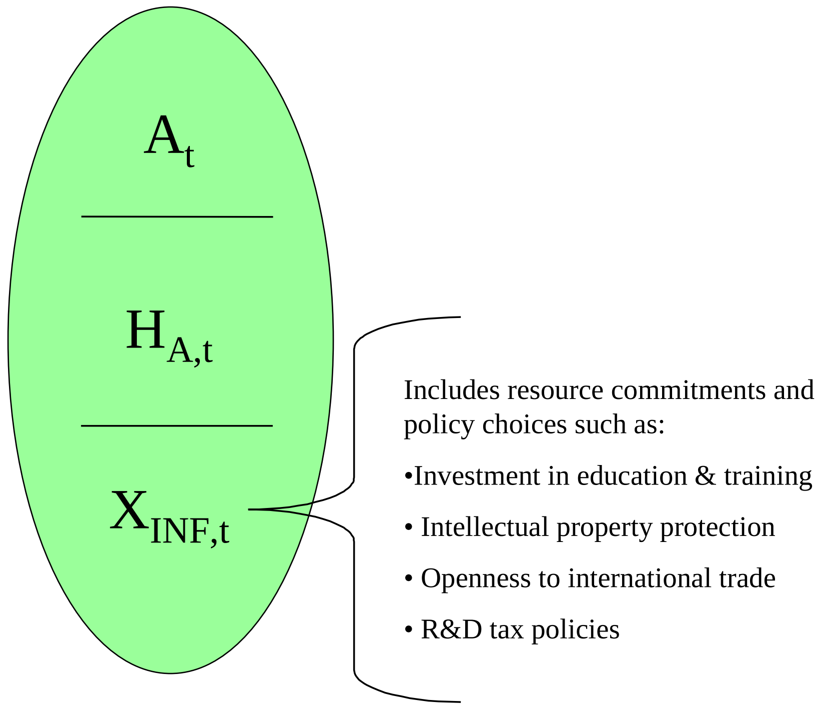


Figure C
The Innovation Environment of National Industry Clusters

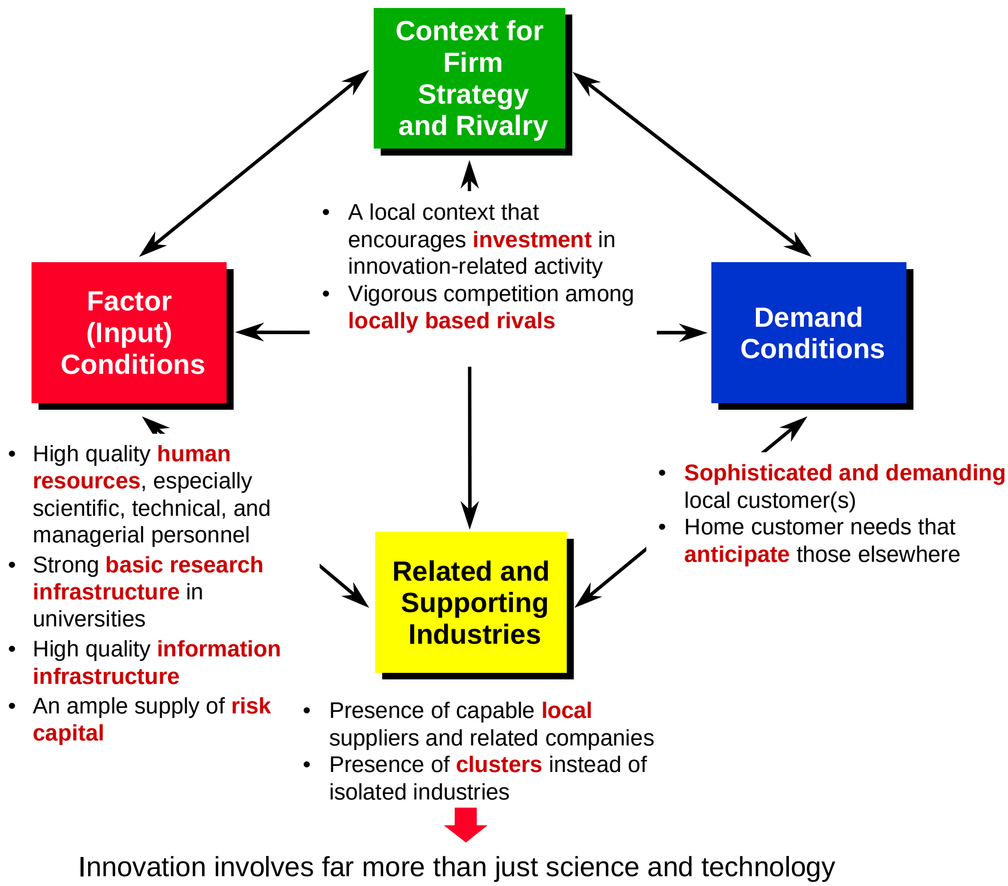


Figure D-1

International Patents per Million Persons

(selected countries)

