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Missed Opportunities: Innovation and Resource-Based Growth in Latin America

The twentieth century offered opportunities for rapid resource-based growth that Latin America systematically missed. Even if it were clear that resource-abundant countries have, on average, experienced relatively slow growth, the more interesting question is why some—Australia, Canada, and the nations of Scandinavia, for example—developed successfully while others did not.[1] This paper argues that the causes of Latin America's underperformance and acute sense of dependency can be found in barriers, with deep historical roots, to technological adoption and innovation. The most important was and remains deficient

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1. An emerging literature argues that resource abundance is associated with slower growth, on average (see, for example, Sachs and Warner, 2001). This paper does not attempt to resolve this debate, but a couple of cautionary points are worth making. First, the time period for which the data permit reasonable analysis covers twenty-five years at the end of the twentieth century. This is probably not a representative period since it includes the debt crisis (see Manzano and Rigobon, 2001) and structural reforms, and as suggested by the regressions here, it probably cannot be extrapolated to earlier eras. Second, the finding may not be robust to using different measures of resource abundance, including the Leamer measure used here. Third, it is important to know whether underperformance is intrinsic to natural-resource-based sectors or a nonessential correlate, such as destructive political economy issues (see Auty, 2001). See also footnote 8.

national "learning capacity," exacerbated in the postwar period by the perverse incentives of inward-looking development policies.

Concerns that resource-based sectors intrinsically lack dynamism have probably been exaggerated.[2] Even in Prebisch's era, future Nobel Prize winner Douglass North argued that "the contention that regions must industrialize in order to continue to grow . . . [is] based on some fundamental misconceptions," while the pioneer trade economist Jacob Viner held that "there are no inherent advantages of manufacturing over agriculture."[3] Viner's claim is supported by estimates that total factor productivity (TFP) growth, which explains roughly half of the differences in the growth of per capita gross domestic product (GDP), was roughly twice as high in agriculture as in manufacturing globally from 1967 to 1992.[4] Blomström and Kokko argue that forestry will remain a dynamic sector in Sweden and Finland, where rapid productivity growth ensures competitiveness relative to emerging low-wage producers.[5] Wright draws on the early experiences of the United States and Australia to demonstrate that the stock of minerals is, to an important degree, endogenous, and major increases in productivity can be realized in discovery and exploitation.[6] More generally, the literature clearly indicates that these development successes based their growth on natural resources, and by Leamer's measure of resource abundance, several still do (see figure 1).[7]

Latin America seemed unable to follow their lead. As a crude summary, regressing Maddison's well-known growth data from 1820–1989 (table 1) on Leamer's measure of resource abundance suggests that resources had a positive growth impact from 1820–1950, but that Latin America's especially poor performance in the postwar period is responsible for the appar-

2. See, of course, Prebisch (1959), but also more recently Matsuyama (1991); Sachs and Warner (2001); Rodríguez and Rodrik (1999).

3. North (1955, p. 252); Viner (1952, p. 72).

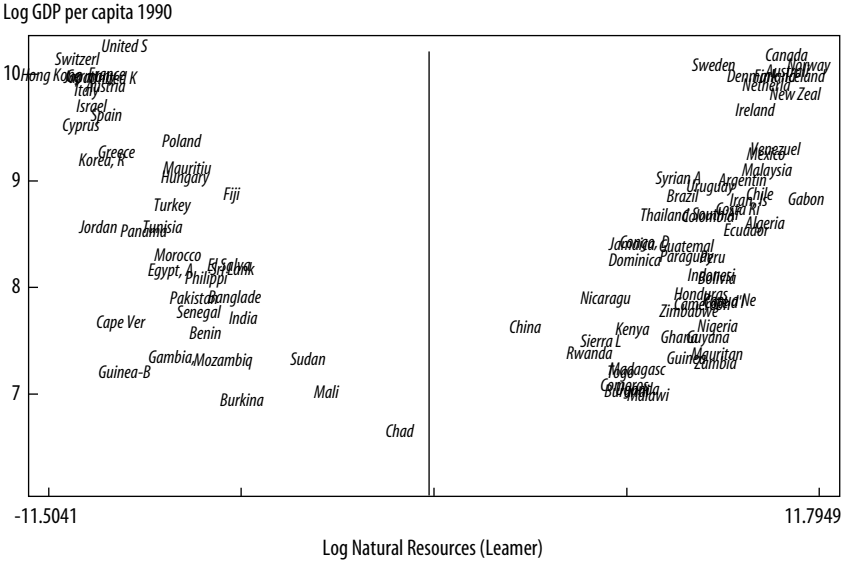
4. On the role of TFP in per capita GDP growth, see Parente and Prescott (2000); Dollar and Wolff (1997); Klenow and Rodríguez-Clare (1996). For estimates of TFP, see Martin and Mitra (2001), as well as Bernard and Jones (1996); Martin and Warr (1993).

5. Blomström and Kokko (2001).

6. Wright (2001).

7. See Irwin (2000) for the United States; Innis (1933) and Watkins (1963) for Canada; Wright (2001) and Czelusta (2001) for Australia; Blomström and Kokko (2001) and Blomström and Meller (1991a) for Scandinavia. Latin America also offers its success stories: Monterrey in Mexico, Medellín in Colombia, and São Paolo in Brazil all grew to become dynamic industrial centers based on mining and, in the latter two cases, coffee.

FIGURE 1.



Source: Author's calculations.

ent resource curse afflicting that era.[8] This underperformance is illustrated more starkly by several examples at the microeconomic level. Despite being far from the innovation frontier, and thus having the potential to play catch-up, the growth of total factor productivity in Latin America in both agriculture and manufacturing perversely lags that of the countries at the technological frontier (see figure 2).[9] The 1944 Haig technical assistance mission to Chile revealed the "indisputable truth that an adequate management of our forests could become the basis for a great industry of forest products," yet nothing remotely similar to the dynamic Scandinavian

8. The data are from Maddison (1994). Leamer's measure of resource abundance, net exports per worker, is broadly supported by the Heckscher-Ohlin framework (Leamer 1984). The expanded temporal scope comes at a high cost in terms of available control variables used in other studies, and the regressions must therefore be treated as suggestive only. Furthermore, both the lack of any temporal variation in our natural resource and the knowledge variables proscribe any meaningful panel treatment of the data. This implies that more sophisticated approaches, such as that suggested by Arellano and Bond (1991), that would address important issues of unobserved heterogeneity correlated with regressors, or the endogeneity of both the initial income and investment variables, cannot be employed. See Lederman and Maloney (2002) for a partial review.

9. Martin and Mitra (2001).

TABLE 1. Growth Correlates: Maddison Data, 1820–1989[a]

	Period					
	1820–1989		*1820–1950*		*1950–1989*	
Growth summary regressions	*(a)*	*(b)*	*(a)*	*(b)*	*(a)*	*(b)*
Convergence measure[b]	–0.265**	–0.265**	–0.51**	–.52**	–0.19**	–0.206**
	–(2.25)	–(2.26)	–(5.31)	–(5.44)	–(1.05)	–(1.15)
Net primary exports per worker	–0.076	–0.048	0.107*	0.090	–0.34*	–0.270
	–(0.75)	–(0.46)	(1.89)	(1.56)	–(1.64)	–(1.30)
Latin America		–0.38		0.23		–0.86*
		–(1.29)		(1.30)		–(1.64)
1870–1913	0.612	0.618	0.721**	0.722		
	(1.54)	(1.56)	(4.16)	(4.19)		
1913–1950	0.406	0.434	0.528**	0.517		
	(1.09)	(1.16)	(3.22)	(3.16)		
1950–1973	2.64**	2.66**			1.43**	1.43**
	(7.00)	(7.07)			(3.72)	(3.78)
1973–1989	1.19**	1.21**				
	(3.22)	(3.28)				
Constant	0.82**	0.857**	0.935**	0.92**	1.96**	2.11**
	(2.69)	(2.80)	(6.73)	(6.63)	(5.25)	(5.55)
Summary statistic						
No. observations	147	147	73	73	74	74
R^2	0.35	0.36	0.38	0.40	0.19	0.22

Source: Author's calculations, based on Maddison (1994) and World Bank, *World Development Indicators*.

* significant at 10 percent.

** significant at 5 percent.

a. Dependent variable is the average annual growth rate; t student values are in parentheses.

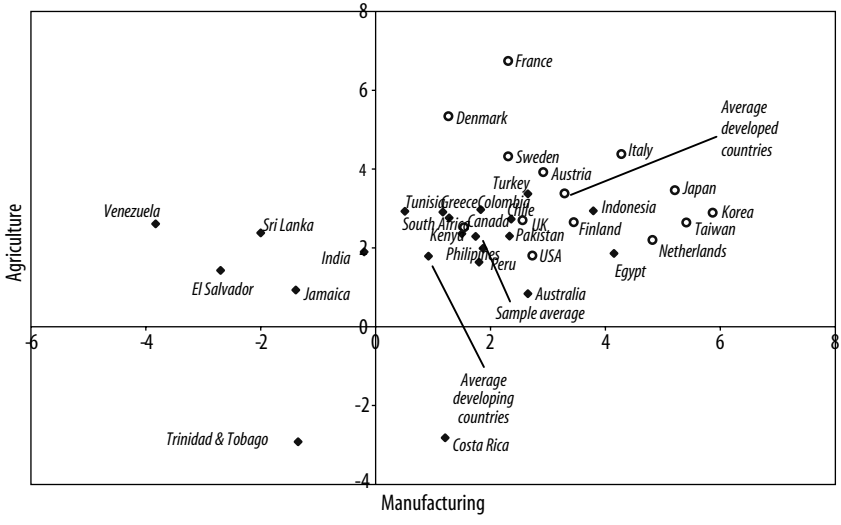
b. Initial level of income relative to the maximum per capita GDP of each period.

experience appeared in this country until the late 1970s.[10] Wright categorizes Latin American countries as traditional mineral underachievers, and massive discoveries of deposits throughout the region in recent years confirm his view.[11] More emblematically, the question arises why it was Australia, another small antipodal dependency, that discovered La Escondida, Chile's largest copper mine, a century after Chile's once-dominant native industry had all but vanished.

10. Cited in Maloney (1997, p. 25).

11. Wright (2001). Baer (2001) notes how the recent application of satellite technology has led to vastly expanded estimates of mining potential in Brazil relative to the stock, which was confidently seen as fixed in the 1960s. Mining exports doubled between 1992 and 1999 in Peru, making it the world's second larger silver, bismuth, and tin producer, sixth in copper, and eighth in gold; but Wright (2001) argues that this is still far below potential.

FIGURE 2. TFP Growth (1967–92)



Source: Martin and Mitra (2001).

