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

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Latin America missed opportunities for rapid resource-based growth that similarly endowed countries- Australia, Canada, Scandinavia- were able to exploit. Fundamental to this poor performance was deficient technological adoption driven by two factors. First, deficient national "learning" or "innovative" capacity, arising from low investment in human capital and scientific infrastructure, led to weak ability to innovate or even take advantage of technological advances abroad. Second, the period of inward-looking industrialization discouraged innovation and created a sector whose growth depended on artificial monopoly rents rather than the quasi-rents arising from technological adoption, and at the same time undermined resource-intensive sectors that had the potential for dynamic growth.

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I. Introduction

The 20th century offered opportunities for rapid resource-based growth that Latin America systematically missed. Even if it were clear that on average natural resource abundant countries have experienced slower growth, the more interesting question is why some – Australia, Canada and the nations of Scandinavia-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 to technological adoption and innovation with deep historical roots. The most important was and remains deficient national "learning capacity", exacerbated in the post war 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 (1955 p.252) argued that "the contention that regions must industrialize in order to continue to grow ... [is] based on some fundamental misconceptions;" and the pioneer trade economist Jacob Viner argued that "There are no inherent advantages of manufacturing over agriculture" (Viner, 1952 p. 72). His claim is supported by estimates that Total Factor Productivity (TFP) growth, the dominant explanation of differences in the growth of GDP/capita,[3] was roughly twice as high in agriculture as in manufacturing globally from 1967 to 1992.[4] Blömstrom and Kokko (2001) argue that forestry will remain a dynamic sector in Sweden and Finland, where rapid productivity growth ensures competitiveness relative to emerging low-wage producers. Wright (2001), drawing on the early US and Australian cases, argues that the stock of minerals is, to an important degree, endogenous and major increases in productivity can be realized in discovery and exploitation. More generally, the literature is clear that these development successes based their growth on natural resources and, by Leamer's measure of resource abundance, several still do (See figure 1).[5]

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[1] An emerging literature (see, for example Sachs and Warner 2001) has argued that resource abundance is associated with slower growth on average. Though this paper will not attempt to resolve this debate, a couple cautionary points are worth making. First, the time period where the data permit reasonable analysis covers 25 years at the end of the 20th century. This is probably not a representative period, including as it does the debt crisis (see Rigobon and Manzano 2001) and structural reforms, and as suggested by the regressions here, 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 NR based sectors, or a non-essential correlate, such as destructive political economy issues (See Auty 2001). See also fn 6.

[2] See, of course, Prebisch, but also more recently Matsuyama (1991), Sachs and Warner (2001), and Rodriguez and Rodrik (1999)

[3] See Parente and Prescott (2000), Dollar and Wolff (1997), Klenow and Rodriguez-Clare 1996.

[4] Martin and Mitra (2001). See also Bernard and Jones (1996), Lewis, Martin, and Savage (1988), Martin and Warr (1993).

[5] See Irwin (2000) for the US; Innis (1933) and Watkins (1963) for Canada; Wright 2001, Czelusta 2001 for Australia; Blömstrom and Kokko (2001) and Blömstrom and Meller (1987) for Scandinavia. Latin

Latin America seemed unable to follow their lead. As a crude summary, regressing Maddison's (1994) well-known growth data from 1820-1989 (table 1a) on Leamer's measure of resource abundance suggests a *positive* growth impact of resources from 1820-1950, but that Latin America's especially poor performance in the post-war period is responsible for the apparent "resource curse" afflicting that era.[6] This underperformance is illustrated more starkly by several examples at the micro level. Despite being far from the innovation frontier, and hence with 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 (Mitra and Martin 2001, and Figure 2). 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 experience appeared in this country until the late 1970s.[7] Wright (2001) categorizes Latin American countries as traditional mineral "underachievers," and massive discoveries of deposits throughout the region in recent years confirm his view.[8] More emblematically, we could ask why a small antipodal dependency, Australia, would discover *La Escondida*, Chile's largest copper mine a century after Chile's once dominant native industry had all but vanished.

Central to every example are the foregone opportunities to exploit the global stock of knowledge to increase productivity growth and create, or perpetuate, dynamic industries as the Nordic and the East Asian miracles have done (Baumol, Nelson, and Wolff 1994, Amsden and Hikino 1994). Or, to paraphrase Di Tella's (1985) 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 "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.[9]

America also offers its success stories: Monterrey Mexico, Medallin Colombia, and São Paolo, Brazil all grew to become dynamic industrial centers based on mining and in the later two cases, coffee.

[6] Leamer's measure of resource abundance, net exports per worker is broadly supported by the Heckscher-Ohlin framework. The greater temporal scope comes at a high cost in terms of available control variables used in other studies and the regressions must be treated as suggestive only. Further, 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 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 or investment variables cannot be employed. (See Lederman and Maloney 2002 for a partial review).

[7] Cited in Maloney (1997, p. 25).

[8] 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, 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.

[9] 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

This article argues that this failure has two central, although by no means exhaustive, explanations. The first is a deficient national "innovative" or "learning" capacity: the human capital and networks of institutions that facilitate the adoption and creation of new technologies.[10] Wright (1999 p. 308) argues that the U.S. success in mining "was fundamentally a collective learning phenomenon" incarnated in intellectual networks linking world class mining universities, and both government and private research, features also under girding Australia's current success and absent in the underachievers. Blömstrom and Kokko (2001 p. 34) 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." 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 (1958 p 57) early on argued 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.…" Parente and Prescott's (2000) simulations suggest that costs in a dynamic context of such barriers to new entry far exceeds the few percentage point differences in GDP accounted for by the Harberger triangles of traditional static models. Anti-competitive forces that discourage innovation or inhibit entry can take the form of guilds, labor unions, concentrated credit markets that only lend to insiders, explicit trade barriers that impede knowledge spillovers from trade interactions (Barro and Sala-i-Martin 1997, Grossman and Helpman 1991), or barriers to FDI. All of these were exacerbated by the prolonged turning inward of the ISI period.

The impact of both factors can be formalized by hijacking Howitt and Mayer's (2001) "convergence club" model that 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. 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; and those with even lower levels of

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 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).

[10] See Stern, Porter, and Furman (2000), Romer (1990), Nelson and Wright (1992)

human capital will not be able to adopt and will stagnate. Though in the steady state the first two groups of countries grow at the same rate, driven by the arrival of new technological advance, the progress to their higher steady-state income levels will cause innovators to appear to grow faster.

Three additional findings of their model are salient to the discussion of rest of the article. 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 in which equilibrium the country finds itself. The inward looking policies of the post-war period merit special focus in this respect. On the one hand, 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 the same effect by reducing the need to innovate to compete.[11]

As a crude test of the plausibility of this view, table 1b adds to the post WWII regressions a "knowledge index" (see technical appendix) comprising measures of scientists per capita, R&D expenditure and patent applications, Sachs and Warner's (2001) measure of trade openness, and the investment rate. The first two columns use the two pooled cohorts of the post-1950 Maddison data, and the last two columns use the single cross-section of Sachs' and Warner's data. Both data tell very similar stories. The new variables appear to capture the effect of the Latin America 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 data set does the measure of resource abundance enter significantly.