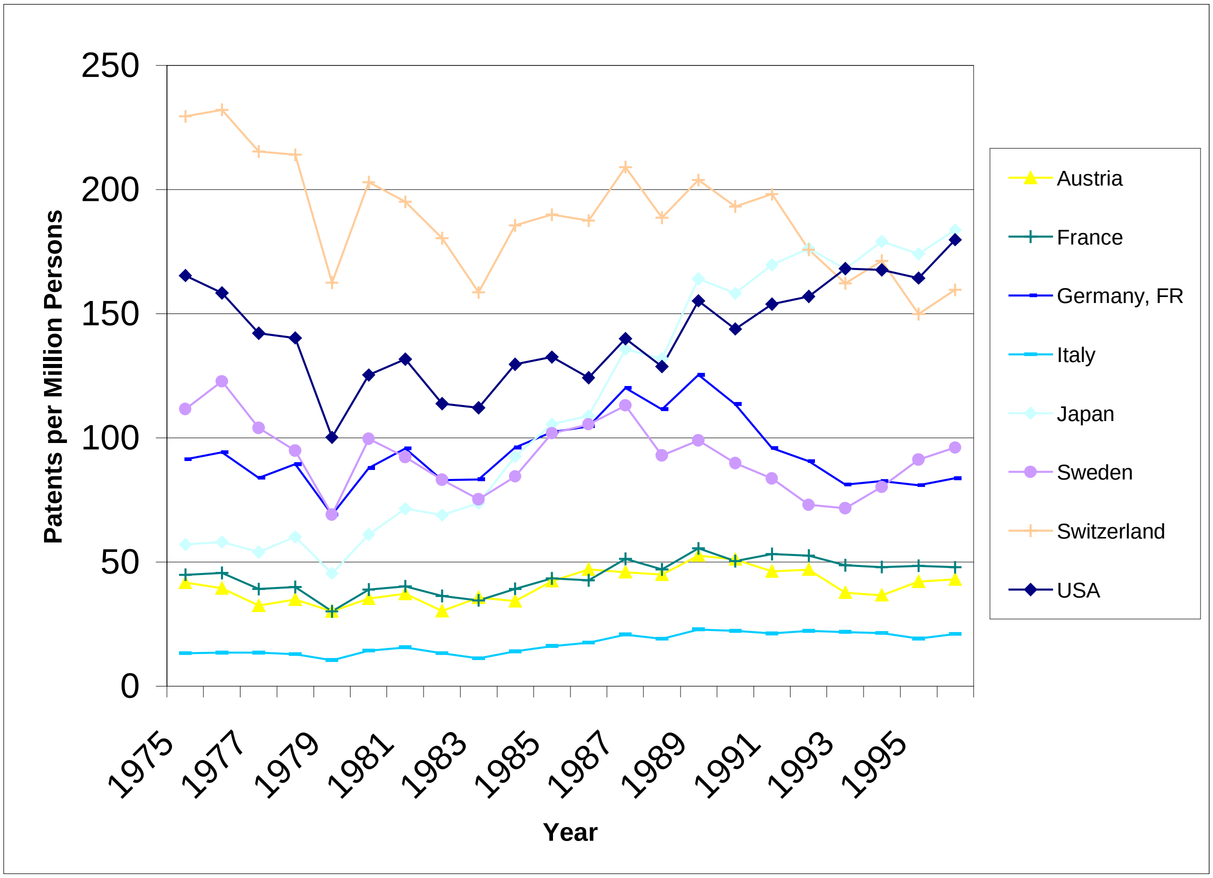