Central to every example are the forgone opportunities to exploit the global stock of knowledge to increase productivity growth and create, or perpetuate, dynamic industries, as the Nordic and East Asian miracles have done.[12] Or, to paraphrase Di Tella's broader historical view, the region proved unable to move beyond a state of exploiting the pure rents of a frontier or extraction of mineral riches, and beyond the collusive rents offered by state-sanctioned or otherwise imposed monopoly, to tap the "unlimited source of growth" found in exploiting the quasi-rents of innovation.[13]

12. Baumol, Nelson, and Wolff (1994); Amsden and Hikino (1994).

13. Di Tella (1985). Referring to the closing of the Argentine frontier, he argues, "This kind of area of new settlement was bound to see its rates of growth falter after initial colonization. Argentina behaved, to some extent, in this fairly predictable fashion. But the same was not true for the other countries. It must be acknowledged that the ability of the United States, Canada and Australia to continue a process of vigorous growth even at the end of the expansion of the frontier has been a most extraordinary feat, and one that could not be take for granted. . . . At that point the successful cases were able to move to a quasi-rent based stage—early for the most successful of all, the United States, less so for Canada and Australia, and rather later for Argentina; further development for the United States and Canada was more clearly based on innovation and less so in Australia. For Argentina it

This failure has two central, although by no means exhaustive, explanations. The first is a deficient national innovative or learning capacity: that is, the human capital and the networks of institutions that facilitate the adoption and creation of new technologies.[14] Wright argues that the U.S. success in mining "was fundamentally a collective learning phenomenon" incarnated in intellectual networks linking world-class mining universities and government and private research. These features also undergird Australia's current success, but are largely absent in the underachievers.[15] Blomström and Kokko argue that knowledge networks, or clusters of universities and private and public think tanks, are the key to further productivity growth and development of new products and are "perhaps the main strategic and competitive asset of the Swedish forest industry."[16] Such knowledge clusters, by virtue of preparing firms to identify and exploit unforeseeable technological opportunities, also make possible apparently discontinuous jumps such as Nokia made from excellence in forestry (Nokia was the site of Finland's earliest pulp mill) to leadership in telecommunications.

The second consists of the myriad barriers to technological adoption usually associated with artificially created monopoly power. Hirschman argued early on that in an uncompetitive situation such as the one posed by the guild system, "an innovation in producing a given commodity could only be introduced by someone who was already engaged in its production by the old process. . . . [T]his fact would, in itself, militate against many innovations that might render painfully acquired skills useless and valuable equipment obsolete."[17] Parente and Prescott's simulations suggest that in a dynamic context the costs of such barriers to new entry far exceed the differences of a few percentage points in GDP accounted for by the Harberger triangles of traditional static models.[18] Anticompetitive forces that discourage innovation or inhibit entry can take the form of guilds, labor unions, concentrated credit markets that only lend to insiders,

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arose exclusively from collusive quasi-rents. To the extent that development was based on innovation, these countries were switching to an alternative and unlimited source of growth. To the extent that it was based on collusion, it opened up a limited, alternative path" (di Tella, 1985, p. 51).

14. See Stern, Porter, and Furman (2000), Romer (1990), Nelson and Wright (1992).
15. Wright (1999, p. 308).
16. Blomström and Kokko (2001, p. 34).
17. Hirschman (1958, p. 57).
18. Parente and Prescott (2000).

explicit trade barriers that impede knowledge spillovers from trade interactions, or barriers to foreign direct investment (FDI).[19] All of these were exacerbated by the prolonged turning inward of the import substitution industrialization (ISI) period.

The impact of both factors can be formalized by borrowing Howitt and Mayer's convergence club model, which offers an explanation for how the scientific revolution led to large global income inequalities, and applying it to the present question of why similarly endowed countries perform so differently.[20] In the face of new technological shocks, countries with high innovation-effective (relative to the current level of technological advance) human capital, which I construe broadly to include knowledge clusters, will be able to create further new technologies; those with lower stocks of human capital will implement or adopt technologies developed elsewhere; and those with even lower levels of human capital will be unable to adopt and will stagnate. The first two groups of countries grow at the same rate in the steady state, driven by the arrival of new technological advance, but the progress to their higher steady-state income levels will cause innovators to appear to grow faster.

Three additional findings of the convergence club model are salient to the rest of discussion. First, once a leading economy introduces the institutions supporting science, lagging economies have only a finite window of opportunity in which to do so as well, after which they remain trapped in an implementation equilibrium or worse. Second, countries can slip out of the better equilibria if their innovation-effective knowledge infrastructure does not keep pace with technological progress. Third, policies that either promote or impede innovation are influential in determining the equilibrium in which a country finds itself. The inward-looking policies of the postwar period merit special focus in this respect. The extreme negative rates of protection found in many traditional sectors during the ISI period were a clear disincentive to innovation, but the excessive protection in the manufacturing sectors may have had the same effect by reducing the need to innovate to compete.[21]

19. Barro and Sala-i-Martin (1997); Grossman and Helpman (1991).

20. Howitt and Mayer (2001).

21. Recent literature by Aghion, Bloom, and others (2002) and Aghion, Harris, and others (2001) stresses that for low levels of competition, the traditional Schumpeterian effect that reducing rents decreases innovation is outweighed by the incentive to innovate to escape competition from rivals.

As a preliminary test of the plausibility of this view, table 2 adds to the postwar regressions a knowledge index, comprising measures of scientists per capita, research and development (R&D) expenditure and patent applications, the investment rate, and Sachs and Warner's measure of trade openness (see the technical appendix for further details on the index).[22] The first two columns in the table use the two pooled cohorts of the post-1950 Maddison data, while the last two columns use the single cross-section of Sachs and Warner's data. Both sets of data tell very similar stories. The new variables appear to capture the effect of the Latin American dummy appearing in columns 1a and 2a and contribute in the predicted ways: more open economies and those with a more developed knowledge infrastructure grow faster. In neither dataset does the measure of resource abundance enter significantly.

The next sections attempt to complement such overworked cross-country regressions with a historical comparison of several Latin American countries with a group of "beta" countries that have had more success with resource-based growth. This approach has two attractions. First, it presents what students of these countries have identified as critical elements of success or failure. Second, it establishes that Latin America was not sui generis in its concerns about dependency, in its degree of suffering during the Great Depression, or even in adopting the inward-looking policies it did. But the region's response lies at the extreme end of a continuum that extends through Canada and Australia to Sweden at the most successful terminus. Acknowledging the similarities with more successful countries is vital, since it prevents us from isolating the region as some sort of rare and unredeemable case operating under separate economic laws. Indeed the persistent Australian interest in Argentina stems precisely from a perceived kinship and a desire to avoid its fate. By the same logic, there was probably nothing preordained about the disappointments of the last half of the twentieth century—different policies could have led to better outcomes.

Deficient National Learning and Innovation Capacity

Harvard historian David Landes, in his encyclopedic *Wealth and Poverty of Nations,* sees the divergence of the two paths of Latin America and

22. Sachs and Warner (2001).

TABLE 2. Growth Correlates with Measures of Openness and Knowledge: Maddison and Sachs and Warner Datasets[a]

	Maddison dataset		*Sachs and Warner dataset*	
Explanatory variable	*(1a)*	*(1b)*	*(2a)*	*(2b)*
Initial level of income[b]	−0.215	0.975**	0.335	−1.284**
	−(1.17)	(3.31)	(1.62)	−(4.78)
Net primary exports per worker	−0.258	−0.088	−0.259*	−0.106
	−(1.26)	−(0.46)	−(1.66)	−(0.89)
Latin America	−0.890*	0.703	−1.483**	−0.547
	−(1.67)	(1.29)	−(3.30)	−(1.35)
1950–1973	1.411**	1.908**		
	(3.61)	(5.21)		
Openness		2.203**		2.140**
		(3.46)		(4.74)
Investment		5.848*		1.224**
		(1.71)		(5.06)
Knowledge index[c]		0.390**		0.184*
		(3.24)		(1.68)
Constant	2.149**	−3.009**	−1.375	7.848**
	(5.47)	−(2.85)	−(0.80)	(3.70)
Summary statistic				
No. observations	72	72	91	91
R^2	0.22	0.47	0.15	0.57

Source: Author's calculations, based on Maddison (1994) and Sachs and Warner (1995).
* Significant at 10 percent.
** Significant at 5 percent.
a. Dependent variable is the average annual growth rate; *t* student values are in parentheses.
b. For 1a and 1b, initial level of income relative to the maximum per capita GDP of each period.
c. Missing values were computed using factor analysis (see technical appendix).

Scandinavia as stemming from the differing reactions of northern and southern Europe to the phenomenon of British industrialization.[23] The literature is uniform in its assessment that while Scandinavia was poor at the beginning of the nineteenth century, it had laid the groundwork for rapid growth. Scandinavians enjoyed high levels of literacy and excellent higher education, and Landes argues that they were "equal partners in Europe's intellectual and scientific community. . . . They also operated in an atmosphere of political stability and public order. . . . Property rights were secure; the peasantry was largely free; and life was a long stretch of somber hard work broken intermittently by huge bouts of drinking and seasonal sunshine."[24]

23. Landes (1998).
24. Landes (1998, pp. 248–52).

To this depiction Landes contrasts the dramatic counterexample of Mediterranean Europe, in particular Italy, Spain, and Portugal, which were hurt by political instability and a religious and intellectual intolerance with roots in the reconquista and counter-reformation. Furthermore, Spain in the eighteenth century was a resource-rich nation that used its fantastic returns from silver and gold mines in the New World to purchase all that was needed, thus developing a rentier mentality rather than one of a nation of hands-on tinkerers such as appeared in Great Britain, the United States, and Scandinavia. This cultural Dutch Disease was exported wholesale to the New World.

There is no shortage of Latin American observers disposed to self-flagellation far more severe than Landes' critique. Encina and Pinto, for example, are only the best read of a line of critics of the aristocratic dandyism and indolence that lie at the root of Chile's stagnation and dependence on foreigners.[25] Nor, in the light of extraordinary expenditures on luxury goods, are these critics receptive to savings shortfalls as unavoidable binding constraints on growth.[26]

25. Encina (1911); Pinto (1959). Monteon (1982) summarizes the underlying critique that "The economic ideal of the nineteenth century remained that of a rentier—someone who makes his fortune in one quick speculation and thereafter lives on land rents or some other long-term yield. Domingo Sarmiento in 1842 referred to the effect of this ideal on native entrepreneurs: southern *hacendados* and northern mine-owners left their 'affaires' in the hands of supervisors and moved to Santiago where they 'tried to imitate or rather parody the European Aristocracy' " (Monteon, 1982, p. 14). This critique finds an even earlier expression in Juan José Santa Cruz, who in his *Reflections on the Economic State of Chile in 1791* saw the potential for displacing the British fishing and whaling activity off the Chilean coast with a small outlay. But he lamented the introduction into the colony of "luxury, ostentation and expensive tastes" and saw no permanent improvement in the economic conditions of Chile as possible as long as the population remained improvident and susceptible to sumptuous living (Will, 1957, p. 57). The theme recurs in a speech by Marcial Gonzalez in 1874 entitled "Luxury our Enemy," in which he argued that the clothes, jewels, coaches, and statues exceeded those found anywhere else in America (see Monteon, 1982). Pinto (1959, p. 75) cites the historian Francisco Encina: " 'If half of what we have wasted in the last forty years or invested in luxury we had applied to buying nitrate mining machinery or to setting up the copper industry, to irrigating our fields . . . the position of Chile in America would today be different.' The propensity to save and invest was not, then, the most striking virtue of our community."