The next sections attempt to complement such overworked cross-country regressions by 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, its degree of suffering during the Great Depression, or, in fact, 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

[11] Recent literature by Aghion et. al. (2000, 2002) stresses that for low levels of competition, the traditional Shumpeterian effect that reducing rents decreases innovation is outweighed by the incentive to innovate to escape competition from rivals.

nothing preordained about the disappointments of the last half of the twentieth century—different policies could have led to better outcomes.

II. Deficient National Learning/Innovation Capacity?

Harvard historian David Landes (1998) in his encyclopedic *Wealth and Poverty of Nations* sees the divergence of the two paths of Latin America and Scandinavia as stemming from the differing reactions of northern and southern Europe to the phenomenon of British industrialization. The literature is uniform that Scandinavia was poor at the beginning of the nineteenth century, but 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…"(pp. 248-252).

To this depiction Landes offers the dramatic counterexample of Mediterranean Europe, in particular of Italy, Spain, and Portugal, hurt by political instability and a religious and intellectual intolerance with roots in the *reconquista* and counter-reformation. Further, 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 that of a nation of hands-on tinkerers such as appeared in 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. As examples, Encina (1911) in *Nuestra Inferioridad Economica* and Pinto (1959) in *Chile, Un Caso de Dessarollo Frustrado* are only the best read of a line of critics of aristocratic dandyism and indolence at the root of Chile's stagnation and dependence on foreigners.[12] Nor, in the light of extraordinary expenditures

[12] 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 Jose Santa Cruz, who in his *Reflections on the Economic State of Chile in 1791* saw the potential with a small outlay of displacing the British fishing and whaling activity off the Chilean coast. 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 again recurs in Marcial Gonzalez 1874 speech "Luxury our Enemy" where he argued that the cloths, jewels, coaches, and statues exceed those found anywhere else in America. (Reference in Monteon). Pinto (1959, p.75) cites the historian Francisco Encina: "'If half of what we have wasted in the last 40 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

on luxury goods, are they receptive to savings shortfalls as unavoidable binding constraints on growth.[13]

But there must be some tempering of the condemnation of the entrepreneurial mettle of the Chilean elite, and that of the region more generally. Pinto is also clear that the elimination of Spanish restrictions on trade caused Chilean exports to boom immediately after, 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 pioneered copper mining in their home country. When the price of copper rose in the mid-nineteenth century, production by Chileans increased four-fold from 1844-1860. In response to increased demand rising from the Gold rushes in California and Australia, Chilean wheat exports rose ten-fold in value during 1848-1850.[14] Southern hacendados borrowed heavily to clear lands to expand acreage three-fold from 1850 to 1870 (Conning 2001). Cariola and Sunkel (1985) argue that the early nitrate economy was not merely an enclave in the Norte Grande, but elicited strong response from Chilean entrepreneurs throughout the economy. In general, local talent proved very responsive in certain non-technical sectors and would earn global acclaim across history: two Nobel prizes in literature, a major surrealist/abstract expressionist painter, and first-class musicians.

In fact, Encina's lament was precisely that Chile was losing the dynamism that it once had and this he partly attributes to a dearth of technical education that would permit staying at the forefront of development. Or to borrow Howitt and Mayer's (2001) formalization, Chile's innovation-effective human capital (relative to the technological frontier) depreciated below the critical level for innovation and even for effective adoption. The disappointing growth of Latin America had more to do with a lack of supporting infrastructure for learning and innovation that would enable local

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would today be different.' The propensity to save and invest was not, then, the most striking virtue of our community."

[13]Though Pinto (1959, p. 57) acknowledges some, although almost certainly not enough, of a role for corruption, "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 finance was very important, the British had dominated the nitrates 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 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 does emerge as to why Chilean capital was so willing to sell and to why it did not protest more after the fact. One of the earlier Chilean nitrate pioneers, Jose Santos Ossa, petitioned that, given this dearth of local entrepreneurship, the government 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, implying, 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 1956, p. 56) and not play the Schumpeterian entrepreneurial midwife would cost the country, not only in income foregone, but also in expertise and dynamism that Pinto argues let foreigners dominate in every field of domestic endeavor.

[14] Encina, *Historia de Chile* XIII, p. 486, cited in Will (1957).

entrepreneurs to innovate and hence stay abreast of competition than any *rentier* temperament inherited from Spain.[15] The next sections focus on weaknesses in literacy and technical education as particularly important.

The Foundation of Technical Absorptive Capacity: Literacy

Recent thinking suggests that Latin America's persistent wealth inequality may have had a role to play in slowing the region's ability to adopt foreign technologies.[16] Engerman, Haber, and Sokoloff (2000) 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 due to the patterns of settlement and crops that led to a relative unequal distribution of income in the slower growing areas. This concentration 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.

The marginalization in education may have been particularly important. The concerns with social control, extreme inequality of income, weak public finance, and perhaps an intellectual commitment to a small state, all led to dramatically smaller efforts in Latin America toward universal education than the successful natural resource exporters made. As figure 3 suggests, by 1870 more than 70 percent of the population age 10 or above in Australia, the United States, Canada, and Sweden 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, Uruguay, Chile, and Costa Rica would attain literacy rates of over 66 percent, while Mexico, Brazil, Venezuela, Peru, Colombia, Bolivia, Guatemala, and Honduras would hover at 30 percent until much later (Mariscal and Sokoloff 2000).

As Engerman and Sokoloff (1997, p. 287) note, this is particularly important given that early industrialization reflected the cumulative impact of incremental advances made by individuals throughout the economy, rather than being driven by progress in a single

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

[16] 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 Blömstrom 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 and Armstrong, 1985) and the United States, Blömstrom 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."

industry or the actions of a narrow elite. As one manifestation critical to the development of innovation, they note that the greater equality in human capital accounted partially for the high rates of invention in the United States overall. They also 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."

Blömstrom and Kokko (2001) argue that in Sweden, the introduction of a mandatory school system in 1842 and emphasis on literacy and numeracy was essential for the ability of individuals and firms to learn and adopt new technologies: much elementary learning and technology transfer was based on written instructions like blueprints and handbooks. This also suggests that the extensive literature comparing Argentina and Australia may be missing a critical point. Despite a strong feeling of "there but for the grace of God go we" on the part of Australian authors, it is very clear that, in the mid-nineteenth century, Australia was far closer to the industrialized countries in levels of literacy; this, in a country that until the 1840s was a penal colony of the United Kingdom. The story of the global conglomerate Broken Hill Proprietary Company, LTD (BHP), started by a boundary rider on a sheep station, suggests the importance of a broad base of literate everymen to run with ideas and enjoy supporting institutions.

