CHILE'S INNOVATION SYSTEM
IN INTERNATIONAL COMPARISON

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1 INTRODUCTION

1. **Where should the priorities lie?** More or less all countries are currently grappling with how to build a competitive and prosperous economy. This report examines particularly the case of Chile, one of the most developed and prosperous countries in the Latin American region. Similar issues are on the agenda of some of the richest as well as some of the poorest countries around the world, however. Innovation and entrepreneurship have caught attention in this context. This is not because other issues like macroeconomic stability or international trade do not matter – on the contrary, a stable and predicable macroeconomic situation, as well as the presence of open and transparent markets, is a must for putting in place socially effective and successful ventures in most areas of economic activity. The observation today, however, is that more and more countries have put their macroeconomic "house" in order. As for international trade, a lot remains to be achieved. On some trade issues, progress is much less swift than what would seem reasonable, given the scale of the costs afflicted on many industries and societies as a whole. In principle, however, it is now relatively well understood what should be done to maintain or improve conditions in these domains. With respect to microeconomic conditions, and institutional development, things are a lot less clear. This applies particularly to innovation and entrepreneurship, which are fundamental to sustained growth and increasing welfare.

2. **How can countries form an environment conducive to innovation and entrepreneurship?** There are no simple answers to this question, because innovation and entrepreneurship depend on a range of institutions and market conditions. Often, the strength and dynamism of a *national innovation system* are hampered by impediments to potentially valuable research and development activities within private business, as well as barriers to entrepreneurial creativity. The innovative potential also partly depends on the strength and quality of linkages, between different kinds of actors, and different kinds of competencies. The interplay between key entities – academia, private sector, and government – is critical in that synergies and the bridging between research and technological and commercial opportunities are often frustrated by various factors. In the midst of intensifying globalization processes, marked by increasingly mobile production factors, the creation of a fertile local environment that can serve to seed the emergence and growth of new ideas and opportunities is becoming essential for building an attractive location that can link what is small, young and promising to what has already become big and established around the world.

3. **The experiences of other countries can provide critical input to the national policy making process.** With increasingly rapid processes of scientific discovery, technical progress and dissemination of information and new technologies, individuals, firms and societies are gaining the means to seek out new knowledge wherever it is available. There is no one single international best practice model for strengthening local innovative systems – visions as well as policy formulation will and must ultimately build on the local context. Yet, there is much to learn from other countries' successes and mistakes. Around the world, governments are in the process of examining what is being done by others in these areas, for the purpose of understanding them better and exploring ways forward. International exchange and partnerships are becoming crucial for capturing the best of

[1] This report benefited from exchanges and discussions with representatives of a number of Chilean institutions, among them Corfo and Fundación Chile. It also draws on the experiences of an innovation policy seminar organized in Santiago de Chile, in May 2004. The authors thank, without implication, Daniel Friberg, IKED, Cristina Chaminade and Olof Ejermo, University of Lund, and Lennart Norgren, VINNOVA, for comments and input.

learning opportunities. Not least, there is a lot to learn from developments in the newly industrialised economies, some of which display an impressive spirit of innovativeness and economic dynamism. Amongst them, Chile offers noteworthy performances, with its recognised success in promoting growth, economic stability, and social equity.[2] Chile has developed into a diversified economy which is fast approaching the frontier in many areas of new technology. Chile is also characterized by strong public institutions and regulatory frameworks. While the country has undertaken market-oriented economic reforms for a number of years, it has put heavy emphasis on macroeconomic reforms as the silver bullet for securing better-functioning markets and economic progress, however. As new challenges arise, the time appears to have come for Chile to pay relatively greater attention to several structural issues associated with innovation and entrepreneurship.

4. **Contrasting cases can reveal some illuminating differences in terms of challenges** (**Figure 1**). Comparisons can be useful not only between countries at the same income level, but also between those that may appear far apart, especially if there are similarities in structural respects. Although the motivating challenges may be different, many of the underlying policy issues - including improving linkages between different actors, securing the benefits of globalization, and supporting a competitive business sector - are common to countries at very different income levels.

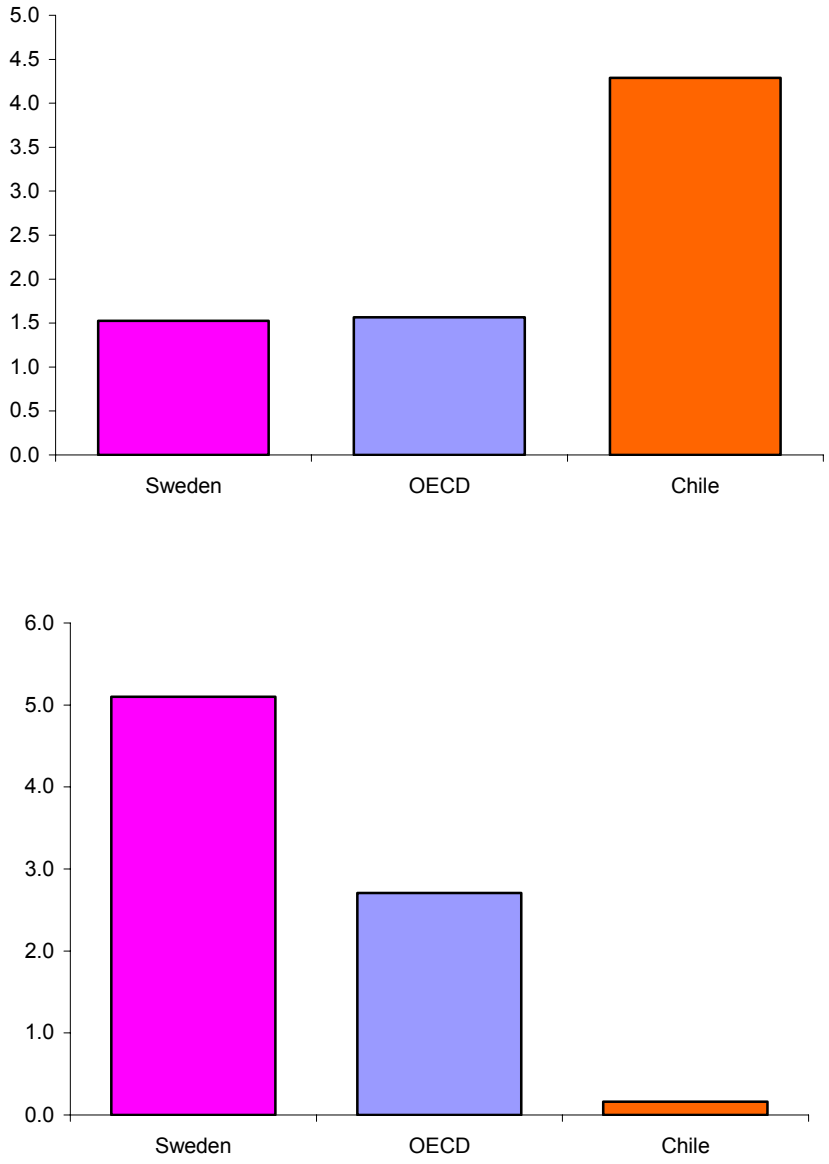
5. This is illustrated by contrasting the case of Chile vs. a high-income country such as Sweden. Chile's growth rate has been remarkably high in the past decade. At the same time, there are now questions on the endurance of this record, including on the implications of the dependence on extraction of natural resources. More particularly, Chile's capacity to innovate is low by international standards, whether measured against standard indicators of innovation such as patents and publications, or outcomes such as the share of high-technology exports in the economy. In spite of a strong economic record, Chile now faces the challenge to move from more traditional sources of growth to a more innovative and internationally competitive economy. A concern in this context has to do with the evident weaknesses in linkages between academia and industry. Sweden, in contrast, ranks very high internationally in terms of registered patents and R&D intensity, and the share of high-technology exports in GDP is above OECD average. Whereas Sweden indeed has recorded high productivity and overall income growth in recent years, compared to other developed countries, questions are raised here as well on the viability of present costs, taxes, and incentives for firms and individuals to upgrade competencies and to invest in Sweden. Whereas differences in income levels and economic structure need to be kept in mind, a close scrutiny shows that the issues faced by both countries illustrate the overriding challenge of how to ensure that innovation efforts translate into overall economic and societal improvements.

6. **The remainder of this paper provides an overview of some important aspects of Chile's innovation system** as they compare to other countries, looking primarily across Latin America, OECD and Asia, but also contrasting with the situation in developed countries. Rather than offering a comprehensive analysis, the paper paints the big picture by highlighting a few stylized facts – indeed, many important areas including firm demographics, labour market structure, regional innovation dynamics, and linkages in the innovation system, will not be addressed in any depth. Section 2 outlines the main features of Chile's economic challenges. Section 3 looks at different indicators of Chile's competitiveness vis-à-vis the rest of the world. Section 4 concentrates on a few important aspects of the innovation system, from an international comparative perspective. The fifth and final section concludes.

[2] See, for example, *Poverty Reduction and Growth: Virtuous and Vicious Circles*, World Bank, Washington, D.C., 2006.