26. Though Pinto (1959, p. 57) acknowledges some role for corruption, he holds that "what was decisive was the absence of local individuals and groups interested in developing, on their own, the nitrate riches." In fact, although Chilean capital was very important, the British had dominated the nitrate industry in Peru and Bolivia and had substantial marketing networks. This made them the natural agents to continue mining once these lands were taken by Chile. Monteon (1982) also argues that the global condemnation of Chile's

But this condemnation of the entrepreneurial mettle of the Chilean elite, and that of the region more generally, must be tempered in light of episodes of energetic responses to economic opportunity. Pinto clearly describes how Chilean exports boomed immediately after the elimination of Spanish restrictions on trade, and this was the case throughout the continent. Chilean entrepreneurs were the second largest presence in Peru's nitrate fields, ahead of the British, and they pioneered copper mining in their home country. When the price of copper rose in the mid-nineteenth century, production by Chileans increased fourfold from 1844 to 1860. In response to increased demand stemming from the gold rushes in California and Australia, Chilean wheat exports rose tenfold in value during 1848–50.[27] Southern *hacendados* borrowed heavily to clear lands from 1850 to 1870, expanding acreage threefold.[28] Cariola and Sunkel argue that the early nitrate economy was not merely an enclave in the Norte Grande, but elicited a strong response from Chilean entrepreneurs throughout the economy.[29] In general, local talent proved very responsive in certain nontechnical sectors and earned global acclaim across history: two Nobel prizes in literature, a major surrealist/abstract expressionist painter, and first-class musicians.

In fact, Encina's lament is precisely that Chile was losing the dynamism that it once had, and this he partly attributes to a dearth of technical education that would keep the country at the forefront of development. To borrow Howitt and Mayer's formalization, Chile's innovation-effective

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imperialism may have induced a strategy of dividing the world community by offering Britain a sweet deal. In any case, it appears that the British were aware of a government plan to allocate ownership on the basis of who owned the Peruvian titles. This inside information allowed them to purchase shares at a discount and emerge as owners. A question that arises is why Chilean capital was so willing to sell and why it did not protest more after the fact. One of the early Chilean nitrate pioneers, José Santos Ossa, petitioned that given this dearth of local entrepreneurship, the government should take over the job of mining; but the minister of the interior replied that the state would be corrupted by such an undertaking and that it was better to leave it to private interests, meaning foreign capital. This may have been due as much to an embrace of classical liberal economic values during the period as much as any Spanish rentier hangover, but Pinto seems less convinced. "The decision of the managing groups of the country to 'live from the rents' of the industry" (Monteon 1982, p. 56) and not play the Schumpeterian entrepreneurial midwife would cost the country, not only in forgone income, but also in expertise and dynamism that Pinto argues let foreigners dominate in every field of domestic endeavor.

27. Encina, *Historia de Chile* XIII, p. 486 (cited in Will, 1957).
28. Conning (2001).
29. Cariola and Sunkel (1985).

human capital (relative to the technological frontier) depreciated below the critical level for innovation and even for effective adoption.[30] Latin America's disappointing growth had more to do with a lack of supporting infrastructure for learning and innovation that would enable local entrepreneurs to innovate and hence stay abreast of competition than with any rentier temperament inherited from Spain.[31] The next sections focus on weaknesses in literacy and technical education as particularly important factors.

The Foundation of Technical Absorptive Capacity: Literacy

Recent thinking suggests that Latin America's persistent wealth inequality may have played a role in slowing the region's ability to adopt foreign technologies.[32] Engerman, Haber, and Sokoloff argue that the period of sustained economic growth during the eighteenth and early nineteenth centuries that distinguished the United States and Canada from the other New World economies was fundamentally the result of patterns of settlement and crops that led to a relatively equal distribution of income in those economies.[33] The corresponding patterns in slower-growing areas, in contrast, promoted a concentration of wealth that preserved the political influence of the advantaged elites and led to the marginalization of much of the population, as measured by lower access to the franchise, natural resources, financial institutions, and property rights, as well as primary schooling.

30. Howitt and Mayer (2001).

31. Pushing the argument further, if investment was constrained by human capital, it may have been rational to be purely rentiers.

32. The Scandinavian countries did not start with an egalitarian tabula rasa. In the eighteenth century, Danish land was in the hands of a few thousand families on large estates tilled by serfs, and only 23 percent of rural households owned land in Finland. But as Blomström and Meller (1991a, p. 6) argue, "what laid the foundation for the Scandinavian transformation to modern wealthy societies were the agrarian reforms" that created small- and medium-size privately owned farms, and which ranged in timing from Denmark's precocious beginnings in 1788 to Norway and Sweden's efforts in the 1850s and Finland's of the 1920s. As with the relatively equal distribution of land in Canada (Watkins, 1963; Armstrong, 1985) and the United States, Blomström and Kokko (2001) argue that "it is hardly possible to over-emphasize the importance of the improvement in agricultural productivity for Swedish industrialization which facilitated transfer of labor and made possible exports that generated capital for investment in forestry and manufacturing in addition to providing a local market."

33. Engerman, Haber, and Sokoloff (2000).

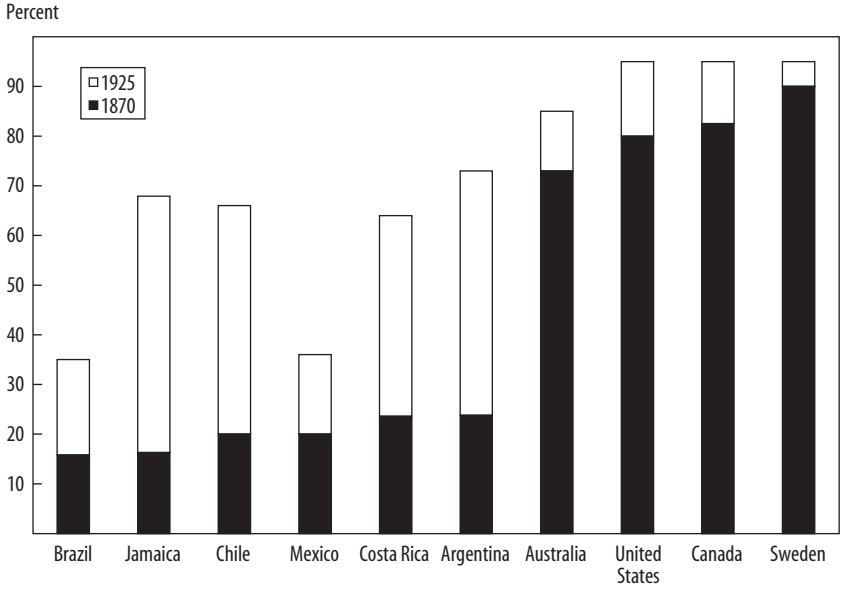
The marginalization in education may have been particularly important. Concerns with social control, the extreme inequality of income, weak public finance, and perhaps an intellectual commitment to a small state all led to dramatically smaller efforts toward universal education in Latin America than among the successful natural resource exporters. As figure 3 suggests, by 1870 more than 70 percent of the population age ten or above in Australia, Canada, Sweden, and the United States was literate—three times the percentage in Argentina, Chile, Costa Rica, and Cuba and four times the percentage in Brazil and Mexico. Latin America progressed unevenly toward these levels over the next half century. By 1925, Argentina, Chile, Costa Rica, and Uruguay had attained literacy rates of over 66 percent, while Bolivia, Brazil, Colombia, Guatemala, Honduras, Mexico, Peru, and Venezuela hovered at 30 percent until much later.[34]

As Engerman and Sokoloff note, these trends in education had important ramifications because early industrialization reflected the cumulative impact of incremental advances made by individuals throughout the economy, rather than being driven by progress in a single industry or the actions of a narrow elite. In the United States, for example, the greater equality in human capital partially accounted for the high rates of invention overall. Engerman and Sokoloff further argue that "the more general concern with the opportunities for extracting returns from inventions contributed to a patent system which was probably, at the time, the most favorable in the world to common people. This stands in stark contrast to Mexico and Brazil, where patents were restricted by costs and procedures to the wealthy or influential, and where the rights to organize corporations and financial institutions were granted sparingly, largely to protect the value of rights already held by powerful interests."[35]

Blomström and Kokko argue that in Sweden, the introduction of a mandatory school system in 1842, with its emphasis on literacy and numeracy, was essential for developing the ability of individuals and firms to learn and adopt new technologies: much elementary learning and technology transfer were based on written instructions like blueprints and handbooks.[36] The extensive literature comparing Argentina and Australia may thus be missing a critical point. Despite a strong feeling on the part of

34. Mariscal and Sokoloff (2000).
35. Engerman and Sokoloff (1997, p. 287).
36. Blomström and Kokko (2001).

FIGURE 3. Literacy Rates in Latin America, the Caribbean, and Elsewhere, 1870–1925



Source: Mariscal and Sokoloff (2000), Meredith (1995).

Australian authors that "there but for the grace of God go we," it is very clear that in the mid-nineteenth century, Australia was far closer than Argentina to the literacy levels of the industrialized countries—this, in a country that until the 1840s was a penal colony of the United Kingdom. The story of the global mining conglomerate Broken Hill Proprietary Company (BHP), which was started by a boundary rider on a sheep station, demonstrates the importance of having a broad base of literate everymen to run with ideas and enjoy supporting institutions.

Technical Education: The Critical Lag

A central theme in Blomström and Kokko's account of the Swedish growth experience is the early abundance of high-level human capital—the impoverished sophisticate, Sandberg called it.[37] The universities in Uppsala and

37. Sandberg (1979).

Lund date from the fifteenth and seventeenth centuries, and technical schools were established in the early 1820s. Examples of other institutions include the Swedish Academy of Science, founded in 1739, and the Swedish Ironmasters' Association (1747), which published a mining science journal beginning in 1817 and financed foreign-study trips for Swedish engineers and scientists. New engineering workshops, established for the construction of iron bridges and lock gates on the Göta canal, served as training centers. Sweden possessed the fundamentals of a modern engineering industry by about 1850 and was exporting engineers by 1900.[38] In that same year, serious research in chemistry was undertaken at the University of Oslo that laid the foundation for the dominant fertilizer, electrochemical, and electrometallurgical industries in Norway.[39] As in Great Britain and the United States, Scandinavian mechanization was a slow process that implied ongoing accumulation of know-how, continuous interaction with the outside world, and extraordinary contributions at the technological frontier.[40] The exceptional long-run performance of Swedish firms established during this period "has been based on the ability of Swedish industry to create, adapt, and disseminate new technologies."[41]

By contrast, the colonial period in Latin America in many ways enforced a negative intellectual bias that exactly discouraged the adoption of foreign innovations. Many countries hosted a local franchise of the Inquisition, which in Colombia is memorialized for, among other things, having contributed to the "suffocation of the spirit of creativity and investigation."[42] Largely for reasons of political control, the icon of intellectual discourse—the printing press—was banned in Brazil until 1809.[43] The

38. Blomström and Kokko (2001).

39. Hveem (1991).

40. Very early on, for example, Scandinavia was exporting know-how in the form of its own émigrés toward czarist Russia, where Alfred Nobel was one of the pioneers of the infant petroleum industry. To a significant extent, the expansion of manufacturing during the first decades of the twentieth century was based on Swedish innovations: steam turbines, centrifugal separators, ball bearings, the adjustable spanner, the safety match, air compressors, automatic lighthouse technique, various types of precision instruments, techniques for precision measurements, and so forth (Lindbeck, 1974, p. 5). The great companies known today were built on innovations in these areas. Ericson (founded in 1876) thrived on the telephone, Alfa Laval (1879) on the separator, ASEA (1890) on electrical equipment, and SKF (1907) on bearings (Amsden and Hikino, 1994).