Technical Education: The Critical Lag

A central theme of Blömstrom and Kokko's account of the Swedish growth experience is the early abundance of high-level human capital—the "impoverished sophisticate" Sandberg (1979) called it. The Universities in Uppsala and Lund date from the fifteenth and seventeenth centuries and technical schools were established in the early 1820s. Examples of other institutions are the Swedish Academy of Science, founded in 1739, and the Swedish Ironmaster's 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 construction of iron bridges and lock gates of the Göta canal, served as training centers. Sweden possessed the fundamentals of a modern engineering industry by about 1850 (Ahlström 1992) and was exporting engineers by 1900. In the same year, serious research in chemistry was undertaken at the University of Oslo that would lay the foundation for the dominant fertilizer, electrochemical, and electrometallurgical industries in Norway.[17] As in 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.[18] The exceptional long-run

[17] Hveem (1991).
[18] Very early on, for example, Scandinavia was exporting know-how in the form of its own émigrés toward tsarist 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

performance of Swedish firms established during this period, Blömstrom and Kokko (2001, p. 10) note, "has been based on the ability of Swedish industry to create, adapt and disseminate new technologies."

By contrast, the colonial period in Latin America enforced a negative intellectual bias in many ways that exactly discouraged the adoption of foreign innovations. Many countries had 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."[19] Largely for reasons of political control, the icon of intellectual discourse, the printing press, was banned in Brazil until 1809 (Baer 2001). The Spanish crown kept out non-Spanish and non-Catholic businessmen, traders, and craftsmen and thus deprived the New World of important skills and knowledge.

Further, 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, and theology, and somewhat less respectably, medicine, and this pattern was replicated in the colonies. The Spanish enlightenment after 1750 saw the establishment of groups of autonomous *sociedaded economicas* 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 had only one functioning *Escuela de Ingenieros Industriales*, located in Barcelona.[20]

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.[21] However, as Will (1957, p. 17) documents for Chile, "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." Similar stories for developments in the nineteenth century are found throughout the region:[22] recurring political instability silenced prominent scientists and undermined fledgling universities; fiscal weakness prevent consistent financing of the sciences; and the unreliable demand for local engineers prevented the career from being lucrative, let alone socially respectable. An

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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)

[19] Memorial plaque at the *Casa de la Inquisicion* in Cartegena de las Indias, Colombia.

[20] Riera i Tuébols (1993).

[21] See Will (1957) for Chile; Safford (1976) for Colombia and Lopez Soria (1999) for Peru. Despite having one of the oldest universities in Latin America, Peru would fail twice, once in 1852-53 with the Escuela Central de Ingenieros Civiles and again in 1875 with the Escuela de Minas, in establishing technical education. They would succeed in 1876 by creating the Escuela de Ingenieros Civiles.

[22] See Safford (1976) for Colombia, Villalobos (1990) and Greve (1938) for Chile, and Baer (1969) for Brazil.

important exception appears in Mexico where the precursor to the *Universidad Nacional*, the *Real Seminario de Mineria*, was founded in 1792 and taught higher mathematics, physics, chemistry, topography, dynamics, and hydraulics. Mexico was the primary exporter of technical knowledge on the continent, and occupied the Vice Presidency of the World Mining Association at the turn of the nineteenth century.[23] Unfortunately, as Cárdenas (1997) makes clear, Mexico was not completely exceptional. 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 70 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. Interestingly, railroads may have played a similar role. As Safford (1976) makes clear, troubled politics and public finances that frequently stalled railway construction undermined the momentum of the engineering profession in Colombia.

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 5 times the numbers of Chile or Colombia in 1920 and Meredith (1995) argues that by 1926, Australia had 27 times more graduates of technical schools per capita than Argentina, perhaps the most educated country in Latin America. Sweden had almost 10 times the density of engineers as Colombia or Chile and to repeat, in this period Scandinavia was exporting engineers innovating at the frontier. 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 Argentina (0.55), Chile (0.7), Educator (0.18), and Uruguay (0.42).[24] Further, it is not clear how good the quality of the Latin American product was. 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.

Does This Really Matter?

The U.S., Scandinavian, and Australian literature strongly supports the idea that such technical capacity, and more generally the ability to learn from abroad, was critical to accessing technological progress abroad and in the long run, the establishment of knowledge clusters. And there are some provocative examples from Latin America.

Perhaps the first bit of evidence is the extraordinary dependence on immigrants as innovators and entrepreneurs in new sectors. Industrialization in Mexico in the late nineteenth century would be almost entirely undertaken by the resident foreigners

[23] I'm grateful to Rodrigo García Verdú of the Banco de México for calling the Mexican case to my attention. http://ingenieria/unam.mx/historia/historial1b.html
[24] OECD (1969).

(Hansen 1971). Using machinery from their homeland, the French started the textile industries in Veracruz and Puebla (Buffington and French 1999), and foreigners also started 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. Hansen argues that there were entrepreneurial spillover effects that drew many Mexicans into the capitalist ranks, but the initial impulse came from foreigners.

Collier and Sater (1996) also note the influence of immigrants in introducing new industry and technologies in Chile. Immigrants set up many of the industrial enterprises of the 1860s and 1870s: 36 of the 46 dressmakers counted in 1854 were French; Americans installed the flourmills; Americans and British built the railroads. Loveman (1979, p. 193) notes that 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, Tiffou, Mitchell, Gabler, Lanz, Klein, Muzard, Lyon, Bernstein, Crichton, Osthous, Stuven."

Fogarty (1985) tells a similar story for the development of beef, Argentina's "super staple," wherein a small group of hacendados, recently arrived from Europe, formed the Sociedad Rural Argentina in 1866. This group spearheaded the transformation of the pampas improving the quality of livestock, pastures, and methods of animal husbandry necessary to take over the U.S. position as principal exporter of cattle to Europe by WWI, with dramatic forward and backward linkages throughout the economy. Fogarty also notes that while in the United States, Canada, and Australia, railroads were sponsored, financed, and constructed largely by nationals, in Argentina, Europeans were the prime movers. In each of these major sectors in the three countries, it was not locals who saw the possibilities for technological arbitrage, as was the case in Scandinavia, but those embodying the knowledge from abroad.

Just as important is the emphasis observers both present and contemporary put on the impact of engineering schools, such as the Antioquia *Escuela de Minas*, as critical providers of talent for emerging industry (see, among others, Safford 1976). In Brazil, Baer (1969) 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. Of the 30 ironworks in the headwater region of the Rio Doce in 1879, only seven used Italian forge methods and 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 Preto, Minas Gerais, which led to the establishment of the first new blast furnace since the failures of the beginning of the century. Graduates of the *Escola de Engenharia do Exercito* established in 1930 would lead the steel industry as it developed through the 1960s.

Australian observers also put great emphasis on the role of non-university innovation infrastructure in explaining the disparate evolution of the wheat industry in Australia, Canada, and Argentina. In all three countries, wheat had an early and firm toehold, but it became the super staple in Canada, largely due to government assistance to prairie agriculture in the form of experiment stations, seed testing services, and technical assistance. Again, this assistance also came on top of determined efforts in Canada and Australia to achieve widespread literacy in the prairies that have no analogue in Latin America. There was also provision of other important public goods that were less knowledge related: for instance, public granaries and a wheat grading system provided quality control that gave Canada an edge over Argentina's wheat, which had the reputation for inferior quality and lack of uniformity.[25] But the provision of an extensive institutional and scientific infrastructure was recognized as key to Canada's success by contemporary Argentines, and compared poorly with the lackluster efforts of the Argentine government.

Case Study 1. Convergence Clubs in Mining in Chile and Australia: Innovation versus Adoption Equilibria, or worse?