Figure 1. Country contrasts: the cases of Chile and Sweden

Per capita growth (per cent per year), 1990-2002 (top) and percentage share of high-technology exports in the economy, 2001 (bottom)

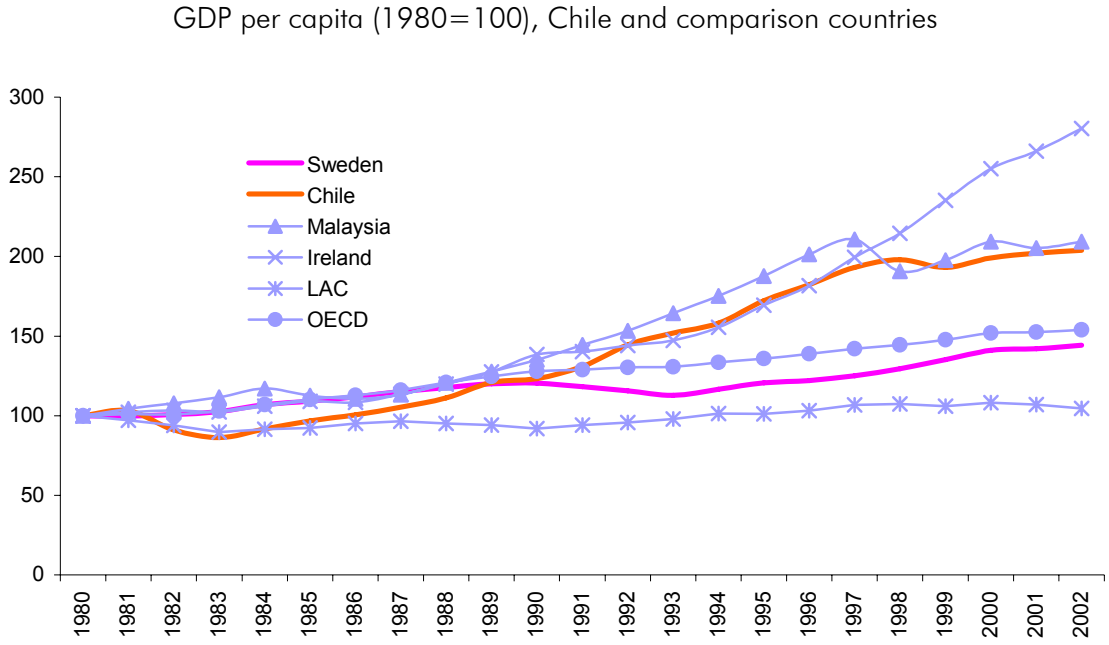


Source: World Development Indicators 2004

2 CHALLENGES FOR CHILE

7. **Chile is a regional economic leader** that has combined high and stable growth rates and far-reaching economic reforms with social stability and impressive reductions in poverty. In the 1990s, Chile's growth by far outperformed that of the Latin American region and of the OECD countries as a whole. Set against a group of comparison countries, Chile also approached the economic level of a fast-growing Southeast Asian economy like Malaysia (**Figure 2**). Chile's progressive social policy was also reflected in a wide range of social indicators such as higher school enrolment rates and reduced infant mortality.

Figure 2. In the 1990s, Chile's growth rates outpaced those of most comparison countries



Source: World Development Indicators, 2004

8. **But growth has levelled off since 1997 and unemployment has increased.** Towards the end of the 1990s, Chile's growth rate fell substantially and even turned negative in 1999, which in turn was mirrored in higher unemployment, rates (**Figures 3 and 4**). The economic downturn was linked to falling prices for copper in connection with the Asian crisis. As copper prices have picked up, the Chilean economy has regained strength – but unemployment remains higher than in the 1990s. Moreover, research suggests that growth no longer is driven primarily by total factor productivity – representing technological improvements and efficiency gains – as was the case in the 1980s and 1990s.

Figure 3. GDP growth is closely linked to copper prices

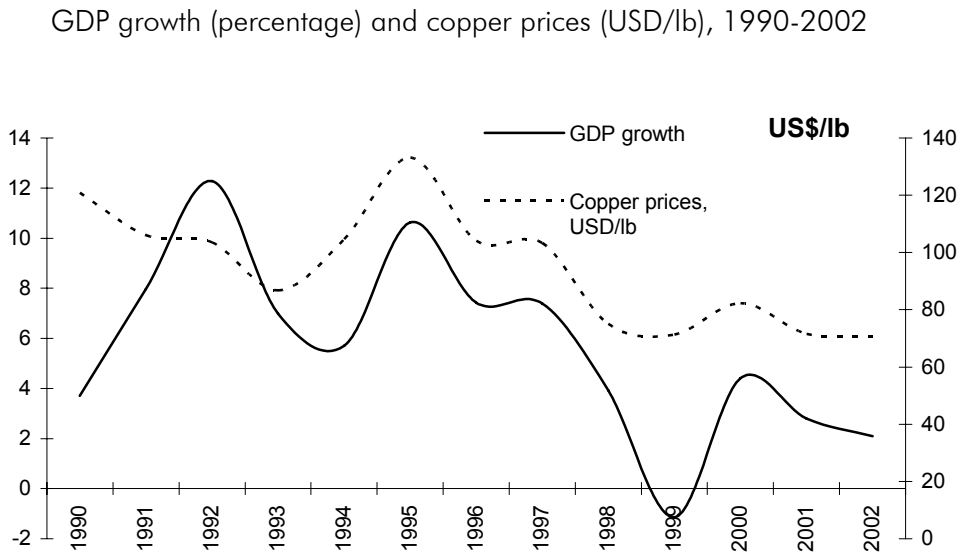


Figure 4. Unemployment has not fallen back in spite of the overall economic recovery

Source: Central Bank of Chile

9. **Natural-resource intensive sectors have continued to see the highest growth rates and still dominate exports.** Sectors intensive in natural resources – agriculture, fisheries and mining – have seen the highest growth rates over the past 8 years (**Figure 5**), in spite of the slump in copper prices at the end of the 1990s. Manufacturing growth, in contrast, has remained very limited and below countrywide growth. Moreover, Chile's exports structure has, if anything, become more concentrated on mining and agriculture since the mid-1990s. Together, the natural-resource intensive sectors continue to account for almost two thirds of Chile's exports value (**Figure 6**).

Figure 5. Growth rates in the agriculture and mining sectors were 2 and 3 times higher than in manufacturing…

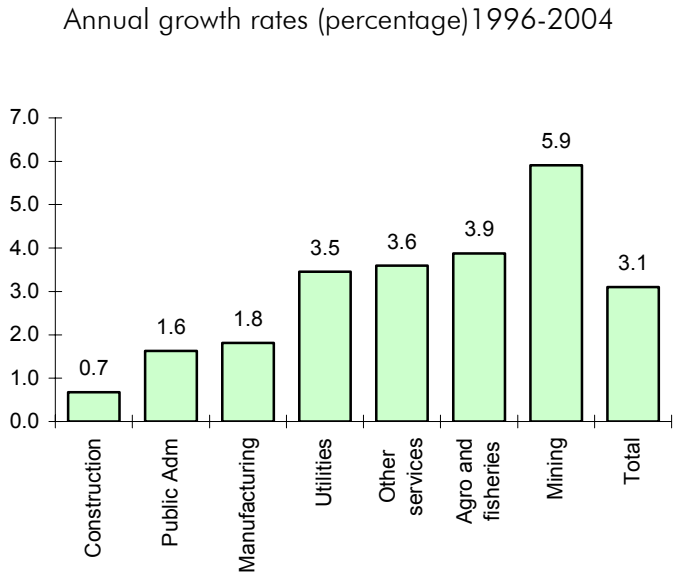
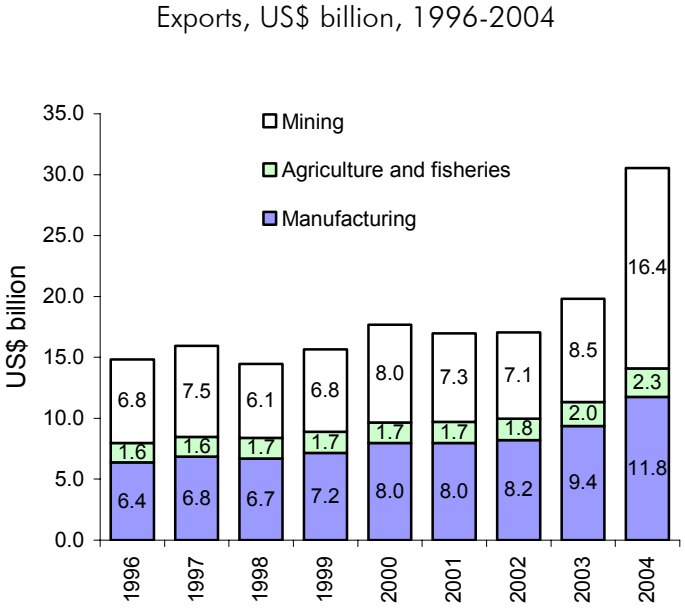


Figure 6. …and the export structure remains poorly diversified



Source: Central Bank of Chile

10. **Can sustained growth be achieved with the present economic structure?** The dependence on natural resources and the ensuing volatility in growth together with fading productivity gains, suggest that Chile needs to tap into new sources of growth in order to sustain convergence with OECD income levels. Diversification away from traditional sources of growth means that Chile needs to strengthen the ability of its citizens, institutions and enterprises to innovate. The rapid advancements taking place internationally in the mechanisms for developing, diffusing and exploiting new innovations opens up new possibilities. The extent to which countries and organizations are able to respond to them makes a tremendous difference for economic performance. Technology and innovation – not only technological, but also process and organizational innovation – together with the business climate in general, are widely held to be key factors in explaining variations in country development.[3] Measured against other economies, Chile's track record appears to be mixed. On the one hand, there has been some success in developing advanced technology clusters in traditional sectors, such as mining and fisheries. On the other hand, the lack of dynamics in the economic structure is in itself witness to the difficulties Chile so far has faced in developing a competitive edge in new sectors.[4]

[3] *The sources of economic growth in OECD countries*, OECD, Paris, 2003.
[4] *Economic Survey of Chile*, OECD, Paris, 2003.