41. Blomström and Kokko (2001, p. 10).

42. Memorial plaque at the *Casa de la Inquisición* in Cartagena de las Indias, Colombia.

43. Baer (2001).

Spanish crown kept out non-Spanish and non-Catholic businessmen, traders, and craftsmen and thus deprived the New World of important skills and knowledge.

Furthermore, the nature of education in Latin America was less technical than that found in Scandinavia or the former English colonies. Spanish higher education was largely religiously based and focused on law, philosophy, theology, and, somewhat less respectably, medicine. This pattern was replicated in the colonies. The Spanish enlightenment after 1750 saw the establishment of groups of autonomous *sociedades económicas* that sought to diffuse technology from abroad and establish libraries throughout the country, as well as some Royal Societies emphasizing applied science. But Spain began training engineers seriously only in the 1850s, and by 1867 the country had only one functioning Escuela de Ingenieros Industriales, located in Barcelona.[44]

Latin America for the most part lagged behind Spain and Portugal in developing a technical class. In both Chile and Colombia, specific royal initiatives gave the initial impetus to scientific inquiry in the last decades of colonization.[45] As Will documents for Chile, however, "With the exception of the inadequate facilities provided by a few religious organizations, there did not exist . . . before the middle of the eighteenth century an institution capable of furnishing the youth of the colony with the barest essentials of a secular education."[46] Similar stories of developments in the nineteenth century are found throughout the region.[47] Recurring political instability silenced prominent scientists and undermined fledgling universities, fiscal weakness prevented consistent financing of the sciences, and the unreliable demand for local engineers kept the career from being lucrative, let alone socially respectable. An important exception is found in Mexico, where the precursor to the Universidad Nacional, the Real Seminario de Minería, was founded in 1792 and taught higher mathematics, physics, chemistry, topography, dynamics, and hydraulics. Mexico was

44. Riera i Tuébols (1993).

45. See Will (1957) for Chile; Safford (1976) for Colombia; and López Soria (1999) for Peru. Despite having one of the oldest universities in Latin America, Peru failed twice in establishing technical education, once in 1852–53 with the Escuela Central de Ingenieros Civiles and again in 1875 with the Escuela de Minas. They succeeded in 1876 by creating the Escuela de Ingenieros Civiles.

46. Will (1957, p. 17).

47. See Safford (1976) for Colombia; Villalobos (1990) and Greve (1938) for Chile; and Baer (1969) for Brazil.

the primary exporter of technical knowledge on the continent, and it occupied the Vice Presidency of the World Mining Association at the turn of the nineteenth century.[48] Unfortunately, Mexico was not completely exceptional.[49] The struggle for independence had devastating effects on the mining sector—martyred scientist-patriots, capital flight, flooding of mines, and a roughly 50 percent fall in output that took almost seventy years to reverse, causing a lost half century of Mexican growth.

The low supply of engineers was, in part, driven by the limited and unstable demand for them, and arguably, resource-based industries were catalysts pushing countries to reach better innovation equilibria. In Chile, Colombia, Mexico, Australia, and the United States, mining institutes were the kernels of technical schools and later important universities. Railroads may have had the potential to play a similar role: troubled politics and public finances that frequently stalled railway construction undermined the momentum of the engineering profession in Colombia.[50]

A corps of locally trained engineers emerged by the end of the nineteenth century in many countries, but this may have been too little and too late. As table 3 suggests, Australia had at least five times the number of engineers working in Chile or Colombia in 1920. By 1926, Australia had twenty-seven times more graduates of technical schools per capita than Argentina, perhaps the most educated country in Latin America.[51] Sweden had almost ten times the density of engineers found in Colombia or Chile, and as mentioned above, in this period Scandinavia was exporting engineers, many working at the frontier of innovation. The persistence of this deficit, measured as the percentage of architects and engineers per worker, continued into the 1960s: Sweden (5.03), Finland (2.52), and Denmark (1.03) had the highest densities, compared to the lows of Chile (0.7), Argentina (0.55), Uruguay (0.42), and Ecuador (0.18).[52] The quality of the Latin American product may also have been below international standards. At the end of the nineteenth century in both Colombia and Chile, local engineers complained that the government and private firms preferred to import engineers from France or the United States, even for fairly straightforward tasks.

48. I am grateful to Rodrigo García Verdú of the Banco de México for calling the Mexican case to my attention (ingenieria/unam.mx/historia/historial1b.html).

49. See Cárdenas (1997).

50. Safford (1976).

51. Meredith (1995).

52. OECD (1969).

TABLE 3. Density of Engineers at the Turn of the Twentieth Century

Country	*Year*	*Engineers per 100,000 workers*
Australia	1920	47
Chile	1930	6
Colombia	1887	8
Sweden	1890	84
United States	1920	128

Source: Australia, United States: Meredith (1995); Chile: Villalobos (1990); Colombia: Safford (1976); Sweden: Ahlström (1992).

Does This Really Matter?

The literature on Australia, Scandinavia, and the United States strongly supports the idea that such technical capacity, and more generally the ability to learn from what was happening abroad, was critical to accessing technological progress generated abroad and, in the long run, establishing knowledge clusters. Latin America offers some provocative examples.

The first bit of evidence is the extraordinary dependence on immigrants to act as innovators and entrepreneurs in new sectors. Industrialization in Mexico in the late nineteenth century was undertaken almost entirely by the resident foreigners.[53] The French started the textile industries in Veracruz and Puebla, and foreigners also established Mexico's first iron and steel plant in 1903, the Fundidora de Fierro y Acero de Monterrey, which would build on the region's ore deposits and anchor its industrial development.[54] Hansen argues that while entrepreneurial spillover effects drew many Mexicans into the capitalist ranks, the initial impulse came from foreigners.

Collier and Sater similarly note the influence of immigrants in introducing new industry and technologies in Chile.[55] Immigrants set up many of the industrial enterprises of the 1860s and 1870s: thirty-six of the forty-six dressmakers counted in 1854 were French; Americans installed the flour mills; Americans and British built the railroads. The list of officers and members of the executive committee of SOFOFA, the principal organization of industrialists, showed the disproportionate influence of immigrants: "Only three Spanish surnames accompanied those of the other members of the directorate: Edwards, Subercasseaux, Hillman, Tupper,

53. Hansen (1971).
54. Buffington and French (1999).
55. Collier and Sater (1996).

Tiffou, Mitchell, Gabler, Lanz, Klein, Muzard, Lyon, Bernstein, Crichton, Osthous, Stuven."[56]

Fogarty tells a similar story for the development of beef in Argentina, where a small group of *hacendados*, recently arrived from Europe, formed the Sociedad Rural Argentina in 1866.[57] This group spearheaded the transformation of the pampas, improving the quality of livestock, pastures, and methods of animal husbandry and taking over the U.S. position as principal exporter of cattle to Europe by World War I, with dramatic forward and backward linkages throughout the economy. Fogarty also notes that while railroads were sponsored, financed, and constructed largely by nationals in Australia, Canada, and the United States, Europeans were the prime movers in Argentina. In each of these three examples, it was not locals who saw the possibilities for technological arbitrage, as was the case in Scandinavia, but those embodying the knowledge from abroad.

The second piece of evidence is the emphasis both present and contemporary observers put on the impact of engineering schools, such as the Antioquia Escuela de Minas in Colombia, as critical providers of talent for emerging industry.[58] In Brazil, Baer argues that despite a tradition of iron smelting dating from the mid-sixteenth century, the techniques used at the end of the nineteenth century were primitive.[59] Of the thirty ironworks in the headwater region of the Rio Doce in 1879, only seven used Italian forging methods, while the rest used the old African *cadinho* (crucible) technique. Baer sees the critical event for the development of the native steel industry as the foundation in 1879 of the Escola de Minas at Ouro Prêto, Minas Gerais, which led to the establishment of the first new blast furnace since the failures at the beginning of the century. Graduates of the Escola de Engenharia do Exercito established in 1930 led the steel industry as it developed through the 1960s.

Australian observers emphasize the role of the nonuniversity innovation infrastructure in explaining the disparate evolution of the wheat industry in Argentina, Australia, and Canada. In all three countries, wheat gained an early and firm toehold, but it became the super staple in Canada, largely as a result of government assistance to prairie agriculture in the

56. Loveman (1979, p. 193).
57. Fogarty (1985).
58. See, among others, Safford (1976).
59. Baer (1969).

form of experiment stations, seed testing services, and technical assistance. This assistance came on top of determined efforts in both Canada and Australia to achieve widespread literacy in the prairies, efforts that have no analogue in Latin America. The government also provided other important public goods that were less knowledge related: for instance, public granaries and a wheat grading system introduced quality control that gave Canada an edge over Argentina's wheat, which had a reputation for inferior quality and lack of uniformity.[60] The provision of an extensive institutional and scientific infrastructure was recognized by contemporary Argentines as key to Canada's success, and the lackluster efforts of the Argentine government compared poorly.

Case Study: Convergence Clubs in Mining in Chile and Australia

Howitt and Mayer's view of multiple convergence clubs offers insight into the differing trajectories followed by Chile and Australia in copper mining.[61] Arguably, the initially deficient local technical capacity, exacerbated by technological progress elsewhere, led to Chile's loss of leadership in copper over the course of the last two centuries. It also helps explain why Australia's BHP, hailing from an antipodal dependency of similarly small size, discovered La Escondida and became the major force in expanding Chilean production in the 1980s and 1990s. Chile saw its world share fall from one-third to under 4 percent by 1911, and even as early as 1884 the Sociedad de Minería wondered openly whether Chile's copper mines would survive at all.[62] This trajectory casts doubt on theories arguing that market scale is the key complementary factor in explaining why some resource-abundant countries, the United States in particular, became technological leaders.[63] Chile once had the world market for copper and presumably a scale advantage.

60. Fogarty (1985) cites the example of Spanish Merino sheep, which were introduced into New South Wales, Australia, and Argentina's River Plate region in the same year. European capital was available for sheep breeding in both areas, and both suffered the ups and downs of the world wool market. In 1885, the two countries had the same number of sheep, but the average "clip" was getting almost twice as much on the world market in Australia as in Argentina, owing not only to differences in wool types and quality, but to inferior yields per sheep. He attributes the differences to the innovation and visions of individual figures, rather than to any structural features of the economy.