Howitt and Mayer's (2001) view of multiple convergence clubs offers insight into the differing trajectories followed by Chile and Australia in copper mining. 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, would discover *la Escondida* and be 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 by 1884 the *Sociedad de Mineria* openly wondered whether Chile's copper mines would survive at all (Collier and Sater 1996, p. 139). This trajectory casts some doubt on theories that argue that market scale is the key complementary factor in explaining why some resource-abundant countries, the United States in particular, became technological leaders(Romer 1996). Chile once had the world market for copper and presumably a scale advantage.

Instead, the missing complementarity was likely to be 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, and excessive reliance on the wasteful *piriquen* system. Chilean historians date this technological slippage to the beginning of the nineteenth century when they note that there was little diffusion of European technologies and that "the work of mining was not very systematic" (Villalobos 1990, p. 95). With the disappearance of the Academy of San Luis, there was no technical teaching of mining in the country and the "receipt of industrial innovations was slow and without visible influence" (Villalobos 1990, p. 96). Charles Lambert, representative of a British mining company in La Serena and trained in the Politechnique in Paris, noted the primitive mining practice, scarce knowledge of minerals, and inefficient smelting, all of

[25] As an illustrative pseudo-experiment, Fogarty (1985) cites that fact that the same year that Spanish Merino sheep were introduced into New South Wales, Australia, a flock was introduced to the River Plate region. 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, due 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 any structural features of the economy.

which represented poor technique relative to that employed in Europe. The Polish mining engineer, Ignaci Domeyko, in 1841 helped establish a small school, and in 1847 the *Universidad de Chile* would begin to teach engineering. But Chile was at this point 80 years behind the first mining school in Europe, and 50 years behind Mexico.

Chilean historians note the dominance of foreigners in applying new technologies[26] and Pinto (1959, p.71) spectacularly underlines how Chile tragically passed up the power that gradual accumulation of know-how offered to maintain competitiveness and dynamism:

> [T]he 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 had behind them neither sufficient accumulated resources, nor the organizational or administrative capacity that 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.

We can imagine a bad feedback loop where inability to innovate leads to lower profits and less innovation-effective human capital arising from experience and hence further inability to innovate or even transfer technology, 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 that Chileans were perhaps "unfit for the modern era" (Monteon 1982 p.62). 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?"[27] 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.[28] One can imagine a sense a frustration among concerned Chileans that the big and visible advances were in

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

[27] Cited in Moran (1974).

[28] 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).

the Guggenheim mines at el Teniente and Chuquicamata, a French steel mill "El Tofo" in Coquimbo, and experiments in fishing by foreign capitalists (Monteon 1982, p. 75).

Chile would continue to slip in its technical capacity in copper. Meller (1991 p. 44) 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." The fact that, in 1952 the Controller General admitted that he had no idea of what went on in the companies (Moran 1974) suggests that part of the feeling of vulnerability and dependency must be attributed to the lack of technical capacity to monitor and confidently critique the actions of the *Gran Mineria*. It was not until 1955 that a government agency was created to oversee U.S. firms' operations and a bureaucracy of Chilean professionals, engineers, and economists created. "In short, it took about forty years, from 1925-1965, 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]" (Meller 1991 p. 45). This is a striking statement in a country that began exporting copper long before the U.S. or Australian firms that would 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, Lagos (1997) argues, may be necessary to transform the north into a regional service center after the inevitable decline in mining production over the next decades.

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, and this firmly linked the country to U.S.-generated innovations (Wright 1999). Diaz Alejandro (1985) would note that Australia's mining exports provided a general interest in scientific and technical research absent in Argentina. Duncan and Fogarty (1984, p. 129) 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." Although far ahead of Chile, Australia lagged the United States (until after 1920) in engineers per 100,000 population—47 versus 128—but Australia would reach 163 per 100,000 by 1955. Several important universities offer 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 the diffusion of 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 a core focus on 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.[29]

In this context, one of Australia's most influential mining companies and industrial conglomerates emerged in 1883: Broken Hill Proprietary Company LTD (BHP). Called

[29] http://www.mines.unsw.edu.au/school.htm; http://unsw.edu.au/about/about_history.html

by those of the region "the cradle of Australian industrialization"[30] Broken Hill oversaw the expansion of mines and smelters and in 1893 the establishment of Australasian Institute of Mining and Metallurgy. When the easily accessed oxide zone was exhausted, Broken Hill metallurgists and engineers among others introduced the flotation process, which, as a residual, allowed the expansion of zinc production by new firms. During WWII, Australia, as the principal member of the Allies in the Pacific, benefited from demand for iron-based goods and transfer of technology. Industrial production rose by 45 percent in the war period and technological acquisition jumped, a gain which subsequent Australian governments would seek 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. Inverting the traditional center/periphery dichotomy, BHP attained a global reach, acquiring mines in the U.S. State of Utah, Canada, and Chile. Australia now exports more in mining expertise-environmentally friendly techniques, mine closure methods, mineral detection techologies- than it does wine.

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

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

The barriers to trade and investment that comprised the inward-looking policies implemented after the Great Depression stand as the second impediment to the transition to a innovation-based economy, and offer a rationale for the negative post-1950 Latin American dummy in the growth regressions. Di Tella's (1985) distinction between entrepreneurs being driven to appropriate the quasi-rents arising from innovations abroad versus exploitation of artificially contrived rents is not new. But it does highlight why the natural resources/manufacturing debate probably misses the point. It is not that you have created a manufacturing sector, but whether you have created a source of innovation, or a brake on the dynamism of the traditional sectors who are forced to subsidize it. Blömstrom and Meller (1991b, p. 9) capture much of the ISI critique when they argue that

> 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.

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

However, Latin America's turn inward and suspicion of resource dependency is at one end of a continuum that passes through Australia and Canada and then to Sweden. As a crude proxy, figures 4-6 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 our beta countries move from 0.1 to 0.16. Within the latter, however, Australia is as dramatic as Brazil, Mexico, or even Argentina, and even Canada could pass for Latin across much of the period.

The usual battery of protectionist measures appeared, and from observers in these countries we hear exactly the critiques of inward strategies so familiar in Latin America. Dehem's (1962) cite of the Hirschman quote above (p. 5) about barriers to innovation was employed, not in the developing countries context, but to explain Canada's "stunted growth" of the 1950s. This theme was picked up by Stykolt and Eastman (1960) seeking to explain the 30-35 percent differential in U.S. and Canadian incomes, as well as low labor productivity. One of the deans of Canadian economic history, Melville Watkins (1963, p. 158), ended one of his better known articles by noting the "the emphasis increasingly placed by economists on the link between the inefficiency of Canadian secondary manufacturing industry and the Canadian tariff."

Prolonged Australian protection also remains the general culprit in most analyses of that country's lackluster industrial growth in this century (Anderson 1987; Maddock and McLean 1987). Fogarty (1985) argues that Australia's tariffs probably were responsible for the stagnation of the industrial sector in the late 1920s, precisely when Argentine manufacturing was growing well. Although it did have an indigenous automobile industry of some promise, and BHP-type conglomerates with solid roots, Australia and New Zealand would also would nurture import-substituting industries that were neither of efficient scale or appropriate given comparative advantage. McLean (1989, p 22), summarizing the extensive Australian literature 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."