3 HOW COMPETITIVE IS CHILE?

11. In spite of a favourable domestic economic environment, Chile's competitiveness is hampered by weaknesses in the technology and innovation system. While Chile remains highly competitive relative to countries at comparable income levels, there is some evidence that competitiveness is falling behind, at least relative to the country's potential.

12. **In international comparisons of competitiveness, Chile does well**: in the World Economic Forum's (WEF) ranking of growth competitiveness in 2004, Chile ranks 22nd, a score above all other lower or middle income countries except for Estonia, and above several high income countries including Spain, Portugal, France and Germany.[5] Chile also increased the already sizeable gap to other Latin American countries and improved its relative position since 2003 (when it ranked 28th, thus narrowing the distance to the three top competitiveness countries: Finland, the United States, and Sweden. This picture is consistent with the sustained high growth rates during the 1990s.

13. **High quality public institutions and a very favourable macroeconomic environment are the main reasons Chile ranks so well in this international comparison.** Appendix 1 provides an overview of Chile's rankings at a sub-indices level, based on the 2002/2003 Global Competitiveness report. Importantly, Chile's high aggregate competitiveness ranking masks important variations in terms of its different components. As can be seen, Chile ranks 13th out of 80 countries in terms of favourable macroeconomic environment, and 19th in terms of quality of public institutions. Both these rankings are remarkably high for a middle-income country, and certainly unique for the Latin American region. Indeed, according to these indices, Chile's public institutions are almost at a par with those of the most developed countries, and the macroeconomic environment is in fact judged to be far better. The quality of the institutional system is supported by other studies on governance, that place Chile's indicators relative to regulatory quality, rule of law, and government effectiveness far higher than upper middle income countries in general or the averages for Latin America (**Figure 7**). Finally, estimates suggest that Chile has the smallest shadow economy in LAC and in fact lower than many southern European countries, implying that the economic system is not distorted.[6]

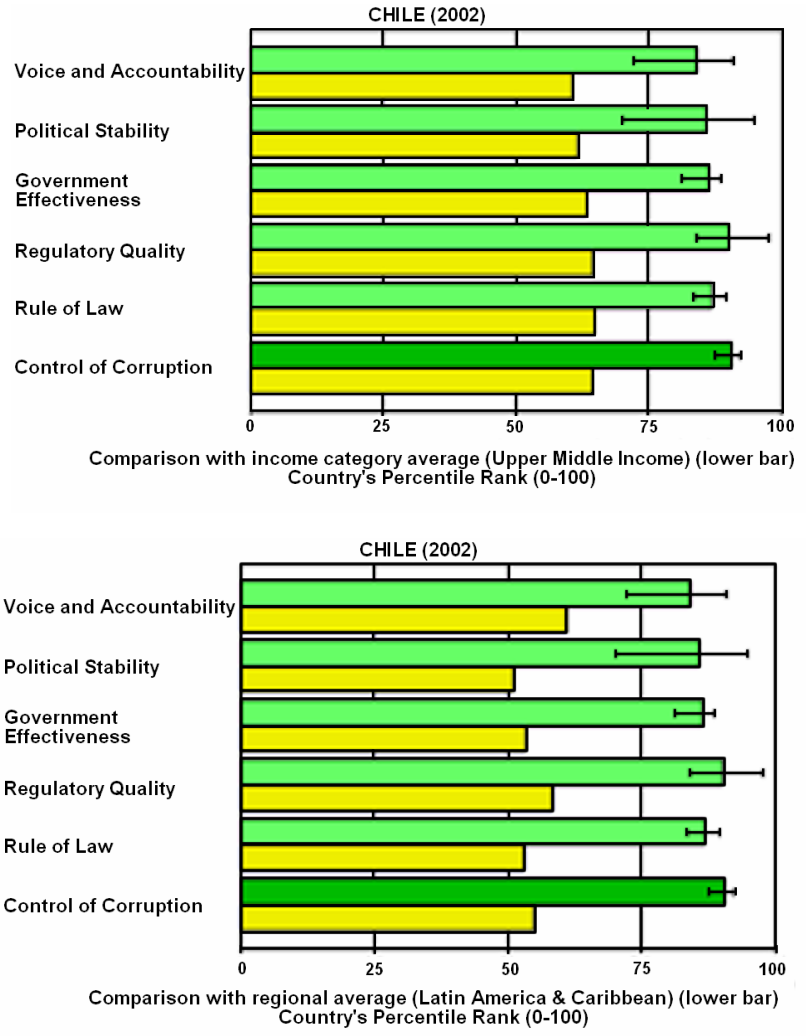
14. **However, a closer look suggests that the environment for technology development and the microeconomic business environment are much less favourable.** Chile's overall competitiveness level is adversely affected by lacklustre performance in the area of science, technology, innovation, and business environment. This constitutes one of the few policy areas where there is a substantial gap between Chile and more developed countries, and where Chile is at par with or even below other Latin American countries. Chile ranks only 33rd country in terms of ICT intensity and, importantly, as low as 37th in innovation outcomes and environment. Nor is Chile performing well in terms of technology transfer – Chile's capacity to absorb and make use of new technology from foreign firms (from imports and FDI) ranks only 24th out of 56 countries, below e.g. Malaysia, India, Thailand, Estonia and, importantly, Brazil and Argentina. Clearly, poor performance in the area of technology and innovation is pulling down Chile relative to its potential.

[5] The Global Competitiveness Report, published by the World Economic Forum, provides a comprehensive assessment of international competitiveness for individual countries. Countries are assessed on their growth competitiveness and microeconomic competitiveness. The growth competitiveness index, in turn, is based on performance regarding technology, macroeconomic environment, and the quality of public institutions.

[6] Schneider, "The Size of the Shadow Economies of 145 Countries all over the World: First Results over the Period 1999 to 2003", IZA DP No. 1431, Forschungsinstitut zur Zukunft der Arbeit, Austria, December 2004.

Figure 7. Chile has much better governance indicators than countries in the region or at the same income level

Governance indicators, compared to upper middle income countries (top) and LAC (bottom)

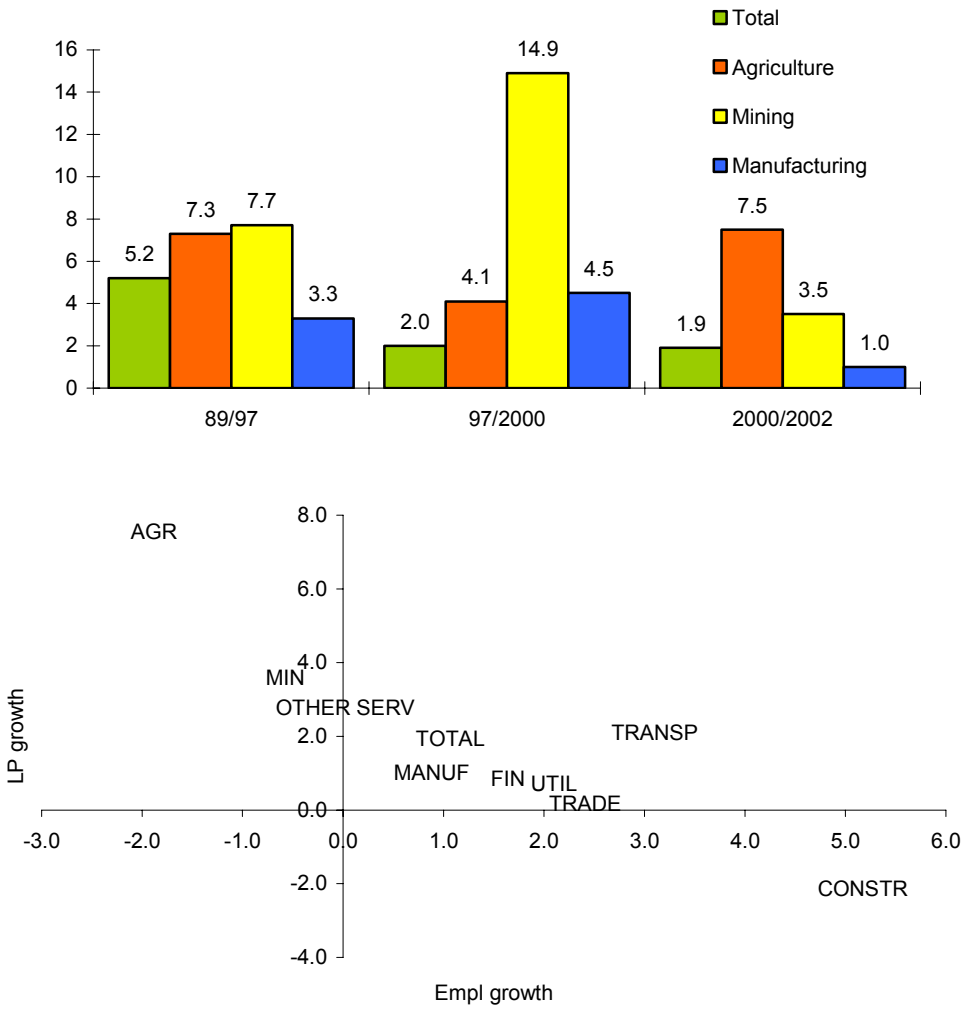


Source: World Bank governance indicators

15. **Productivity growth stalled in the 1990s.** The mediocre performance revealed in technology and innovation indicators is mirrored in a slowdown in productivity growth in the economy. There is evidence that total factor productivity growth fell in the 1990s compared to the 80s, and that growth instead was increasingly fuelled by growth in capital input.[7] There is also evidence that labour productivity growth slowed down after the mid-1990s, and its sectoral composition is cause for some concern. Labour productivity growth has been meagre in all but the natural resource-intensive sectors – mining and agriculture – which have also seen shedding of labour. In fact, in the period 2000-2002, there was a fairly clear negative relationship between labour productivity growth and employment growth at a sectoral level (**Figure 8**).