61. Howitt and Mayer (2001).

62. Collier and Sater (1996, p. 139).

63. Romer (1996).

Instead, the missing complementarity was probably a supply of technologically literate human capital. Collier and Sater attribute Chile's loss in market share to a failure to update technology in the face of declining ore quality, together with excessive reliance on the wasteful *pirquén* system. Chilean historians date this technological slippage to the beginning of the nineteenth century, when there was little diffusion of European technologies and "the work of mining was not very systematic."[64] The disappearance of the Academy of San Luis represented the end of technical teaching of mining in the country in this period, and the "receipt of industrial innovations was slow and without visible influence."[65] Charles Lambert, a representative of a British mining company in La Serena who was trained in the École Polytechnique in Paris, noted in 1819 the primitive mining practice, scarce knowledge of minerals, and inefficient smelting, all of which represented poor technique relative to that employed in Europe. The Polish mining engineer Ignaci Domeyko helped establish a small school in 1841, and the University of Chile began teaching engineering in 1847. But at this point Chile was eighty years behind the first mining school in Europe and fifty years behind Mexico.

Chilean historians note the dominance of foreigners in applying new technologies.[66] Pinto spectacularly underlines how Chile tragically passed up the power that gradual accumulation of know-how offered to maintain competitiveness and dynamism:

> The technological demands of the period, in contrast to what is occurring today in some areas of mining or industry, were relatively modest and thus not too costly. What could and had to be done in the national mining companies and in agriculture, except in certain exceptions . . . was perfectly compatible with the resources accumulated in the long periods of bonanza. If the process had been initiated and maintained adequately, without doubt it would have created the means to confront more challenging tasks, such as those posed by copper mining when it was necessary to exploit less rich veins. However, faced with the technological revolution, the local mining companies did not have the backing

64. Villalobos (1990, p. 95).

65. Villalobos (1990, p. 96).

66. "It is worth noting that the empresarial spirit united with the motivation to apply new techniques was almost always the result of initiatives on the part of foreigners who came to Chile and saw opportunities to develop or solutions to problems based on practical experience. They brought a greater tradition of information, spirit of action, attention to detail, and urgency to capitalize on the results or resources generated; these were not common traits of the average inhabitant of the country, whose nature of work was little developed beyond the artisanal level" (Villalobos, 1990, p. 99).

> of either sufficient accumulated resources or organizational and administrative capacity—both of which were indispensable. In these circumstances, there was no other option but the introduction of foreign capital and expertise at a cost, without doubt, of a considerable retribution.[67]

It is easy to imagine a bad feedback loop in which the inability to innovate leads to lower profits and experience leading to less innovation-effective human capital, which, in turn, leads to further inability to innovate or even transfer technology—and all of which eventually pushes local entrepreneurs out of the market. Perhaps this accumulated deficiency of technical facility was what led to a self-perception on the part of Chileans that they were perhaps "unfit for the modern era."[68] Tancredo Pinochet Le-Brun, granting that Chileans were inferior to Europeans, still wondered, "Don't we have minds in this country that can go to Europe to learn what professors, whom we have imported and continue importing, have studied? Are we truly incapable of steering our own ship?"[69] As mentioned earlier, Encina answered pessimistically in 1911 for a variety of reasons, one of which was the dearth of applied technical education essential to progress in all fields.[70] A sense a frustration arose among concerned Chileans that the big, visible advances were in the Guggenheim mines at El Teniente and Chuquicamata, a French steel mill (El Tofo) in Coquimbo, and experiments in fishing by foreign capitalists.[71]

Chile continued to slip in its technical capacity in copper. Meller argues that "in the 1950s, one could have learned more about Chilean copper in foreign libraries than in Chilean ones. . . . [Nor] was there training of Chilean engineers and technicians specializing in copper."[72] In 1952, the Controller General admitted that he had no idea of what went on in the companies.[73] This suggests that part of the feeling of vulnerability and

67. Pinto (1959, p. 71).
68. Monteon (1982, p. 62).
69. Cited in Moran (1974).
70. See Encina (1911). He notes that "from the point of view of capital and of technical and administrative aptitude, the copper industry is as demanding as the most complicated manufacturing industry" (p. 45). His studies reveal "an extraordinary economic ineptitude in the national population, . . . consequence of an education completely inadequate to meet the demands of contemporary life" (p. 17).
71. Monteon (1982, p. 75).
72. Meller (1991, p. 44).
73. Moran (1974).

dependency must be attributed to the lack of technical capacity to monitor and confidently critique the actions of the *Gran Minería*. It was not until 1955 that a government agency was created to oversee U.S. firms' operations, and with it a bureaucracy of Chilean professionals, engineers, and economists. "In short, it took about forty years, from 1925–65, to develop a domestic capacity to analyze the role of copper and to educate Chilean professionals and technicians in the management of the [large copper firms]."[74] This is a striking statement in a country that began exporting copper long before the U.S. or Australian firms that came to dominate the Chilean industry. Even today, there is relatively little interaction between the copper companies and universities or other think tanks. Such a knowledge cluster may be necessary for transforming the north into a regional service center following the inevitable decline in mining production over the next decades.[75]

Australia's trajectory was very different. While most mining was begun by Cornishmen who had a high degree of applied skill, in 1886 Australia recruited highly paid engineers and metallurgists from the United States, thus firmly linking the country to U.S.-generated innovations.[76] Díaz-Alejandro notes that Australia's mining exports provided a general interest in scientific and technical research absent in Argentina.[77] Duncan and Fogarty argue that "geological knowledge and mining expertise became part of the Australian heritage enriched by schools of mines of world class, and the industry has been in the forefront in the development and application of mining and treatment technology."[78] Although far ahead of Chile, Australia lagged behind the United States until after 1920 in engineers per 100,000 population—47 versus 128—but would quadruple this number by 1955. Several important universities offered local beachheads for foreign research. The Sydney Mechanics Institute was established in 1843 and the Sydney Technical College in 1878, both with the goal of diffusing scientific knowledge. The University of New South Wales (UNSW) was founded in 1949 on the campus of the Technical College, with MIT and the Berlin University of Technology as models and with a core focus on

74. Meller (1991, p. 45).
75. Lagos (1997).
76. Wright (1999).
77. Díaz-Alejandro (1985).
78. Duncan and Fogarty (1984, p. 129).

research and teaching in science and technology. The UNSW School of Mining Engineering now ranks as one of the largest educators of mining engineers in the world.[79]

In this context, one of Australia's most influential mining companies and industrial conglomerates emerged in 1883: Broken Hill Proprietary Company (BHP), called by those of the region "the cradle of Australian industrialization."[80] Broken Hill oversaw the expansion of mines and smelters and, in 1893, the establishment of the Australasian Institute of Mining and Metallurgy. When the easily accessed oxide zone was exhausted, Broken Hill metallurgists and engineers were among those who introduced the flotation process, which, as a residual, allowed the expansion of zinc production by new firms. During World War II, Australia, as the principal member of the Allies in the Pacific, benefited from the demand for iron-based goods, as well as from technology transfer. Industrial production rose by 45 percent in the war period and technological acquisition jumped, a gain which subsequent Australian governments sought to continue. BHP and similar conglomerates became modern corporations, with vertical control from mining to blast furnaces to wire rope factories to shipping lines and with links to foreign capital through joint ventures. In an inversion of the traditional center-periphery dichotomy, BHP attained a global reach, acquiring mines in Canada, Chile, and the U.S. state of Utah. Australia now exports more mining expertise—including environmentally friendly techniques, mine closure methods and mineral detection technologies—than wine.

ISI as a Double Disincentive to Innovation: A Continuum of Experiences

The barriers to trade and investment that constituted the inward-looking policies implemented after the Great Depression stand as the second impediment to the transition to an innovation-based economy, and they offer a rationale for the negative post-1950 Latin American dummy in the growth regressions. Di Tella's distinction between the appropriation of quasi-rents arising from innovations abroad and the exploitation of artifi-

79. See www.mines.unsw.edu.au/school.htm; www.unsw.edu.au/about/about_history.html.

80. New South Wales Department of Mineral Resources (www.minerals.nsw.gov.au/silver.htm [2001]). This section also draws on information from www.bhpbilliton.com.

cially contrived rents is not new, but it does highlight why the debate on natural resources versus manufacturing probably misses the point.[81] It is not the creation of a manufacturing sector that matters, but whether the sector serves as a source of innovation or a brake on the dynamism of the traditional sectors that are forced to subsidize it. Blomström and Meller capture much of the ISI critique:

> When Latin America decided to force industrialization by import substitution, it was not an industrialization based on the countries' endowments that was supported. While the Scandinavian countries slowly and gradually filled in the empty slots in their input-output tables, the Latin American countries filled in all the numbers at the same time; and even worse, they tried to fill in the U.S. numbers! Suddenly there were several small Latin American economies with production structures similar to that of the United States.[82]

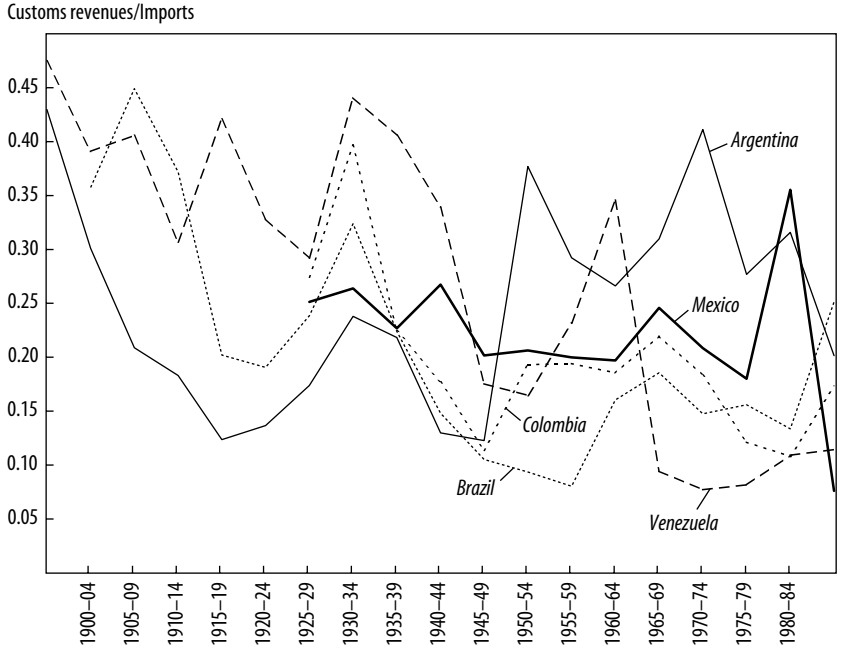
Not only were these sectors out of line with comparative advantage and walled off from competition and the sources of innovation, but they needed to be subsidized, or at least they diverted attention from sectors that had the potential for innovation.