Differing Reactions to a Common Dependency

That the policy of other natural-resource-abundant countries would parallel that 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 America.[31] Figures 7-9 and 10-12 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 by the fall in coffee prices, but some countries in the region, such as Argentina, are not distinguishable from the other sample.

Table 4 suggests somewhat conflicting measures of actual impact. On the one hand, the reported falls in per capita output follow the continuum: Latin America hit hardest, then Canada and Australia, and least affected, the Scandinavian countries. Yet the resulting unemployment rates, although notoriously incomparable, suggest that even the impact on Scandinavian countries was very high, roughly doubling during the Depression to levels between 20 and 30 percent. Meanwhile Argentina remained relatively unscathed at under 5.6 percent unemployment. Supporting evidence suggests that the general picture is broadly correct. Aldaheff (1985) 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, an impression confirmed by Alejandro Bunge, a prominent industrialist, in 1932 to London's Argentine Club.[32] Further, that both the lower need for "safety net" expenditures and the fact that the British carried the railway

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

[32] Sodersten (1991) testifies to the traumatic levels in Sweden as well.

debt implied that Argentina would have far fewer fiscal problems than either Australia or Canada.[33]

At a deeper level, the region's concern with asymmetrical power relations in the world economy can be heard elsewhere. As Love (1996) argued, the Rumanian economist Mihail Manoilescu independently developed a dependency theory that strikingly parallels that of Prebisch to explain the evolution of Central and Eastern Europe. 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 generated widespread protests (Hveem 1991). Finland's extraordinary dependence on Russia as a Grand Duchy and the extraordinary debt service repayments from 1945-48, 5-6 percent of GDP is high by even 1980s Latin standards (Haavisto and Kokko 1991). At Australia's centennial in 1880 a sizable fraction of the population, many the descendents 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 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 (Hughes 1987, p. 509).[34] Canada surely can 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 non-ferrous metals including electrical apparatus (Marshall, Southard, and Taylor 1936, cited in Wylie 1990). Some observers cited the "satellitic" nature of tariff-jumping U.S. industries as responsible for their low rate of innovation.

There are clearly important differences that are being elided here. But the fact is that in many ways these economies were similar and they would react to perceived dependency in the same way Latin America did. Wynia (1990) sees far more similarities than differences in his article "Opening Late-Industrializing Economies: Lessons from Argentina and Australia." Analyzing the difficulties of shifting away from a "rent-

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[33] This also implied that fiscal problems during the Great Depression would be minor in Argentina compared with Canada or Australia. Both the lower demands of supporting the unemployed, and the fact that the railways, which ran major losses in all three countries, were largely in private hands in Argentina (whereas in both Canada and Australia they had far larger public participation), lessened the impact on some Latin states. Aldaheff (1985) suggests that half of Canada's budget deficit in 1932-33 and 1934-35 were 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. Further, in terms of managing external debt, debt service was calculated at 17, 22, 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 and it was Australia, who had overborrowed in the 1920s, which 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.

[34] These same themes would continue through history and would surface over American ownership of Australian mines (which had risen to 41 percent by 1967) and agriculture in the 1960s and 70s. 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.

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 (p. 187-188).

The reaction was one of dependent countries seeking both to diversify away from the natural resources that maintained the dependent relationship and which 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 rare species operating under special economic conditions or laws, but are firmly members of the "late modernizing resource-rich countries" phylum. They share similar liabilities, but similar possibilities for growth.

However, figures 4-9 also suggest some critical differences. First, the Scandinavian experiment with protection reached levels attained by the Latin Americans only at their most open periods. Second, most of the beta countries 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 1980's. The average openness series suggest a similar pattern: the beta countries also became more closed in the 1930s and 1940s, but by 1950 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.

Indeed, the greatest departure from the ISI trajectory is Sweden, which maintained low tariffs and an aggressive outward orientation throughout the postwar period. Sweden's labor dynamics are highly suggestive of the importance of resolving distributional issues early and bringing labor onboard to a country's position along the policy continuum. Hjaalmarsson (1991), in "The Scandinavian Model of Industrial Policy," finds the anchor of the outward-looking policy in the attitude of Swedish trade unions who, "as early as the 1920's strongly promoted a productivity enhancing industrial policy, emphasizing the rationalization of firms" that placed a premium on continual renewal of technology, plant organization, and machinery. He notes that the 1951 policy document of the Confederation of Trade Unions stressed 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." The importance of this case is precisely that it shows that that there were alternative strategies for managing resource-abundant economies than the one that Latin America chose.

Industrial Drag on Natural Resource Development

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

At one extreme, the Scandinavian and United States cases testify to the possibilities of sustained development building on resource endowments. Australian observers again see their country as an intermediate case, where the lesser degree of their turning 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 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.

Argentina, across the same inward looking period of the 1940s-50s, inflicted permanent damage on its traditional leading sector, driving output growth to .2% per year and leaving the country perilously close to ceasing to export food stuffs. This combination of inefficient industrialization with the demise of its traditional export sectors left it exceptionally vulnerable and prey to the cycles of boom and bust characterizing the region. Australia would continue to suffer from a mild cycles of boom 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 that may lead Australia to 4th in per capita income in the near future despite inattention to the continuing inefficiencies of the ISI strategy that would not be addressed until the 1980s.

Case Study 2: Chile Redux: Fruit Redevivus

Lest the magnitude of the impact of the disincentives to innovation and growth of the traditional sectors be underappreciated, it is worth going into some detail again on one case, resource exports in Chile, and particularly fruit. Chile aggressively undertook the public good and pro-innovation policies found in the successful natural resource exporters, but would find them undermined by policies toward the industrial sector. The Promethean efforts of the state development corporation (CORFO), founded in 1939 and growing to control 30 percent of total investment, laid the foundations for the dynamic export industries of the next half-century. Similar to what Wright (1999) documents in the United States case, CORFO financed and promoted prospecting for gold, silver, manganese, and iron. 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, and joined the army and the University of Chile in surveying the coastal waters in 1954. It took the first inventories of forest stocks, and contracted the 1944 Haig technical assistance mission to examine the forestry sector. In 1953 it financed processing plants for cellulose and newsprint. In the fruit industry as well, CORFO financed technical assistance missions, extended credit for cultivation and experimental plots, and invested in supporting infrastructure, and in 1941 it financed efforts to promote exports of wood products and wine. Throughout the 1950s and early 1960s CORFO established an experimental fishing station in Arauco, financed construction of modern boats and dock facilities in Tarapaca and Valivia, and founded fish canneries and fishmeal mills. The World Bank-financed Paper and Carton Manufacturing Company in Bio-Bio stimulated paper and cellulose-related forestry activities after 1957. There appears no want of state support for the fledgling resource sectors.

However, the overall context of incentives worked against them. CORFO may have been correct in boasting on its twentieth birthday of Chilean history being divided in two eras: that before the construction of the Huachipato iron works near Concepción in 1947 and that after which 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 saw 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 laid at the feet of irrational intervention in the price mechanisms and the persistently overvalued exchange rate (Correa Prieto 1954 cited in Maloney 1997).