Figure 8. Labour productivity growth has generally been highest in natural resources intensive sectors, but these have not seen employment growth

LP growth: total, agriculture, mining, manufacturing, 1989-2002 (top), Labour productivity and employment growth by sector, 2000-2002 (bottom). Percentage per year



Source: *OECD Economic Survey of Chile,* 2003

[7] Beyer and Vergara, *Productivity and Economic Growth: the Case of Chile*, Centro de Estudios Publicos, 2001 and Roldos, "Potential output growth in emerging Market Countries: the Case of Chile", IMF Working paper WP/97/107/, 1997, as quoted in "*Chile New Economy Study"*, the World Bank, Washington, D.C., 2004.

16. **In sum**, Chile has very successfully managed its copper assets and other natural resources to sustain high growth rates while avoiding many of the typical pitfalls associated with natural resources management, including high macro instability and a bloated public sector. There has also been some success with increasing the technological content of traditional sectors, notably mining and agriculture. But the dependency on traditional sectors is clearly increasing economic volatility; the economic crisis in 1997-1998 proved how vulnerable Chile's economy is to swings in copper prices. Improvements in the innovation system will be vital to moving towards a more diversified economy, increasing productivity and sustaining income growth.

4 BENCHMARKING THE INNOVATION SYSTEM – WHAT EXPLAINS THE TECHNOLOGY AND INNOVATION LAG?

17. **Innovations are undertaken through interactions which are dependent on several kinds of players and institutions in society**, and also on how they relate to international knowledge flows. No single policy domain or piece of reform may be sufficient for bringing a radical improvement in innovative capacity. The innovation system comprises enterprises, universities, and government and the different links that bind them together: infrastructure, human capital, R&D and science and technology policies more broadly, as well as foreign investments, trade, technology and migration flows which provide fundamental links to "other" innovation systems. In what follows we assess a few of these aspects of Chile's innovation performance and framework conditions against a set of comparison countries in Latin America, OECD, and the EU, with a focus on European core innovator countries like Sweden, Finland and Ireland, and selected fast-growing developing economies. Key innovation indicators: R&D levels, publications, patents, and economic structure.

18. **Chile spends far less on research and development than benchmark countries.** National research and development intensity – expenditures on research and development relative to the size of the economy – is another characteristic of the strength of the innovation system. Chile presently invests only some 0.5 per cent of GDP in research and development activities, a small number compared to OECD countries and other middle-income countries. Korea and Brazil, as well as China, invest far more in research and development relative to their average income levels (**Figure 9**). While expenditures on R&D on average increased in OECD countries in the second half of the 1990s, they stagnated in Chile.

Figure 9. Chile has low R&D intensity1 relative to its income level

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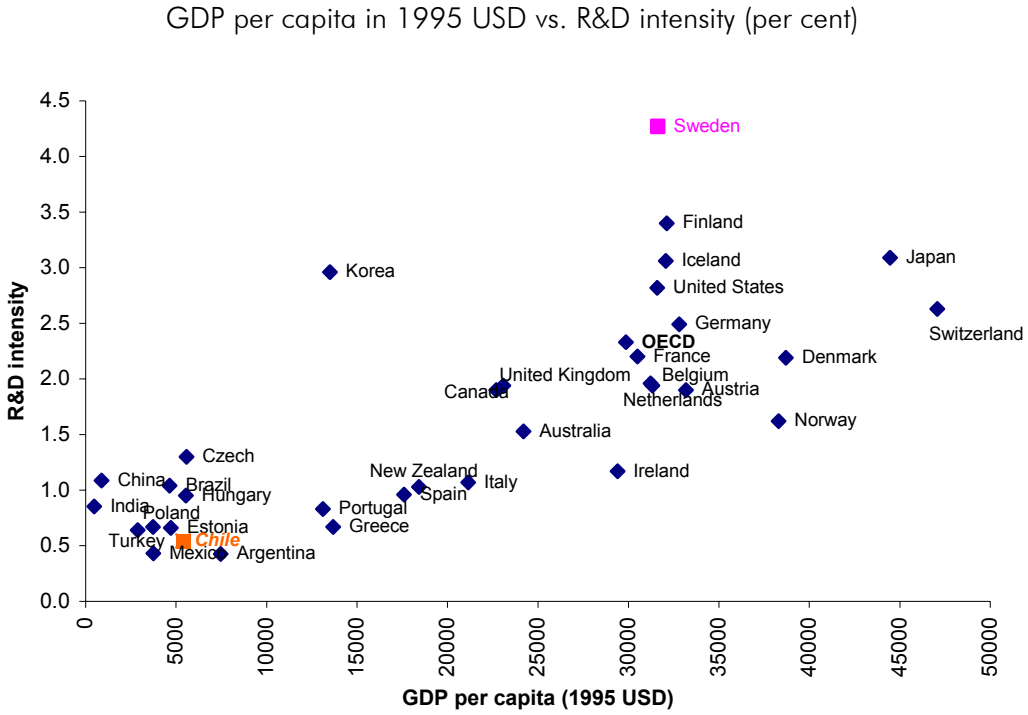
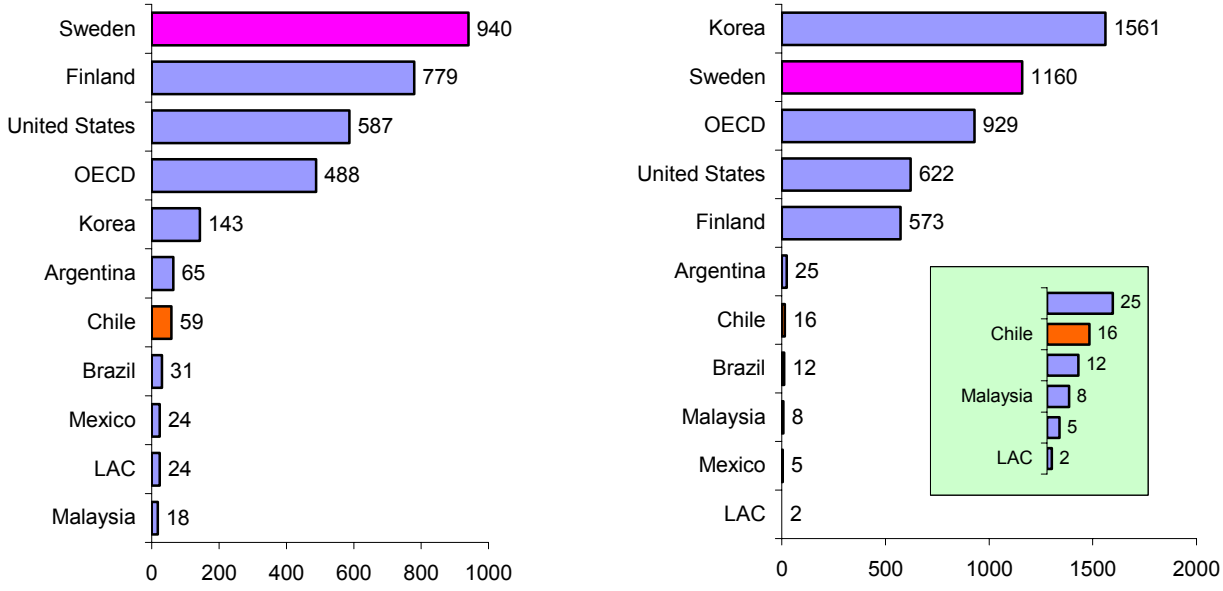


1. Research and development expenditures as percentage of GDP
Source: *OECD Science and Technology Scoreboard*, 2003

19. **Other conventional innovation indicators like scientific publications and registered patents suggest that Chile has low innovative capacity, relative to competitors and core innovator countries in the OECD.** Long term growth and productivity developments are perhaps ultimately the best indicators of innovative capacity. More direct conventional indicators of innovative capacity include scientific publications and registered patents. These data suggest that Chile is not remarkably productive in transforming research into either publications or patents for concrete innovations. In 1999, Chileans produced 59 scientific and technological publications per million people, certainly above China and India, but below Argentina, and much lower than any OECD country. Looking at national patent data, Chile is even less efficient in transforming R&D into patents – in 2000, there were 16 resident patent applications per million people in Chile, compared to over 900 for OECD countries on average (**Figure 10**).