However, Latin America's turn inward, with a corresponding suspicion of resource dependency, is at one end of a continuum that passes through Australia and Canada and then to Sweden. Figures 4 and 5 suggest that virtually all of the sample countries saw an increase in average effective tariffs after the Great Depression. Latin America's average jumps from 0.22 to 0.34, while those of the beta countries move from 0.1 to 0.16. Within the latter, however, Australia is as dramatic as Argentina, Brazil, and Mexico, and even Canada could pass for Latin America across much of the period.

The usual battery of protectionist measures appeared, and observers in these countries offer exactly the critiques of inward strategies so familiar in Latin America. Dehem cited Hirschman's quote on the barriers to innovation not as a description of the developing countries, but as an explanation of Canada's "stunted growth" of the 1950s.[83] This theme was picked up by Stykolt and Eastman, who sought to explain the 30 to 35 percent differential in U.S. and Canadian incomes, as well as Canada's low labor productivity.[84] One of the deans of Canadian economic history, Melville

81. Di Tella (1985).
82. Blomström and Meller (1991b, p. 9).
83. Dehem (1962).
84. Stykolt and Eastman (1960).

FIGURE 4. Average Effective Tariffs, Latin American Countries



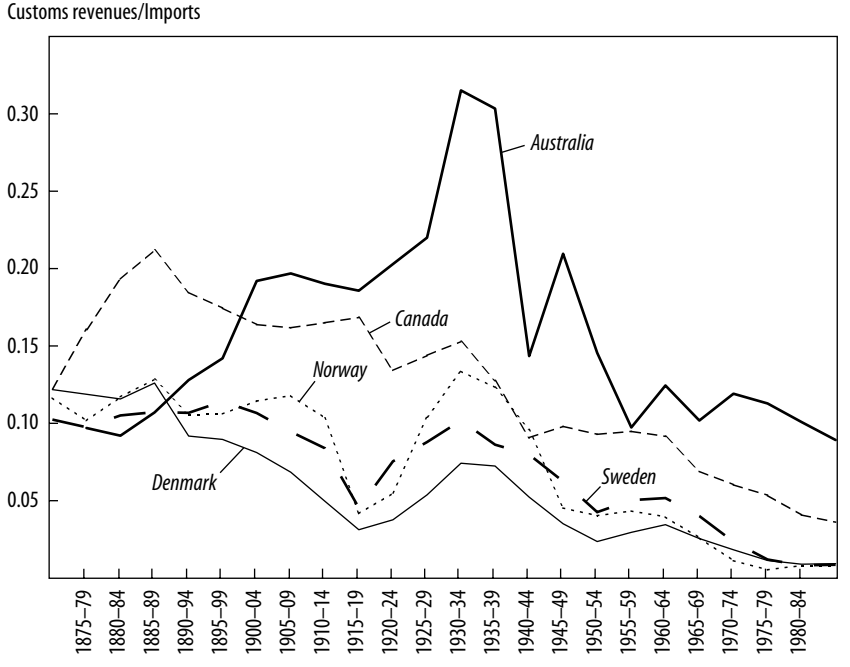
Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

Watkins, ended one of his better known articles by noting the "emphasis increasingly placed by economists on the link between the inefficiency of Canadian secondary manufacturing industry and the Canadian tariff."[85]

Prolonged Australian protection also remains the general culprit in most analyses of that country's lackluster industrial growth in this century.[86] Fogarty argues that Australia's tariffs were probably responsible for the stagnation of the industrial sector in the late 1920s, precisely when Argentine manufacturing was growing well.[87] Although it did have an indigenous automobile industry of some promise and BHP-type conglomerates with solid roots, Australia (and New Zealand, as well) also nurtured import-substituting industries that were neither of efficient scale or appropriate given comparative advantage. McLean summarizes the extensive

85. Watkins (1963, p. 158).
86. Anderson (1987); Maddock and McLean (1987).
87. Fogarty (1985).

FIGURE 5. Average Effective Tariffs, Beta Countries



Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

Australian literature and concludes that ongoing protection of the manufacturing sector into the 1970s "led to a stifling, rather than promotion of desired structural change, no reduction in the dependence on natural resource-intensive exports, and to lower growth and living standards."[88]

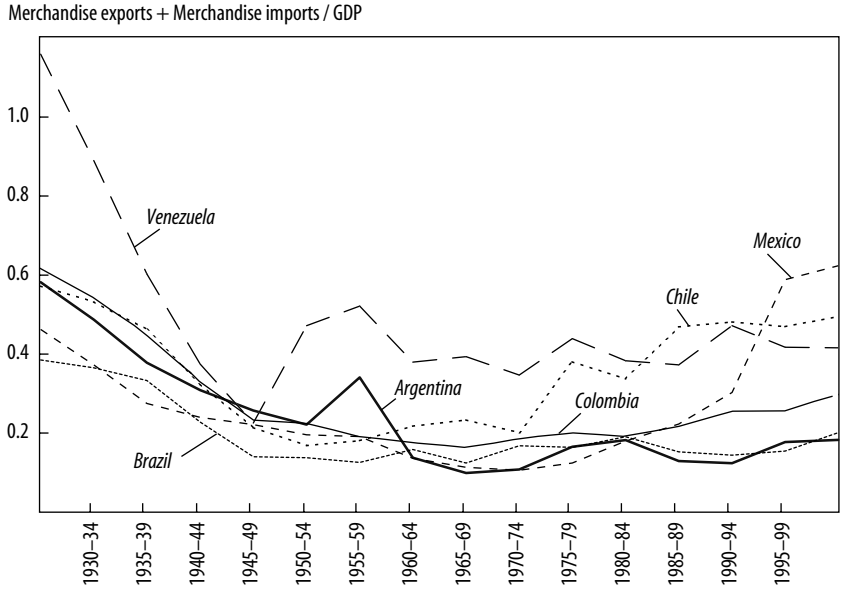
Differing Reactions to a Common Dependency

That the policies of other countries with abundant natural resources paralleled those of Latin America is not so surprising. Many of the factors cited in the canonical recounting of the reasons for the region's turn inward are found elsewhere.

The Great Depression, the watershed period for inward-looking policies, appears to have affected the beta countries as hard as Latin Amer-

88. McLean (1989, p. 22).

FIGURE 6. Openness of Latin American Countries



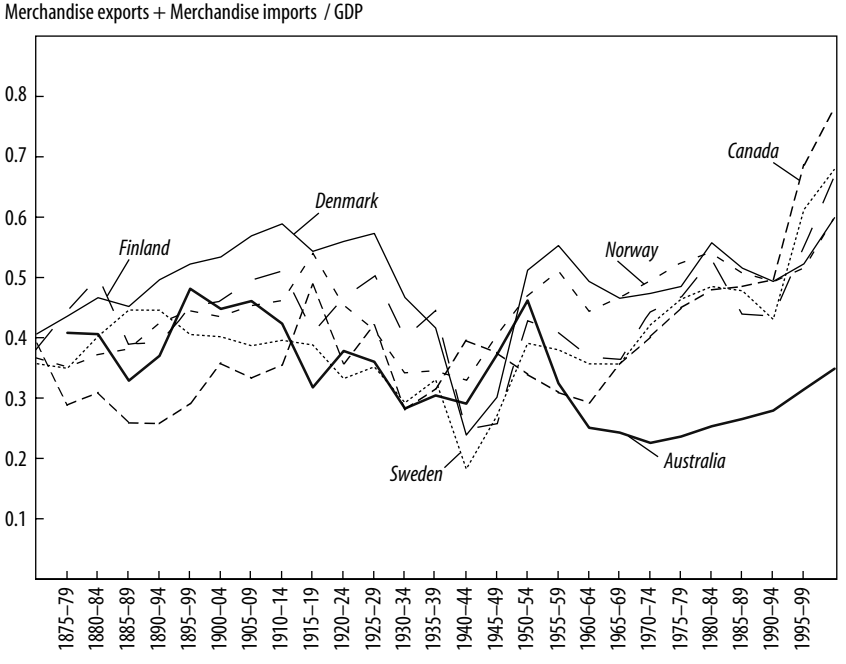
Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

ica.[89] Figures 6 through 9 show that the beta countries were far more open than Latin America; most were exporters of raw materials and most showed falls in export earnings as large as those seen in Latin America. Latin America appeared to recover more slowly, especially Colombia and Brazil, which suffered most from the fall in coffee prices, but some countries in the region, such as Argentina, are not distinguishable from the other sample.

Table 4 (see page 142) suggests somewhat conflicting measures of actual impact. On the one hand, the reported falls in per capita output can be seen as driving the continuum. Broadly, Latin America was hit hardest, Australia moderately, and the Scandinavian countries the least. On the other hand, Canada was hit almost as hard as Chile, and Brazil and Colombia seem almost Scandinavian. Furthermore, the resulting unemployment rates, although notoriously incomparable, suggest that even the impact on

89. See Lederman (2001) for an excellent summary of the literature on determinants of trade liberalization. He also argues that in Chile, trade protection arose prior to the Great Depression.

FIGURE 7. Openness of Beta Countries



Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

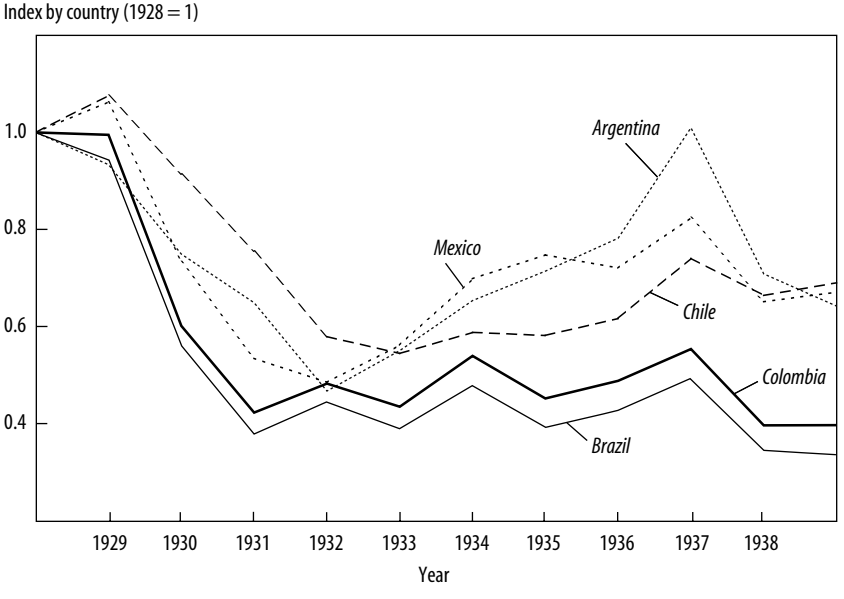
Scandinavian countries was very high, with unemployment roughly doubling during the Depression to levels between 20 and 30 percent. Argentina, however, remained relatively unscathed at under 5.6 percent unemployment. Supporting evidence suggests that the general picture is broadly correct. Aldaheff cites the *Review of the River Plate* as arguing that Argentina was one of the least—if not the least—hard hit countries to be found anywhere in the world.[90] This impression is confirmed by Alejandro Bunge, a prominent industrialist, in an address to London's Argentine Club in 1932.[91] Furthermore, the lower need for safety net expenditures and the fact that the British carried the railway debt imply that Argentina would have had far fewer fiscal problems than either Australia or Canada.[92]