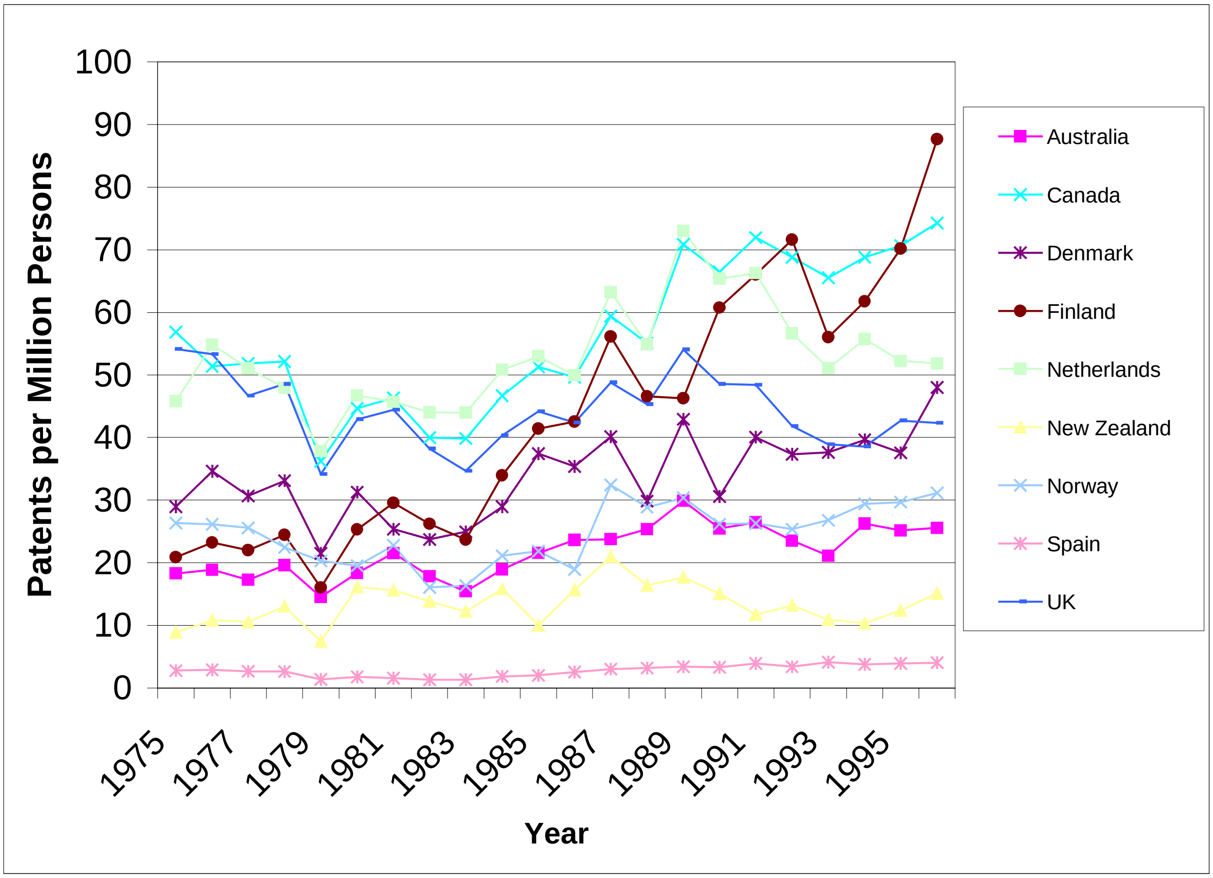