Figure 10. Chile is lagging behind in conventional innovation indicators

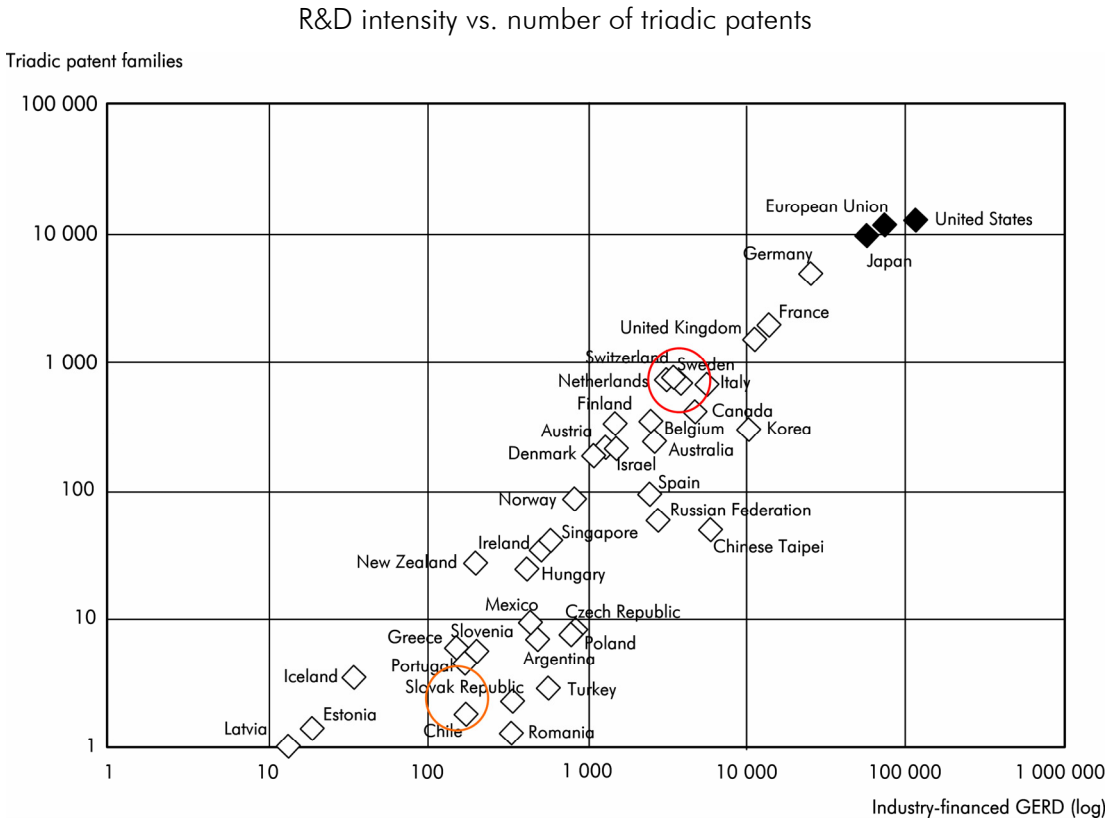
Number of scientific publications per million people, 1999 (left), and number of registered resident patents per million people, 2001 (right)



Source: World Development Indicators, 2004

20. National patent data may not necessarily represent competitive patents. Triadic patents – registered in Japan, the US, and the European Union – are a better indicator of internationally competitive patents. Chile appears to be underperforming also with respect to these patents, however. As may be seen, there is an extremely high correlation between R&D expenditures and the number of triadic patents, and Chile ranks low on both accounts (**Figure 11**).

Figure 11. Triadic patents are strongly correlated with R&D expenditures – Chile scores low on both accounts



1. Patents all applied for at the EPO, USPTO and JPO. 1999 and 2000 figures are estimates
2. Gross domestic expenditure on R&D (GERD) financed by industry, in millions of 1995 USD using purchasing power parities (average over the period 1990-1999)

Source: OECD (2004), Compendium of patent statistics

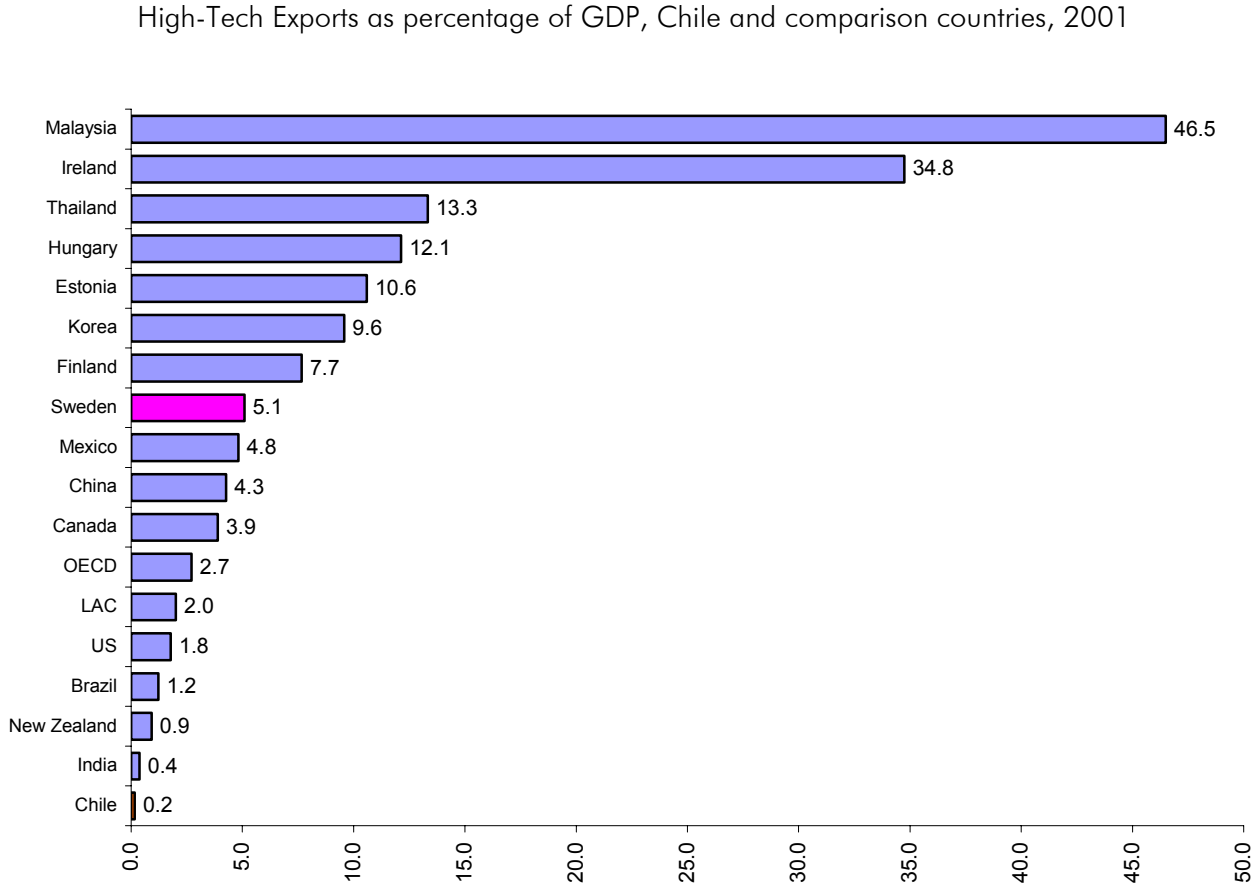
21. **Patents, however, may not be a particularly relevant indicator of innovative development in Chile.** First, many patents do not represent true innovation.[8] Conversely, many innovations are not patented because they are of an intangible sort, or because patents are not valuable. In many developing countries, insufficient protection of intellectual property rights makes it less meaningful to seek patents, because they cannot be enforced. Also, patents rarely capture soft innovations in management, organizational structures, etc., which may be at least as important as technical innovations in raising productivity.

22. **Chile has a remarkably low share of internationally competitive high-technology industries.** Given the weaknesses of patent data, a better indicator of technology innovation may be

[8] Many patents represent strategic protection against unwanted competition, they may not represent any economic value, etc. (Griliches, 1990; Desrocher, 2001).

the role of high-technology industries in Chile. An important share of high-technology exports in the economy would suggest high international standing in technological innovation. High-technology exports make up an insignificant share of total output in Chile, however. Against this benchmark, the Chilean economy is far behind its Latin American competitors and at an overwhelming distance from many fast-growing developing countries (**Figure 12**). It is interesting to note that a country such as Sweden takes an intermediate place in this comparison, above OECD country average, but below many other small open economies. A closer look at Chile's revealed comparative advantages (RCA) also confirms the high concentration of international competitiveness in raw-material based exports: mining and agriculture.[9]

Figure 12. Chile shows remarkably low international competitiveness in high-tech exports



Source: World Development Indicators, 2004

4.1 Innovation system – benchmarking key areas

23. This section looks at a few important aspects of the innovation system that lend themselves to international comparison. The level of qualification of human capital, the organizational technological and non-technological knowledge determine the absorptive capacity of the system of innovation and its ability both to generate new innovation and to absorb innovations generated elsewhere. Chile faces challenges in both areas.

[9] *Economic Survey of Chile*, OECD, Paris, 2003.