90. Aldaheff (1985).

91. Södersten (1991) testifies to the traumatic levels in Sweden, as well.

92. This also implied that fiscal problems during the Great Depression were minor in Argentina compared with Canada or Australia. Both the lower demands of supporting the

FIGURE 8. Impact of Great Depression through Commodity Prices, Latin American Countries

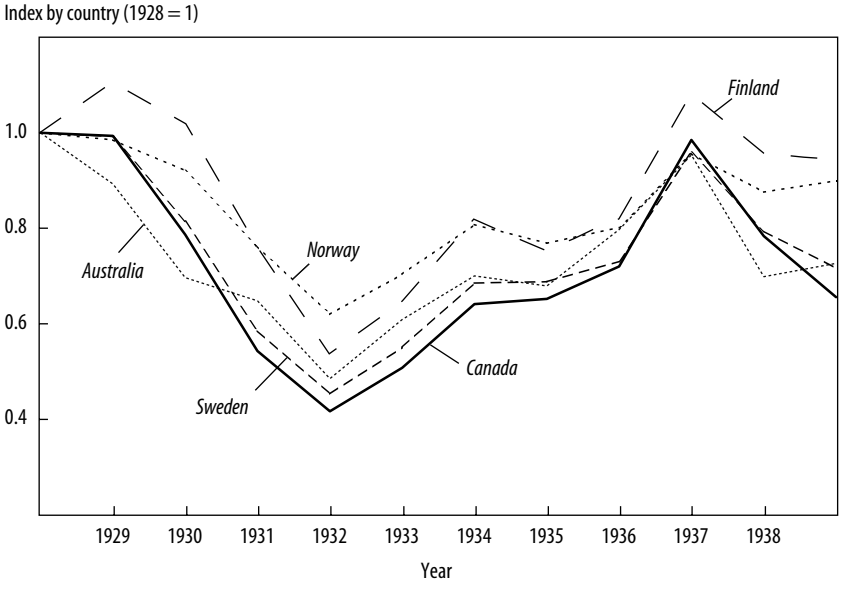


Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

At a deeper level, the region's concern with asymmetrical power relations in the world economy are echoed elsewhere. As Love argues, the Romanian economist Mihail Manoilescu independently developed a dependency theory that strikingly parallels that of Prebisch to explain the

unemployed and the fact that the railways, which ran major losses in all three countries, were largely in private hands in Argentina (whereas they had far larger public participation in both Canada and Australia) lessened the impact on some Latin states. Aldaheff (1985) suggests that half of Canada's budget deficit in 1932–33 and 1934–35 was dedicated to financing. Real expenditures between 1928–29 and 1933–34 rose 66 percent in Canada, 46 percent in Australia, and only 10 percent in Argentina. In terms of managing external debt, debt service was calculated at 17 percent, 22 percent, and 23 percent for Argentina, Australia, and Canada, respectively, and per capita indebtedness was 167 pesos versus 863 and 224. Argentina's repayment record was excellent across the period, whereas Australia, which had overborrowed in the 1920s, had the most trouble servicing the debt. In sum, all three countries showed conservative and reasonable fiscal management in the face of shocks, but the Latin American entrant was relatively better off.

FIGURE 9. Impact of Great Depression through Commodity Prices, Beta Countries



Source: Author's calculations, based on data from Mitchell (1998a, 1998b, 1998c).

evolution of Central and Eastern Europe.[93] Foreign control over the economy emerges as a theme in even the most successful economies. In 1909, 80 percent of Norway's mining, 85 percent of its chemical, 44 percent of its paper and textile, and 33 percent of its metal industries were foreign owned, and foreign control of almost 75 percent of all waterfalls essential to power generation triggered widespread protests.[94] Finland's extraordinary dependence on Russia as a Grand Duchy and the dramatic debt service repayments of 5 to 6 percent of GDP in 1945–48 is high even by 1980s Latin standards.[95] At Australia's centennial in 1880, a sizable fraction of the population, many of whom were the descendants of imported convict labor, expressed resentment about dependence on the United Kingdom. The Republican newspaper *Bulletin* argued that the convict "chains of iron are merely exchanged for chains of gold." Citing the

93. Love (1996).
94. Hveem 1991).
95. Haavisto and Kokko (1991).

TABLE 4. Impact of the Great Depression
In percent

Country	*Change in commodities exports, 1928–1932*	*Maximum unemployment*	*Maximum negative change in GDP relative to 1929*
Latin America			
Argentina	−45.0	7.0; 5.6	−14.0
Brazil	−61.1	—	−6.0
Chile	−45.6	7.0	−27.0
Colombia	−56.5	—	−2.0
Mexico	−51.5	6.0	−17.6
Beta countries			
Australia	−51.5	20.0	−9.7
Canada	−58.3	19.0	−25.1
Denmark	—	32.0	Positive
Finland	−46.3	—	−4.0
Norway	−38.0	33.0	−2.6
Sweden	−55.0	24.0	−4.0

Source: Author's compilation, based on Mitchell (1998a, 1998b, 1998c) and Sadie (1969). Second Argentina estimate from Aldaheff (1985); see text.

exploitative nature of British capital investment, the editorial argued that it was better to be poor and independent, referring to Chile and Mexico as enviable examples.[96] Canada can surely share Mexico's traditional lament about being so close to the United States and so far from God. The percentage of the value of production that was produced by U.S.-controlled and affiliated companies in 1932 ranged from 39 percent in iron and products to 63 percent in nonferrous metals including electrical apparatus.[97] Some observers cited the "satellitic" nature of tariff-jumping U.S. industries as responsible for their low rate of innovation.

Important differences are clearly being elided here. These economies, however, were similar in many ways, and they reacted to perceived dependency in the same way Latin America did. Wynia sees far more similarities than differences in his article, "Opening Late-Industrializing

96. Hughes (1987, p. 509). These same themes continued through history and surfaced over American ownership of Australian mines (which had risen to 41 percent by 1967) and agriculture in the 1960s and 1970s. Protests against perceived dependency would peak in virulent objection to the war in Vietnam, and as a reaction against Yankee imperialism that featured prominently in the 1972 labor campaign.

97. Marshall, Southard, and Taylor (1936), cited in Wylie (1990).

Economies: Lessons from Argentina and Australia."[98] Analyzing the difficulties of shifting away from a rent-seeking approach, he sees both economies as attempting more merciful and less costly industrial revolutions, by relying heavily on government regulations and controls, and contrived economic rents. He is careful to note:

> None of this is confined to Latin America. Rent-seeking economics is not derived from that region's patrimonial political traditions or Hispanic affection for corporatist ways of doing politics. . . . Rather, it was a strategy chosen by authorities in nations that were, at the time that economic modernization was accelerated, already too activated socially and politically to permit less politically self-conscious approaches to economic renovation. . . . The Australians were not radically different from the Argentines in their approach to the protection of industry and labor. . . . They were guided by sentiments of nationalism and nativism, stressing the nation's defense against competition from cheaper labor and/or more powerful foreign economies.[99]

This reaction was one of dependent countries seeking to diversify away from the natural resources that maintained the dependent relationship and that appeared to have taken them down during the Great Depression. Locating the region along a continuum is important since it shows precisely that the Latin American countries are not a rare species operating under special economic conditions or laws, but are firmly members of the phylum of late-modernizing, resource-rich countries. They share similar liabilities, but they also have similar possibilities for growth.

Figures 4 through 7 suggest some critical differences, as well. First, the Scandinavian experiment with protection peaked at levels that the Latin Americans exhibited only in their most open periods. Second, most of the beta countries had reduced tariffs below 0.1 by 1950. By contrast, the Latin series are far more volatile and show no consistent trend toward decrease through the end of the 1980s. The average openness series suggests a similar pattern: the beta countries became more closed in the 1930s and 1940s, but by 1950 they had retained their previous levels. Even at their most closed, they were far more open than their Latin counterparts, which by 1989 still had not recovered their 1895 levels.

The greatest departure from the ISI trajectory is found in Sweden, which maintained low tariffs and an aggressive outward orientation throughout the postwar period. Sweden's labor dynamics are highly

98. Wynia (1990).
99. Wynia (1990, pp. 187–88).

suggestive of the importance of resolving distributional issues early and bringing labor onboard to a country's position along the policy continuum. Hjalmarsson finds the anchor of the outward-looking policy in the attitude of Swedish trade unions, which "as early as the 1920s strongly promoted a productivity enhancing industrial policy, emphasizing the rationalization of firms" and placing a premium on continual renewal of technology, plant organization, and machinery.[100] He notes that the 1951 policy document of the Confederation of Trade Unions stresses competition to increase productivity and force less efficient firms out of the market, combined with active labor market policies to reallocate displaced workers. In the 1950s, the confederation was resolutely free trade, strongly criticized government protectionist measures, and "argued that tariffs would decrease productivity growth since it would protect stagnating and less competitive industries." This case shows that there were alternative strategies for managing resource-abundant economies other than the one that Latin America chose.

Industrial Drag on Natural Resource Development

Broadly speaking, the same continuum of effects runs through the second innovation-impeding feature of ISI: industrialization policies, to a greater or lesser extent, were implemented on the backs of the traditional exporting sectors. Possible productivity gains, as well as growth more generally, were stymied rather than encouraged by price incentives. These disincentives and a general inattention to the primary sectors undercut sectoral dynamism.

At one extreme, the Scandinavian and U.S. cases testify to the possibilities of sustained development built on resource endowments. Australia again represents an intermediate case, where the lesser degree to which the country turned away from traditional exports constitutes the critical difference from the Argentine case at the other extreme. As Australia encouraged investment in petroleum, refining, and electrical equipment in the postwar period, it initially neglected the rural sector, which grew at only half the rate of population growth. This led to debates about the logic of stimulating secondary industry in which the country had no comparative advantage and whose lagging performance, it was argued, had led to the

100. Hjalmarsson (1991).

country's periodic balance-of-payments crises. Agricultural policy was reversed in 1952 with granting of investment subsidies, extension of credit, price stabilization programs, and extension of research and extension programs that led to a doubling of production over the next decade.

In contrast, Argentina inflicted permanent damage on its traditional leading sector during the same inward-looking period of the 1940s and 1950s, driving output growth to 0.2 percent per year and leaving the country perilously close to ceasing to export foodstuffs. This combination of inefficient industrialization with the demise of its traditional export sectors left it exceptionally vulnerable to the boom-bust cycles that characterized the region. Australia also suffered from a mild cycle of booms and balance-of-payments crises (and required IMF assistance in 1952), but a rebirth of interest in traditional mining sectors in the 1960s led to increased dynamism in the resources sector. As a result, Australia may soon be ranked fourth worldwide in per capita income, despite not having addressed the continuing inefficiencies of the ISI strategy until the 1980s.