In the 1960s, recurrent balance-of-payments crises would lead the Christian Democratic Government of Eduardo Frei in Chile to seek to promote 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 (1972, p 95), a researcher at the *Centro de Estudios de Planificación Nacional* at the *Universidad Catolica* (CEPLAN), noted 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." She found effective rates of protection extreme by global standards, ranging from –100 to 650 compared to -50 to 500 for Brazil, -25 to 200 for Malaysia, and –17 to 106 for Norway. These heavy negative rates of protection implied that 10 of 21 industries studied could export only at a loss and that "some of these sectors, principally wood, paper, paper products, fish and other 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" (Mamalakis 1976, p151).

That these disincentives to invest and innovate were critical is borne out by subsequent history. 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. In the next 20 years, non-copper exports increased by a factor of 10, essentially eliminating the traditional foreign exchange bottleneck to industry. The most dramatic story, however, occurs in the fruit sector, where exports grew at a rate of 20 percent annually in the first 20 years after the reforms of 1974. Areas planted to commercial orchard almost tripled, and fruit production and the number of entrepreneurs quadrupled.

Jarvis (1992) 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. CORFO again had played an important role in the early 1960s in laying the foundations for this boom,[35] as did the ten-year program for cooperation with the University of California and the University of Chile, established in 1965 to permit technical cooperation and improve graduate training. This helped the University of Chile to develop first-rate faculty in fruit-related sciences and to begin modern fruit research. But Jarvis is also clear 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 non-excludable good might not be as likely 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 a bias against the sector.

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[35]CORFO's interventions included analysis of potential demand; establishing a in 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 INIA 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 that gained experience with foreign markets.

In Conclusion

The logical question is why Latin America occupies the extreme of the continuum sketched here. Though beyond the scope of this paper, 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. Further, if the data in table 4 are to be trusted, Latin America may have suffered a greater fall in income.

However, in keeping with the general focus on national learning capacity and adoption of knowledge from abroad, three ideas suggest themselves:

First, the necessary degree of protection to preserve or jumpstart 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. But it is perhaps not surprising that 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 have a comparable stimulative effect.

Second, the same deficiency in national learning capacity may have implied reliance on technological from foreign actors, which conferred a greater sense of dependency and additional suspicion of natural resources. It is likely that had Chile had the capacity to monitor the *Gran Mineria* in the 1950s, it would have enjoyed a stronger bargaining position, a greater confidence in copper as continuing growth industry, a less distortive experiment with ISI, and potentially less divisive politics. Together, two these factors suggest that Latin America's poor post-war performance, and 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 factors. Between low levels of general literacy and the same 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 Fogerty (1984) argue that Australia emerged from its traumatic period of Depression unemployment with a renewed commitment to economic management and state intervention. But it retained the professionals from business and the 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 (1992) notes how unusually involved professors of economics were and remain in public life. Globally renowned figures such Cassel, Heckscher, Ohlin, and Wicksell were frequent government advisors, promoters of public debate, and even parliamentarians. But this was the same era when Peron dismissed *tecnicos* like Raul Prebisch, arguing that "there can be nothing more elastic than the economy" and that economists' alarmist warnings should be ignored. The latter suggests that this point should probably not be overstressed. Often in Latin American history, the macro-basics are firmly understood by key actors, but the political circumstances overrode their advice. Nonetheless, it is remarkable to hear many of the current Latin American leaders, in the face of vast international evidence, again recurring to policies that will guarantee that over the long run the region will remain far from the innovation frontier.

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TECHNICAL APPENDIX

Variables:

Initial Level of Income: For the Maddison dataset, GDP per capita was calculated using the average growth rates per period and the GDP per capita (GDPpc) of 1989 in 1995 constant US$. In order 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 we use the their variable LGDPEA70.

Net Primary Exports per Worker:

Leamer (1995) measure of Natural Resources: the sum of the exports minus imports of the categories divided by number of workers:

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)
6. Cereals, Oil, Textile Fibers, Tobacco and others (SITC 4, 8, 9, 12, 22, 26, 41, and 42) divided by total labor force. Data was taken from the database used for de Ferranti and others (2002).

Openness: This variable was taken from Sachs and Warner (1995). It contains a dummy per country and year indicating if the country was open or not.

Investment: For the Maddison database, it is the average of Gross Domestic Fixed Investment / GDP. It is taken from Nehru and Dhareshwa Physical Capital Stock dataset (World Bank). For Sachs and Warner we use their variable LINV7089.

Knowledge Index: The index was taken from the database used for Lederman and Xu (2001) and de Ferranti and others (2002). It was constructed using R&D expenditures as a share of 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, GDP per capita, and general level of education.

Table 1. Rates of Growth of GDP per Capita, 1820–89

(Annual average compound rate of growth)

	1820-70	*1870-1913*	*1913-50*	*1950-73*	*1973-89*
The European capitalist core and its offshoots					
Austria	0.6	1.5	0.2	4.9	2.3
Belgium	1.4	1.0	0.7	3.5	2.0
Denmark	0.9	1.6	1.5	3.1	1.7
Finland	0.8	1.4	1.9	4.3	2.8
France	0.8	1.3	1.1	4.0	1.9
Germany	0.7	1.6	0.7	5.0	1.9
Italy	0.4	1.3	0.8	5.0	2.6
Netherlands	0.9	1.0	1.1	3.4	1.3
Norway	0.7	1.3	2.1	3.2	3.1
Sweden	0.7	1.5	2.1	3.1	1.7
United Kingdom	1.2	1.0	0.8	2.5	1.9
Australia	1.9	0.9	0.7	2.4	1.7
Canada		2.3	1.5	2.9	2.4
United States	1.2	1.8	1.6	2.2	1.6
Average	**0.9**	**1.4**	**1.2**	**3.5**	**2.1**
European periphery					
Czechoslovakia	0.6	1.4	1.4	3.1	1.3
Greece			0.5	6.2	1.7
Hungary		1.2	1.2	3.5	1.2
Ireland			0.7	3.1	2.9
Portugal		0.3	1.4	5.6	1.7
Spain	0.6	1.4	0.2	5.1	1.8
Soviet Union		0.8	2.3	3.6	1.0
Average	**0.6**	**1.0**	**1.1**	**4.3**	**1.7**
Latin America					
Argentina		1.9	0.7	2.1	-1.2
Brazil	0.2	0.3	2.0	3.8	1.7
Chile			1.7	1.2	1.5
Colombia			1.5	2.1	1.8
México	0.4	1.1	1.0	3.1	1.0
Peru			1.4	2.5	-1.2
Average	**0.3**	**1.1**	**1.4**	**2.5**	**0.6**
Asia					
Bangladesh			-0.3	-0.7	2.2
China	0.0	0.3	-0.5	3.7	5.7
India	0.0	0.3	-0.3	1.6	2.7
Indonesia	0.2	0.5	-0.2	2.1	3.4
Japan	0.1	1.4	0.9	8.0	3.0
Korea			-0.2	5.2	6.4
Pakistan			-0.3	1.8	2.8
Taiwan			0.4	6.2	6.1
Thailand		0.4	0.0	3.2	5.2
Average	**0.1**	**0.6**	**-0.1**	**3.5**	**4.2**

Source: Maddison (1994).