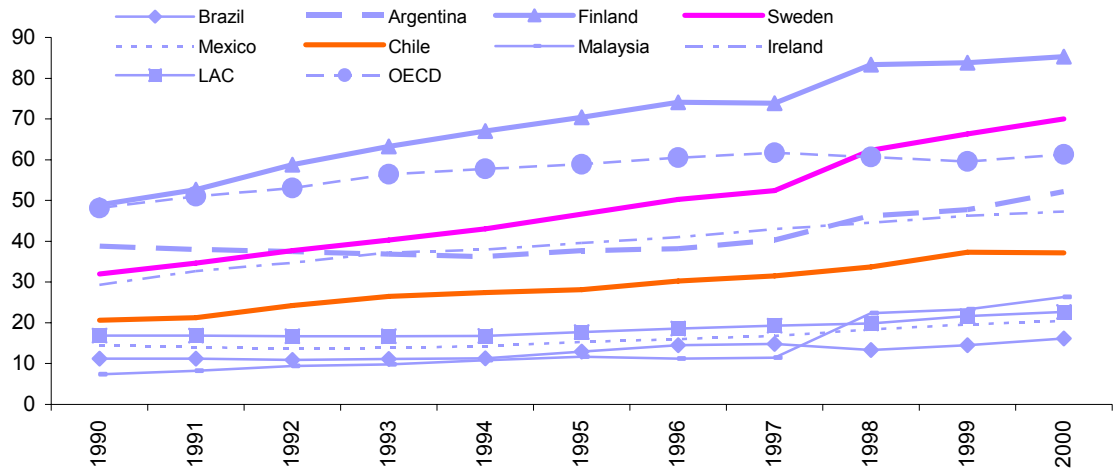
4.2 Human Capital for innovation

24. **The education system delivers researchers and engineers for research and development activities**; universities produce research which can feed into the innovation system. Governments, academic institutions and enterprises spend resources on research and development. The use of information and communications technology speeds up the flow of information between different actors, nationally or internationally. And foreign firms, finally, can provide impetus to the national/local innovation system.

25. While we do not address the crucial aspect of quality here, quantitative indicators suggest that **Chile's education system does not provide sufficient levels of highly educated people**. From the perspective of basic schooling achievements, Chile is doing fairly well, but weaknesses become more evident at higher levels of education. Literacy rates are near universal, at least among the young. Tertiary school enrolment rates have also increased significantly, almost doubling over the past two decades. Yet, from an international perspective, the inflow of university graduates from abroad is limited.[10] With gross tertiary enrolment rates at 37 per cent (in 2000), Chile outperforms Mexico and Brazil, but remains below Argentina and far below the OECD average at 62 per cent. Moreover, trends are not encouraging as Chile has seen a slower increase in enrolment rates than many industrialized countries (**Figure 13**).

Figure 13. Tertiary enrolment rates almost doubled in the 1990s but Chile is still left behind many important competitors or core innovator countries

Tertiary gross enrolment rates (percentage of age group), Chile and comparison countries, 1990-2000



Source: World Development Indicators (2004)

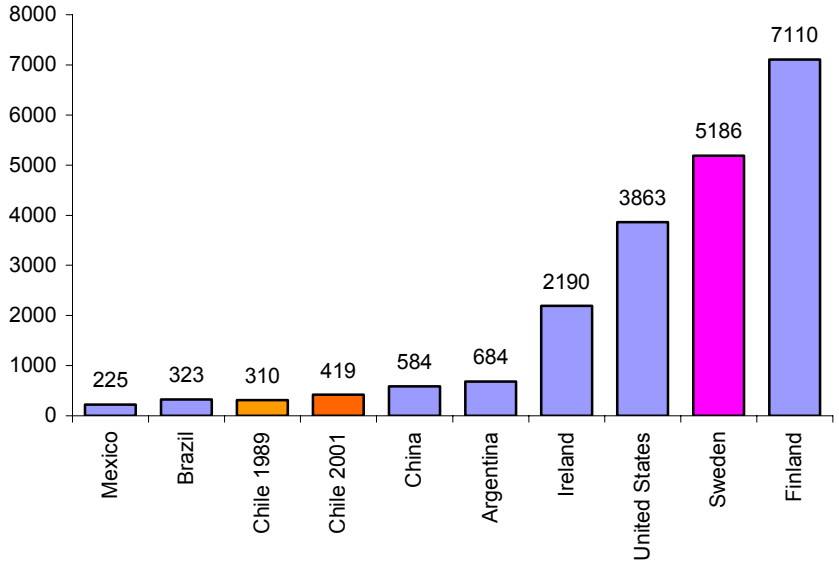
26. **The share of researchers employed in research and development activities is still fairly low**. Does the education system produce researchers for the market? Although the number of researchers involved in R&D increased by one third in the 1990s, by 2001 Chile had only some 400 such researchers per million people. This ratio falls short of the over 500 researchers in China, some 5,000 in Sweden, and over 7,000 in Finland (**Figure 14**). Of course, this pattern may not only be a

[10] Note that international comparisons of education data are fraught with difficulties due to different definitions.

matter of lack of supply (qualified personnel) but also of lack of demand (opportunities for research and development activities).

Figure 14. Chile also has comparatively few researchers involved in research and development activities

Number of researchers in R&D (per million people) - Chile and comparison countries



1. Refers to people trained to work in any field of science who are engaged in professional R&D activity. Most such jobs require completion of tertiary education

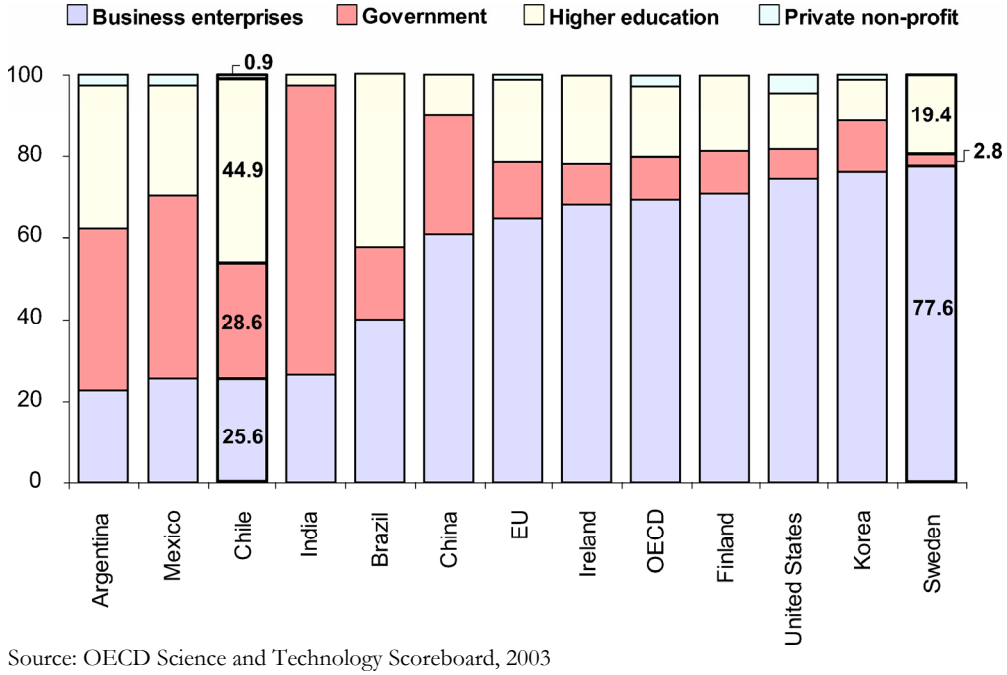
Source: World Development Indicators

4.3 R&D performance and innovation expenditures

27. **Universities are the main performers of research and development, suggesting weak links between firms and academia.** An even more striking feature of the innovation system is the low share of R&D that is taking place in the business sector. Instead, the share of R&D performed by the higher education sector in Chile is among the highest among comparison countries, and the government's share is also fairly high (**Figure 15**). Yet, as seen earlier, the concentration of R&D in academia does not result in a proportionally high share of scientific publications or other forms of innovation indicators. This contrast suggests that there is a problem of linkages between universities and the private sector, and perhaps also of quality, or at least applicability, of the research undertaken. The most technologically-advanced mid-size developed industrialised countries, such as Finland, the Netherlands, Sweden, and Switzerland stand in stark contrast to Chile in this respect. Over three quarters of R&D is performed by the business sector in such countries, with most of these expenditures undertaken by large, highly internationalised firms.

Figure 15. A small share of R&D is taking place in the private sector

R&D expenditures by performing sector, as percentage share of total, Chile and comparison countries



Source: OECD Science and Technology Scoreboard, 2003

28. **The public sector is still the single largest source of funding for research and development.** In the 1970s, the public sector accounted for virtually all spending on R&D. Over time, this dominance has been reduced significantly. By 2002, the public sector accounted for just over half of all R&D spending (53 per cent), with the remainder undertaken by private domestic and foreign firms (35 and 11 per cent respectively).[11] The public-private mix is still opposite to what is typically observed in OECD countries, however: in the US, Japan and the European Union, the government accounts for 27, 18 and 34 per cent, respectively.[12] Moreover, in spite of the importance of public funding, public sector support is not reaching the business sector. According to Chile's innovation survey, only 0.3 per cent of business innovation expenditures are funded by the government, suggesting that the public sector *de facto* does not subsidize innovative activity in firms.