Case Study: Chilean Fruit Exports

The case of resource exports in Chile highlights the magnitude of the impact of the disincentives to innovation and growth of the traditional sectors. Chile aggressively undertook the public good and pro-innovation policies implemented by the successful natural resource exporters, but they were undermined by policies toward the industrial sector. The Promethean efforts of the state development corporation (CORFO), which was founded in 1939 and eventually controlled 30 percent of total investment, laid the foundations for the dynamic export industries of the next half-century. Similar to what Wright documents for the United States, CORFO financed and promoted prospecting for gold, silver, manganese, and iron.[101] To develop the fishing industry, CORFO contracted technical assistance missions, established a marine biology station near Valparaíso in 1945, granted sizable tax exemptions in 1952, joined the army and the University of Chile in surveying the coastal waters in 1954, and established an experimental fishing station in Arauco in the 1960s. It took the first inventories of forest stocks, and it contracted the 1944 Haig technical assistance mission to examine the forestry sector. In the fruit industry, as

101. Wright (1999). See Maloney (1997) for a discussion of Chile in this period.

well, CORFO financed technical assistance missions, extended credit for cultivation and experimental plots, and invested in supporting infrastructure. In 1941, it financed efforts to promote exports of both wood products and wine. There thus appears to have been no want of state support for innovation and progress more generally in the fledgling resource sectors.

The overall context of incentives worked against them, however. CORFO may have been correct in boasting on its twentieth birthday that Chilean history could be divided in two eras—the time before the construction of the Huachipato iron works near Concepción in 1947 and the period after, when the resulting industrial activity transformed the region into an important center of manufacturing. But early on local observers wondered at the costs. A compilation of seminars given in the business community in 1954 entitled "Negative Aspects of Economic Intervention: Failures of an Experiment" praised CORFO's irreplaceable role in creating the electricity and fishing industries, but derided the gross inefficiency of Huachipato and the National Petroleum Company and cited the capriciousness of exchange controls as the overriding disincentive to needed foreign investment. The halving of export volume over the previous decade, the stagnation of agriculture, and the frustration of Chile's tremendous potential in vegetable and fruit exports were traced to irrational intervention in the price mechanisms and the persistently overvalued exchange rate.[102]

In the 1960s, Chile's recurrent balance-of-payments crises led the Christian Democratic government of Eduardo Frei to seek to promote both nontraditional and traditional exports. Yet Chile's areas of natural comparative advantage were stymied by the gross protection and inefficiencies that were the logical culmination of a system of protection and incentives that had mutated into literally incomprehensible degrees of distortion. Jeanneret, a researcher at the Centro de Estudios de Planificación Nacional at the Universidad Católica (CEPLAN), notes that in 1965, "the multiplicity of instruments used, and the frequency with which they were modified, had arrived at such extremes that it was humanly impossible to have a clear vision of their final impact by sector or for the economy as a whole."[103] She finds the effective rates of protection extreme by global standards, ranging from –100 to 650 compared with –50 to 500 for Brazil, –25 to 200 for Malaysia, and –17 to 106 for Nor-

102. Correa Prieto (1954), cited in Maloney (1997).
103. Jeanneret (1972, p. 95).

way. These heavy negative rates of protection implied that ten of twenty-one industries studied could export only at a loss and that "some of these sectors, principally wood, paper, paper products, fish, and other [non-copper] minerals, would have become, perhaps, significant exporters." A contemporary observer, Marko Mamalakis, also wondered at the inability of the agro-export industry to grow, given that "export demand for raw or processed Chilean fruit, seafood, oils, wine, and so forth [was] almost unlimited."[104]

That these disincentives to invest and innovate were critical is borne out by subsequent events. As is well known, the history of the Chilean economy since 1975 has been one of relentless pursuit of integration with the world economy and a correction of the distortions accumulated in the previous decades. Over the next twenty years, noncopper exports increased by a factor of ten, essentially eliminating the traditional foreign exchange bottleneck to industry. The most dramatic expansion, however, occurred in the fruit sector, where exports grew at a rate of 20 percent annually in the first twenty years after the reforms of 1974. Areas planted to commercial orchard almost tripled, and fruit production and the number of entrepreneurs quadrupled.

Jarvis attributes this success to the rapidity with which Chileans were able to transfer, adapt, and extend fruit technologies initially developed for California and other fruit-growing regions to Chile.[105] CORFO again played an important role in laying the foundations for this boom in the early 1960s.[106] Similarly, a ten-year program established in 1965 for cooperation between the University of California and the University of

104. Mamalakis (1976, p. 151).

105. Jarvis (1992).

106. CORFO's interventions included analysis of potential demand; surveying existing fruit orchards; analysis of potential demand in foreign markets; elaboration of production goals; introduction and screening of new varieties; establishment of nurseries to propagate disease-free plants; construction of cold-storage facilities at strategic locations to promote post-harvest care; phytosanitary inspection of exported fruit; and establishment of favorable credit lines and working capital, as well as drawback payments for fruit exports. In 1964 Chile establish the National Institute of Agricultural Research (INIA), which paid relatively higher salaries and attracted more skilled researchers and which initiated a fruit research program. By these means, Chile developed the scientific personnel and knowledge to achieve technological transfer; identified and began to plant new varieties suitable for foreign markets; improved orchard and post-harvest management; upgraded fruit research and teaching; and developed the infrastructure necessary to export fruit to foreign markets. Several export companies emerged and gained experience with foreign markets.

Chile promoted technical cooperation and improved graduate training. This helped the University of Chile to develop first-rate faculty in fruit-related sciences and to begin modern fruit research. Jarvis is clear, however, that most of the post-liberalization initiatives in these areas were privately funded and driven by changes in price relationships and industry structure that increased returns to private R&D. Further down the innovation chain, the number of university theses on fruit submitted in Agricultural Engineering from 1976–80 to 1986–90 increased by a factor of 2.5. Though Jarvis expresses concern that private provision of a nonexcludable good might not continue as profits to the industry are eroded, there can be no question that the story of the renaissance of Chilean fruit is one of innovation made profitable by eliminating bias against the sector.

Conclusion

The logical question is why Latin America occupies the extreme of the continuum sketched here. Much of the explanation lies in political and economic dynamics—timing of the mobilization of urban classes, modernization of the rural areas, the form of integrating new actors into traditional power structures, and so forth—and these dynamics receive attention, particularly among Australian observers. Furthermore, if the data in table 4 are to be trusted, Latin America may have suffered a greater fall in income during the Depression.

However, this paper's focus on national learning capacity and adoption of knowledge from abroad gives rise to three other possibilities. First, the necessary degree of protection to preserve or jump-start industries is likely to be a function of their ability to innovate as fast as their foreign competitors. The Swedish forestry industry does not seek protection from Brazilian and Chilean exporters, whereas nineteenth-century Brazilian iron smelters using archaic *cadinho* technologies complained of competition from more modern producers abroad, despite the high shipping costs. A lower national learning capacity would dictate higher necessary levels of protection to achieve a comparable stimulative effect.

Second, the same deficiency in national learning capacity may have increased the reliance on the technological know-how of foreign actors that exacerbated a sense of dependency and suspicion of natural resources. If Chile had had the capacity to monitor the *Gran Minería* in the 1950s, it

probably would have enjoyed a stronger bargaining position, a greater confidence in copper as a continuing growth industry, a less distortive experiment with ISI, and potentially less divisive politics. Together, these two factors suggest that Latin America's poor postwar performance and the extreme inward-looking policies that contributed to it reflect the cumulative impact of deficiencies with very deep historical roots.

Finally, innovation in economic knowledge may depend on the same national learning capacity. Given the region's low levels of general literacy and the apparent weakness in tapping into foreign advances, Latin America may have been less familiar with the laws of economics and sound management than the beta countries. Duncan and Fogarty argue that Australia emerged from its traumatic period of Depression unemployment with a renewed commitment to economic management and state intervention.[107] However, the country retained the professionals from business and universities who had successfully managed war production and directed them toward maintaining postwar prosperity. There was a fundamental belief in the need for a technically sound basis for economic management and a commitment to remaining engaged in the world economy. In Sweden, Jonung notes how unusually involved professors of economics were and continue to be in public life.[108] Globally renowned figures such as Cassel, Heckscher, Ohlin, and Wicksell were frequent government advisers, promoters of public debate, and even parliamentarians. In the same era, Perón dismissed *técnicos* like Raul Prebisch, arguing that "there can be nothing more elastic than the economy" and that economists' alarmist warnings should be ignored. Comparing Argentina and Sweden in this period almost certainly makes the point too starkly. Nonetheless, it is worrying that many Latin American leaders, in the face of vast international evidence, are even today reverting to policies that will guarantee that the region remains far from the knowledge frontier.

Technical Appendix

Variables

—Initial level of income. For the Maddison dataset, per capita GDP was calculated using the average growth rates per period and the

107. Duncan and Fogarty (1984).
108. Jonung (1992).

per capita GDP (GDPpc) of 1989 in constant 1995 U.S. dollars. To control for different convergence across periods, the variable was calculated relative to the maximum GDPpc in the period. Thus, Initial GDPpc = Max (log GDPpc in *t*) – log GDPpc in *t*. For Sachs and Warner, I use their variable LGDPEA70.

—Net primary exports per worker. Leamer's measure of natural resources is the sum of the exports minus imports of the following categories divided by the number of workers in the labor force:[109]

(1) Petroleum and derivatives (SITC 33);
(2) Raw materials (SITC 27, 28, 32, 34, 35, and 68);
(3) Forest products (SITC 24, 25, 63, and 64);
(4) Tropical agriculture (SITC 5, 6, 7, 11, and 23);
(5) Animal products (SITC 0 to 3, 21, 29, 43, and 94); and
(6) Cereals, oil, textile fibers, tobacco, and others (SITC 4, 8, 9, 12, 22, 26, 41, and 42).

Data are taken from the database used by de Ferranti and others.[110]

—Openness. This variable was taken from Sachs and Warner.[111] It contains a dummy per country and year indicating whether the country was open.

—Investment. For the Maddison database, investment is the average of gross domestic fixed investment divided by GDP. It is taken from Nehru and Dhareshwa's Physical Capital Stock dataset.[112] For Sachs and Warner, I use their variable LINV7089.

—Knowledge index. The index was taken from the database used for Lederman and Xu and de Ferranti and others.[113] It was constructed using R&D expenditures as a share of gross national product (GNP); persons in R&D per million people; patent applications by residents and nonresidents as share of worldwide patents applications; and patent applications in the United States by origin of the applicant as share of total patent applications in the United States. Missing values were imputed using factor analysis with regional and yearly dummies, per capita GDP, and general level of education.

109. Leamer (1995).
110. De Ferranti and others (2002).
111. Sachs and Warner (1995).
112. Nehru and Dhareshwa (1995).
113. Lederman and Xu (2001); de Ferranti and others (2002).