Table 2a. Growth Correlates: Maddison Data, 1820-1989

Growth Summary Regressions	Period					
	1820-1989		1820-1950		1950-1989	
	a	b	a	b	a	b
Convergence measure (1)	-0.265**	-.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	.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**	.935**	.92**	1.96	2.11
	(2.69)	(2.80)	(6.73)	(6.63)	(5.25)	(5.55)
Obs.	**147**	**147**	**73**	**73**	**74**	**74**
R-squared	**0.35**	**0.36**	**0.38**	**0.40**	**0.19**	**0.22**

(t-student values)
Note: * Significant at 10% level; ** Significant at 5% level. (1) Difference in GDP per capita to the most advanced country. (m
Source: Author's construction using Maddison (1995) and WDI
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Table 2b. Growth Correlates including Measures of Openness, Knowledge, Maddison and Sachs, and Warner Data

Dep.var.: Average Annual Growth Rate	1a	1b	2a	2b
Initial Level of Income (1)	-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 (2)		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)
Obs.	**72**	**72**	**91**	**91**
R-squared	**0.22**	**0.47**	**0.15**	**0.57**

(t-student values)

Note: * Significant at 10% level; ** Significant at 5% level. 1a and 2b use Maddison(1995) database. 2a and 2b use Sachs and Warner (1997) (1) for 1a and 1b relative to the maximum GDP per capita of each period.
(2) Missing values were imputed using factor analysis (See Technical Appendix)

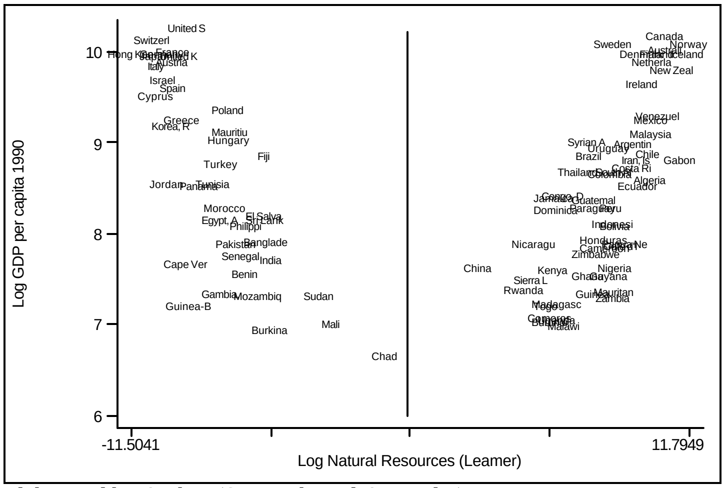
Table 3. Density of Engineers at the Turn of the Twentieth Century		
Country	*Year*	*Engineers per 100,000 workers*
Australia	1920	47
Chile	1930	6
Colombia	1887	8
Sweden	1890	84
United States	1920	128

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

Table 4. Impact of the Great Depression (Percent)

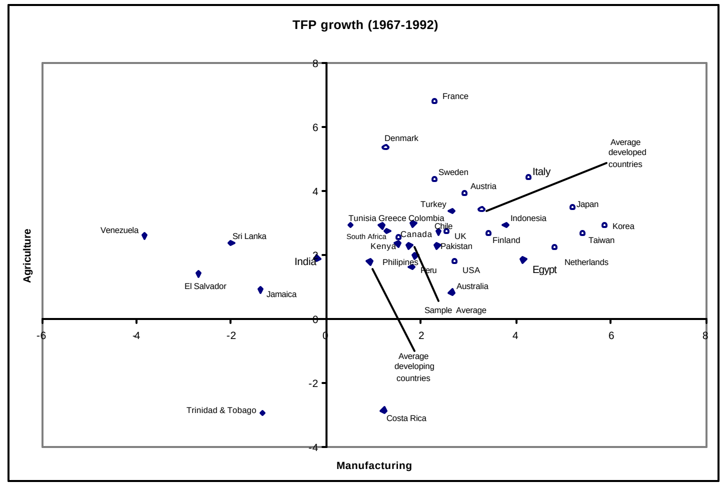
Country	*Changes in terms of trade of commodities exports 1928-1932*	*Max. unemployment*	*Max. negative change in GDP compared with 1929*
Argentina	–45.0	5.6 / 7	–14.0
Brazil	–61.1		–6.0
Chile	–45.6	7.0	–27.0
Colombia	–56.5		–2.0
México	–51.5	6.0	–17.6
Australia	–51.5	20.0	–9.7
Canada	–58.3	19.0	–25.1
Denmark	–	32.0	positive
Finland	–46.3		–4.0
Norway	–38.0	33.0	–2.6
Sweden	–55	24.0	–4.0

Source: Mitchell (1998a, 1998b, 1998c) and Sadie (1969).
Elaborated by Author.



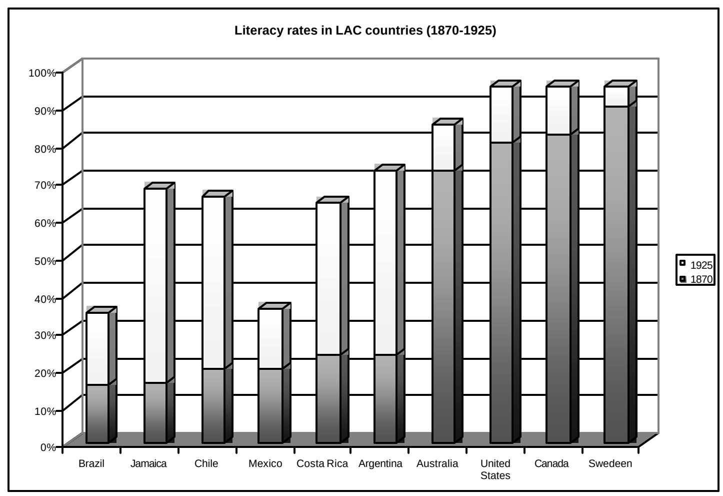
Elaborated by Author (See Technical Appendix)

Figure 1



Source : Martin and Mitra 2001.

Figure 2



Sources : Mariscal and Sokoloff 2000, and Meredith 1995.