29. **Other indicators suggest that innovation *is* taking place at the firm level.** Like patents, R&D intensity may be of limited relevance as an indicator in the Chilean setting. Formal R&D expenditures are concentrated in large firms: only 26 firms, all with more than 500 workers, account for 60 per cent of all R&D expenditures in the manufacturing sector.[13] A vast majority (90 per cent) of the Chilean work force is employed in small- and medium-sized enterprises, however. These innovate, but not in the same formal way as larger firms do, and so are not likely to show up in R&D expenditures. Moreover, the services sector is not included in Chile's reported R&D expenditures, which makes international comparisons difficult. This points to the need for information on non-technological innovation – organizational changes, linkages with other firms, etc. – which is perhaps a particularly strong feature of the services and small firms sectors. In fact, the innovation survey suggests that non-

[11] *Indicadores de C y T año 2004*, CONICYT, 2004. Provisional numbers for 2002.
[12] *OECD Science and Technology Scoreboard*, 2003.
[13] *Gastos en Investigación y Desarrollo Privado en Chile: Resultados de la Encuesta Nacional del año 2002*, Centro de Microdatos, Departamento de Economía, Universidad de Chile.

technological innovations might be of particular importance in Chile. Despite the low nationwide investment in R&D, 42.7 per cent of the manufacturing firms reported to have introduced product innovations in the market in 2001, while 40.1 per cent had introduced process innovations. Innovation takes place in the form of incremental innovations, that is, small gradual changes less likely to be the result of heavy investments in R&D. In this sense, both R&D investments and patent statistics might be of limited use to explain how innovation takes place in certain sectors (for example services) or specific firms (example SMEs).

30. **Evidence suggests weak links between research expenditure and innovation, and between innovation and productivity in Chile.** On the basis of innovation survey data, research expenditures have been shown not to be related to innovation sales, nor is innovation related to productivity as measured by value added per worker for Chilean firms.[14] Additionally, in the innovation survey, only 5 per cent of the firms report that more than 70 per cent of sales are due to new products. This could indicate lacking demand for innovative products that deserves further attention.

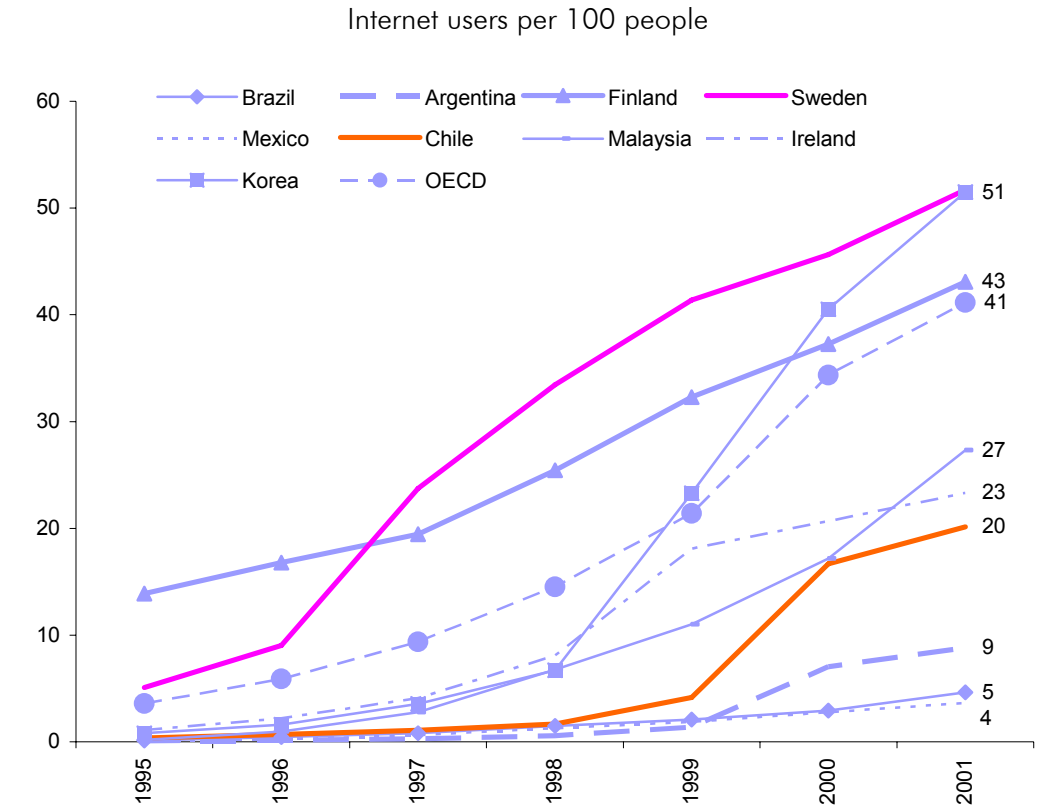
4.4 Linkages in the system of innovation

31. **The performance of a system of innovation is shaped by the strength of the linkages between the different actors in the system**. Those linkages support the exchange of both tacit and explicit knowledge required for innovation. They include the mobility of human resources, ICT infrastructure, collaboration in innovation activities, etc. They provide the linkages with other countries in the form of foreign investment and the technological balance of payments. A first look at those linkages in the Chilean innovation system points to both strengths and weaknesses.

32. **The use of information and communications technology in Chile is advanced by Latin American and OECD standards.** Available indicators show that in the area of ICT intensity, Chile is ahead in Latin America. Chile is spending relatively more on information and communications technology (as per cent of GDP) than other Latin American countries, and is at par or ahead of several comparison countries, including the US, Malaysia, Finland and Korea.[15] Moreover, internet use – an indicator of national and global connectedness and linkages – has expanded rapidly since the mid 1990s, though it remains below that of OECD countries (**Figure 16**).

[14] Benavente, José Miguel, *Análisis de la tercera encuesta sobre innovación tecnológica*. www.innovacion.cl, 2004.
[15] World Development Indicators, 2004.

Figure 16. Internet use has expanded rapidly since the mid 1990s, although it remains well below OECD averages



Source: World Development Indicators, 2004

33. As suggested by innovation indicators, **the linkages between business and research institutions are weak**. In surveys undertaken by the World Bank, less than one third of the firms acknowledge having benefited from innovations from universities, and only 16 per cent from public research institutes. Only 1 out of 4 firms signed a contract with a university and 14 per cent with a public research institute.[16] The weaknesses of the linkages and knowledge flows between institutions in the system of innovation seem to be a shared feature in Latin American countries.[17]

34. **Chile is relatively successful in attracting foreign direct investment, though most prominently to traditional sectors**. Foreign direct investment provides an important potential source of knowledge transfer and is increasingly a driver of international globalization. Partly depending on its sector composition, foreign direct investment can therefore provide important input to country competitiveness. Chile ranks the sixth largest recipient of FDI in Latin American, a fairly impressive result in view of the smaller size of its economy relative to e.g. Mexico and Brazil.[18] The country also ranks as frontrunner in the UNCTAD FDI index, suggesting that high FDI inflows correctly reflect its attractiveness to foreign investors – through economy size and openness, low country risk and more

[16] World Bank, *Closing the Knowledge Gap in Education and Technology*, 2002.
[17] Inter-American Development Bank, *Economic and Social Progress in Latin America*. Report 2001. Chapter 16.
[18] UNCTAD, *World Investment Report 2003*; http://www.unctad.org/fdistatistics.

generally a favourable investment climate.[19] Inward FDI peaked in 1999 and has since fallen, however, following the trend of Latin America's larger economies. The sector composition of foreign direct investment has also changed somewhat over time. In 2000-2004, regulatory reform meant that the utilities and communications sectors received half of all FDI inflows in Chile, which marked an important difference to previous years as FDI to mining and agriculture (with agriculture accounting for a minimal share) was significantly reduced. Yet, mining still accounts for nearly one quarter of all inward foreign direct investment in Chile, and FDI to the manufacturing sector has actually fallen substantially (**Figure 17**).

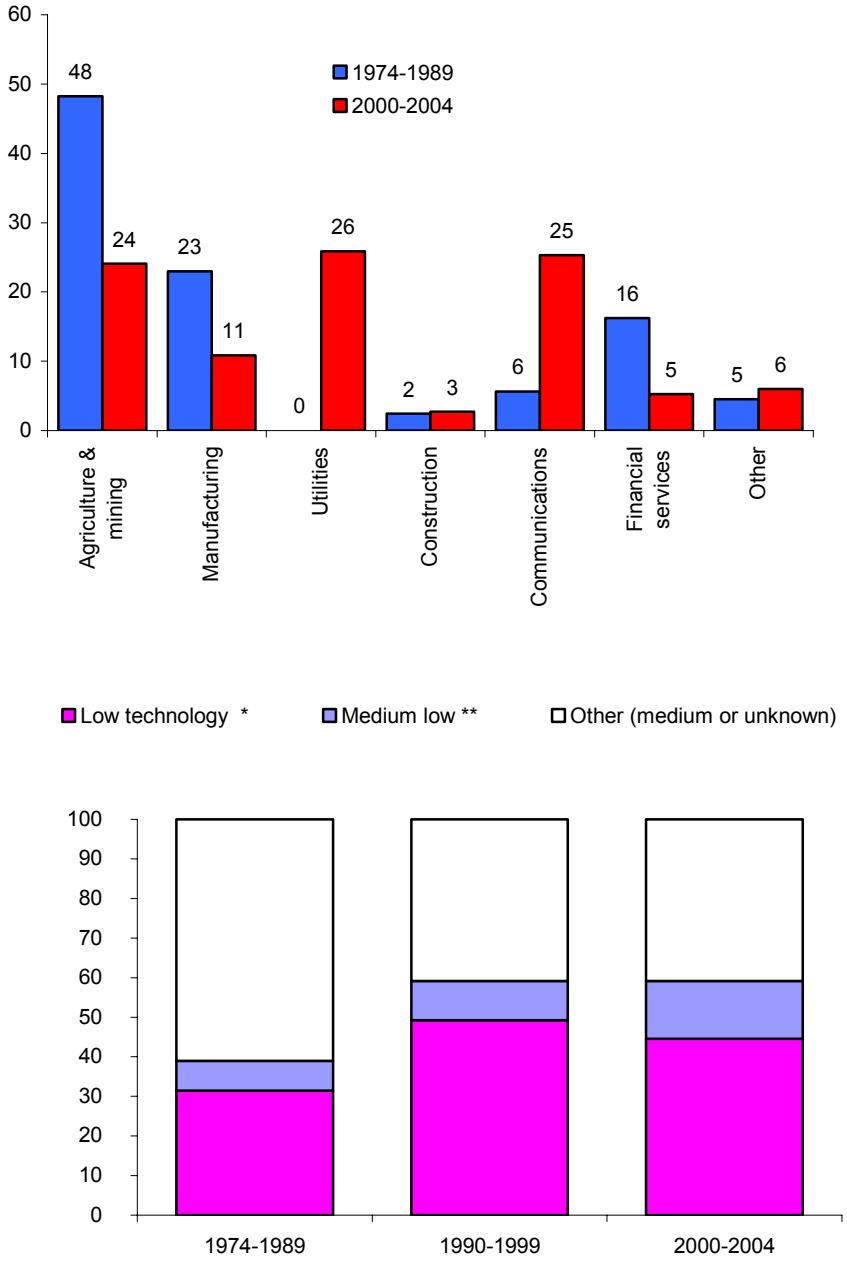
35. **There appears to be scope for improving the interface between foreign and domestic firms.** Within manufacturing, foreign direct investment in manufacturing is concentrated in low-technology sectors, with perhaps smaller potential for technology transfer, and this tendency has increased over time (**Figure 17**). As mentioned earlier, Chile scores only moderately high in terms of technology transfer according to the Global Competitiveness Report. Some evidence of FDI in the manufacturing sector does suggest that foreign-owned firms show higher levels of productivity and growth as compared to domestic. Results are more mixed regarding the indirect impacts, i.e. spillovers to the rest of the economy. Although there are productivity spillovers, the growth rate appears to be unaffected.[20]