Figure D-2

International Patents per Million Persons

(selected countries)



* Note: Scale differs from D-1 in order to highlight cross-country differences in this sample.

Figure E-1

Trends in National Innovative Capacity

(selected countries)

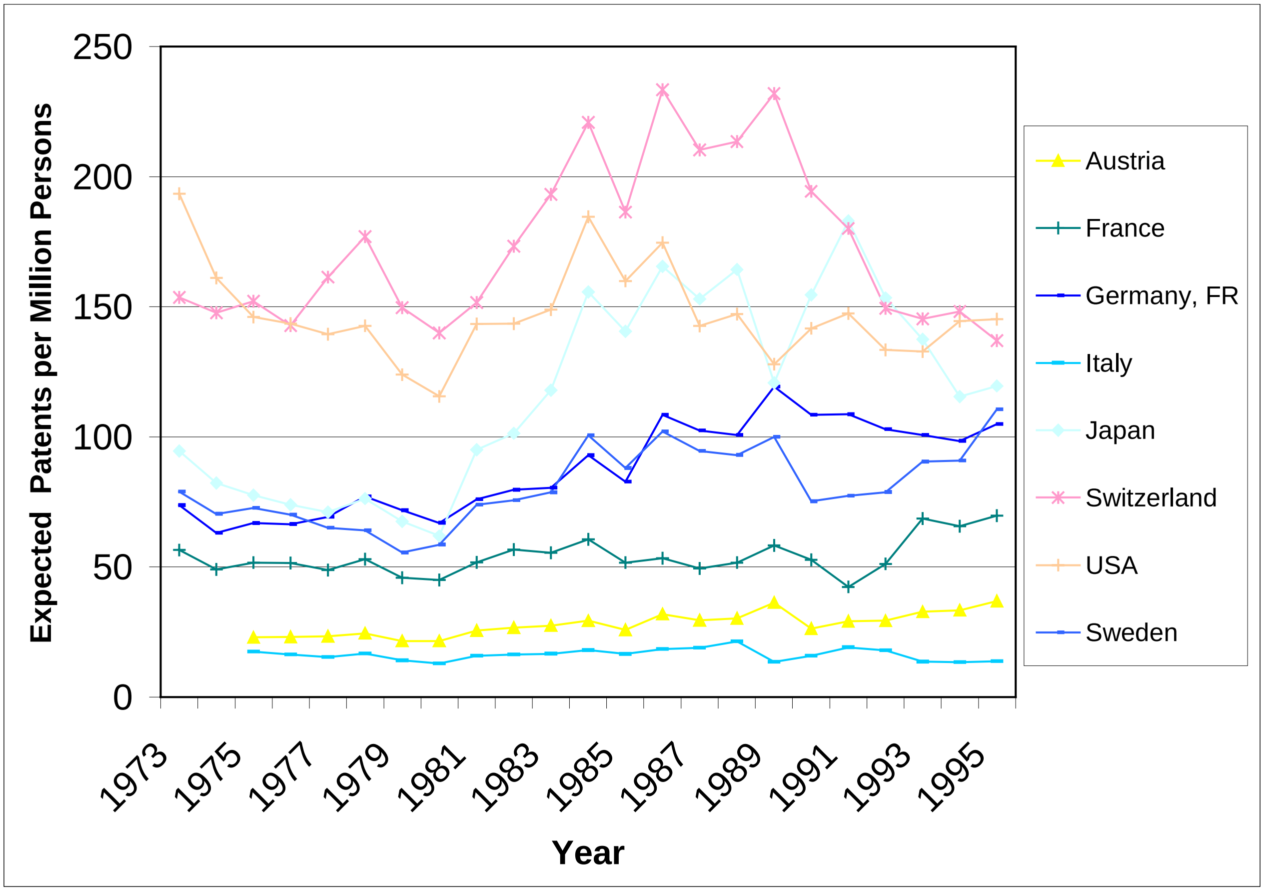
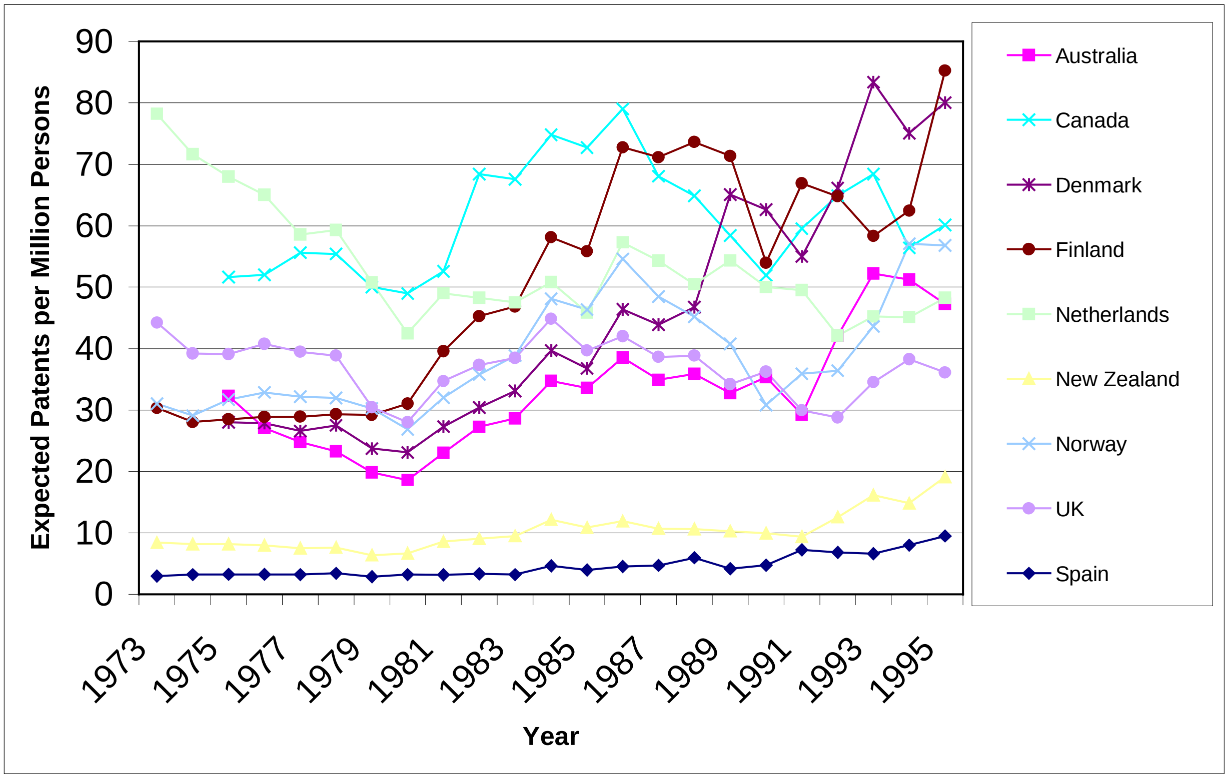