[19] *Ibid.* The UNCTAD FDI index measures performance (actual FDI inflows) and potential (aspects of the host economy which are considered important in attracting FDI) for 140 countries. Chile is among the 45 countries which score high on both performance and potential and are considered FDI front runners.

[20] Alvarez, *Inversion Extranjera Directa en Chile y su Impacto Sobre la Productividad*, Departamento de Economía, Universidad de Chile, 2002.

Figure 17. A quarter of FDI in Chile is still directed to the mining sector, while manufacturing sector FDI has declined, and is increasingly concentrated in low-technology sectors

FDI by recipient sector, 1974-1989, and 2000-2004, percentage of total (top), and technology classification of inward FDI in the manufacturing sector, 1974-2004 (bottom), percentage of total FDI



Source: Chile Foreign Investment Committee, http://www.foreigninvestment.cl/. Classified according to *OECD Science and Technology Scoreboard*, 2003

5 CONCLUSIONS AND ISSUES

36. While Chile displays an impressive track record, compared to both industrialized and developing countries, important questions stand out as to whether its stellar performance can be sustained. The economy has combined a far-reaching economic reform agenda with steady and high income growth, and has proved fairly resilient to external shocks, especially by Latin American standards. Yet, there are concerns that in order to sustain growth, the Chilean economy is facing significant challenges in improving its international competitiveness. This will require, among other things, moving away from an economic structure based on traditional and/or low-technology sectors towards a more dynamic and diversified one.

37. The capacity to innovate makes up one of the most important pillars for such an economy. However, as this paper has shown, there is evidence that **Chile's national innovation system has some weaknesses in the light of international comparison.** Most innovation indicators point to a lacklustre performance. Education levels are still below those of more developed economies, and the private sector takes a very limited part in research and development performance and funding. The linkages between the private sector, academia and government appear weak. Chile's cluster policies have generated some impressive results in terms of fostering innovation and also developing new product areas, but the effects remain, almost by definition, limited to a few sectors. Foreign direct investment, like exports, remains concentrated in traditional sectors. While small- and medium-sized enterprises account for the bulk of productivity and job growth in Chile, value-added remains low in most of these activities.

38. **Many of the foundations for a strong innovation system are in place in Chile.** Chile's solid macroeconomic performance and its high-quality public institutions will be critical for a move towards a more dynamic economy. Chile's economic structure, with a strong presence of small firms, should also be seen as an important advantage. Small firms are potentially more flexible and capable of introducing innovations if the adequate framework conditions are in place – including among other things economic and political stability, government support, and networks with other firms and universities.

39. **A key feature of the innovation system is the policy context and how that shapes the circumstances for innovation.** Policy (in this context) does not only extend to government action, but crucially embraces the interface between different key societal actors, including in the private sector, in the regions, and in various kinds of institutions. Innovative performance will much depend on how the different entities in the system relate to one another, and also how the domestic set-up relates to the wider context of expanding global knowledge flows.

40. **Moving forward requires examining the innovation system in greater depth, while making comparisons with relevant countries and drawing lessons from best practice examples in various places**. Basic indicators of innovation, like those presented in this paper, display only limited aspects of the innovation system. There is a need to analyze the Chilean innovation system in more detail. An important step will be to develop a wider set of indicators, some specifically adapted to Chile, which can provide a more systematic and detailed analysis of inputs and linkages of the innovation system. Outstanding questions relate the dynamics of firms, regional innovation dynamics, the use of innovation within firms, and indicators which provide a better understanding of the strength and direction of linkages in the innovation system. It may be important to tailor such indicators to the

Chilean context, by e.g. focusing on how to measure "software" – social capital, networks etc. – rather than "hardware", such as ICT or R&D expenditures.[21]

41. **This paper has focused on certain areas that raise important policy issues for Chile.** It is suggested that a high priority should be put on addressing the following:

- The policy mix needed to help motivate a greater and more productive R&D effort in Chilean industry.

- The role of policymakers, industry and other key stakeholders in fostering a more dynamic interface so that more productive human networks can be created; ways to ensure that scientists, venture capitalists, established business and entrepreneurs interact to promote upgrading of value-added in industry and the creation of more dynamic new enterprises.

- Policies needed to achieve more effective competence-upgrading and innovation in small firms to achieve a more broad-based and geographically diverse growth performance.

- The role and respective advantages of cluster policies versus broader framework conditions.

[21] IKED has initiated work in this area, looking in detail on the linkages of the innovation system in Chile.

APPENDIX 1

GROWTH COMPETITIVENESS AND MICROECONOMIC COMPETITIVENESS, CHILE AND SELECTED COMPARISON COUNTRIES. GLOBAL COMPETITIVENESS REPORT 2002-2003 RANKING IN BRACKETS

GROWTH COMPETITIVENESS: **Macroeconomic environment, public institutions, technology.**	A. Macroeconomic Environment: Stability, credit rating	B. Public Institutions: Corruption, legal system	C. Technology: C.1. ICT	C. Technology: C.2. Innovation	C. Technology: C.3. Technology Transfer *	**MICROECONOMIC COMPETITIVENESS:** **Company operations and strategy, business environment**
United States (1)	United States (2)	Finland (1)	Finland (3)	United States (1)		United States (1)
Finland (2)	Norway (7)	New Zealand (4)	United States (4)	Finland (3)		Finland (2)
Sweden (5)	China (8)	Canada (9)	Sweden (7)	Sweden (4)		Sweden (6)
Canada (8)	Ireland (9)	Norway (12)	Norway (8)	Canada (8)		Canada (10)
Norway (9)	S. Korea (10)	Sweden (15)	Canada (11)	S. Korea (11)		Ireland (20)
New Zealand (16)	Thailand (11)	United States (16)	S. Korea (19)	Norway (12)		Norway (21)
CHILE (20)	Canada (12)	Ireland (18)	New Zealand (21)	New Zealand (19)		New Zealand (22)
Estonia (26)	**CHILE (13)**	**CHILE (19)**	Ireland (22)	Ireland (22)		S. Korea (23)
S. Korea (21)	Finland (14)	Estonia (28)	Estonia (23)	Estonia (28)	Malaysia (1)	Malaysia (26)
Ireland (24)	New Zealand (17)	S. Korea (32)	Malaysia (32)	Argentina (30)	India (2)	Estonia (30)
Malaysia (27)	India (18)	Malaysia (33)	**CHILE (33)**	**CHILE (37)**	Brazil (3)	**CHILE (31)**
Thailand (31)	Malaysia (20)	China (38)	Brazil (41)	Thailand (40)	Thailand (5)	Brazil (33)
China (33)	Mexico (21)	Thailand (39)	Mexico (46)	Malaysia (52)	Estonia (11)	Thailand (35)
Mexico (45)	Sweden (34)	Brazil (45)	Argentina (47)	Brazil (53)	Argentina (20)	India (37)
Brazil (46)	Estonia (46)	Mexico (58)	Thailand (52)	Mexico (56)	**CHILE (24)**	China (38)
India (48)	Argentina (65)	India (59)	China (62)	China (61)	Mexico (27)	Mexico (55)
Argentina (63)	Brazil (67)	Argentina (66)	India (69)	India (62)	China (29)	Argentina (65)

Note: Only comparison countries are included in the table. In total, 80 countries are ranked. *Refers to ranking of 56 low- and middle-income countries which are considered non-core innovators. As such, they can still benefit from technology transfer from core innovators