Figure E-2

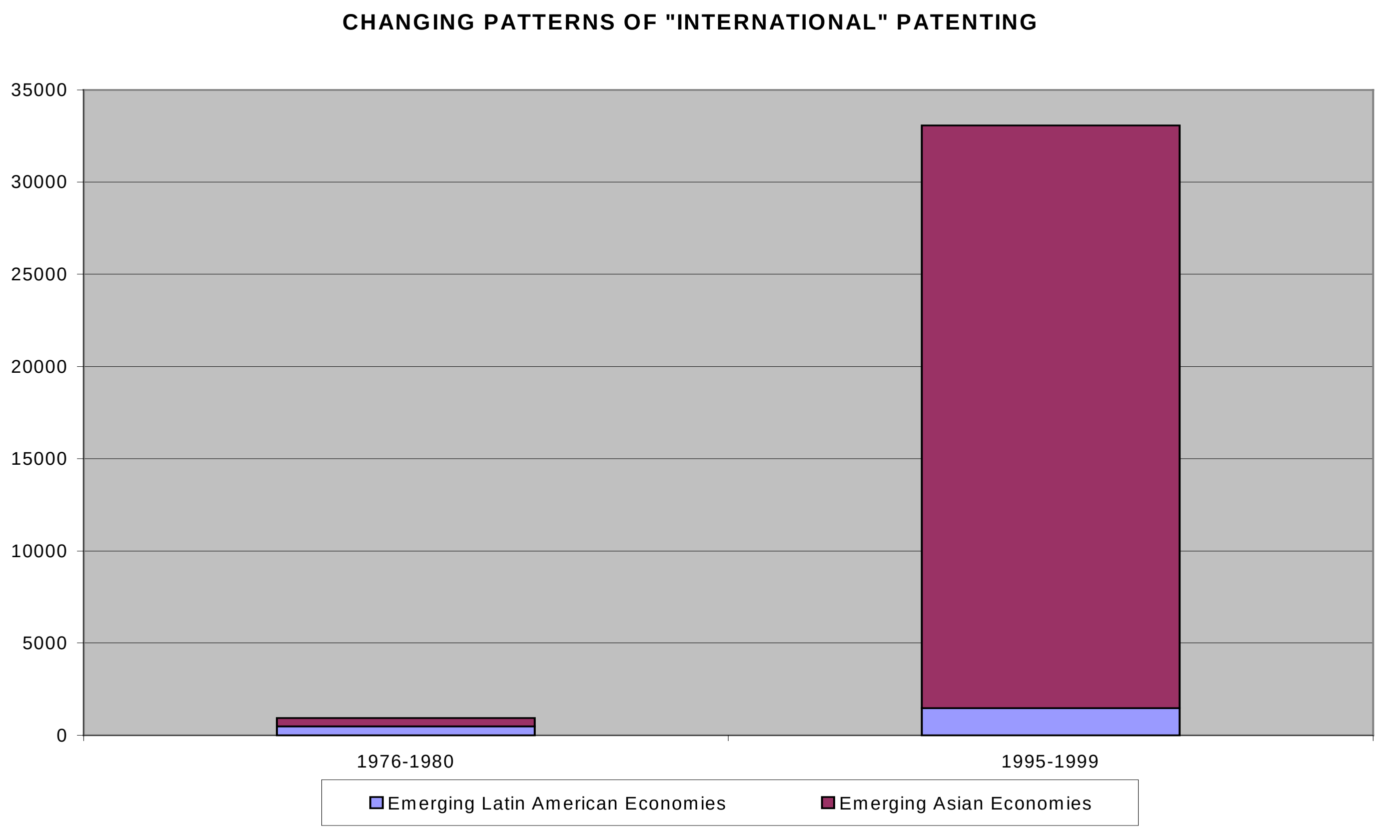
Trends in National Innovative Capacity

(selected countries)



* Note: Scale differs from E-1 in order to highlight cross-country differences in this sample.

FIGURE F


CHANGING PATTERNS OF "INTERNATIONAL" PATENTING
35000
30000
25000
20000
15000
10000
5000
0
1976-1980
1995-1999
Emerging Latin American Economies
Emerging Asian Economies