Figure 3

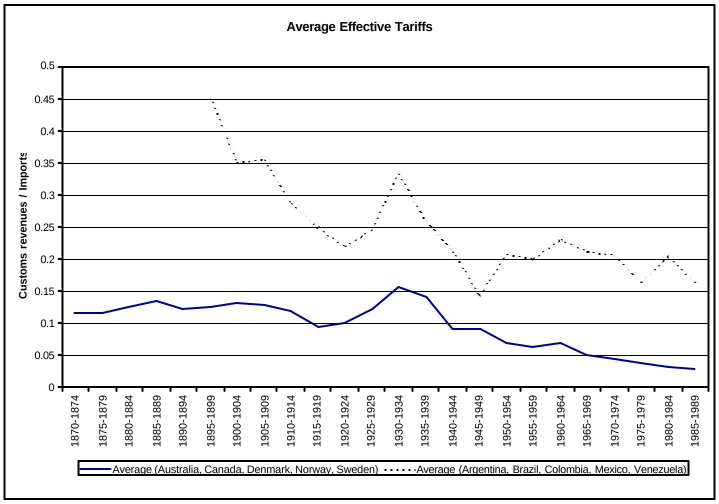


Figure 4*

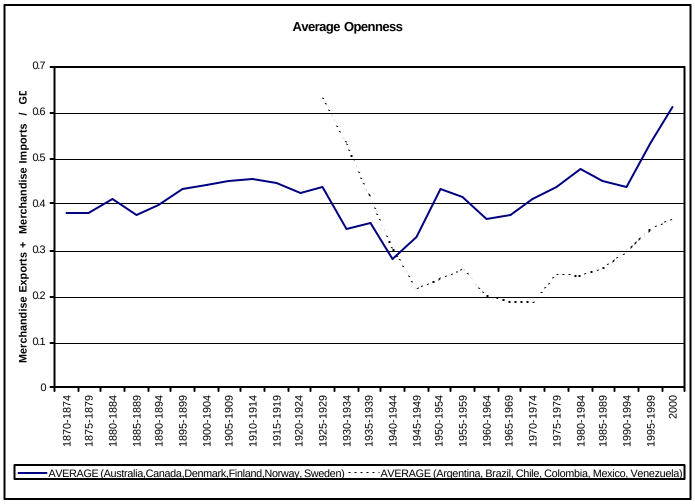


Figure 7*

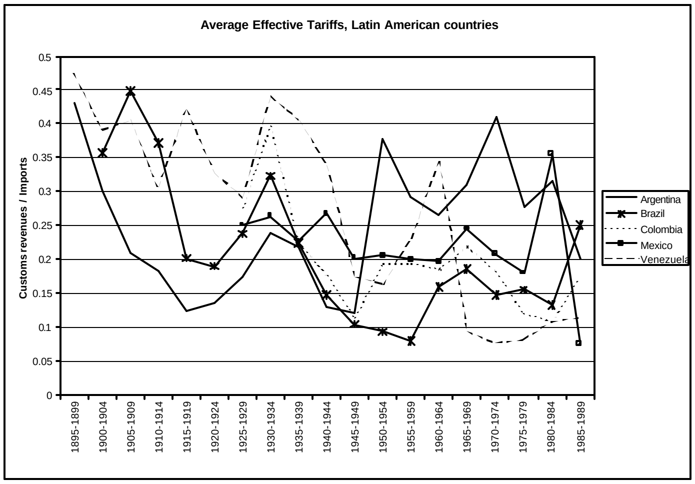
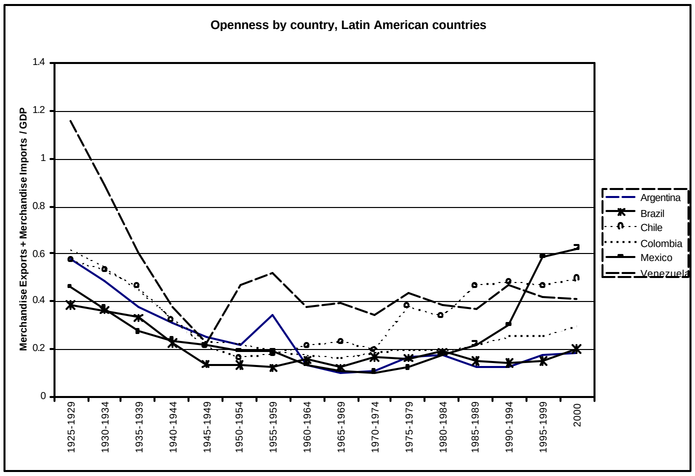


Figure 5*



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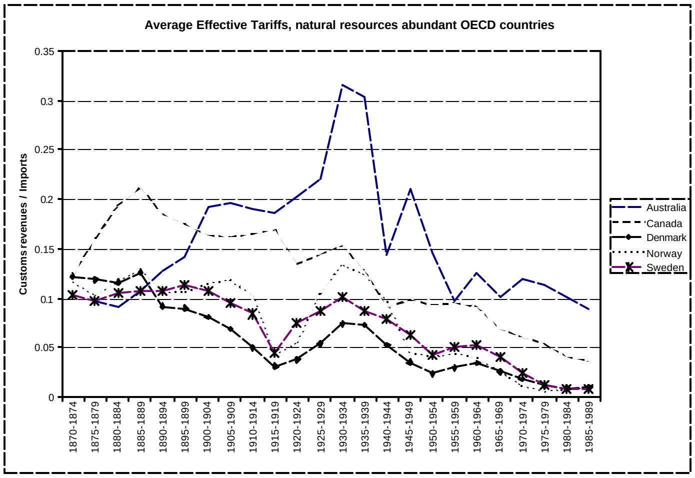

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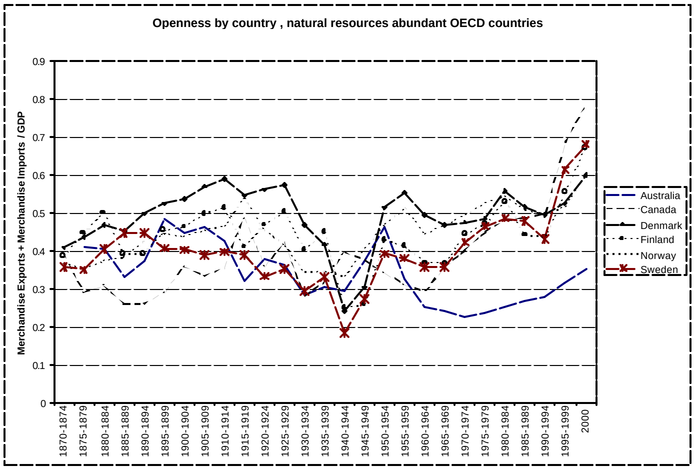

Figure 9*

***** *Source:* Elaborated by Author using Mitchell 1998a, 1998b and1998c.

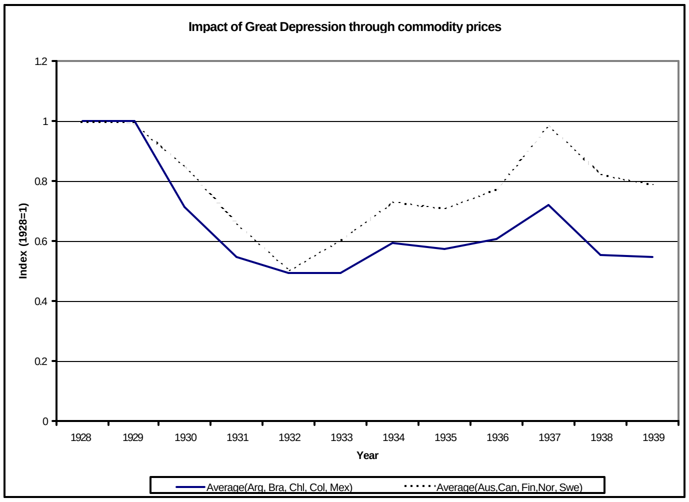

Figure 10*

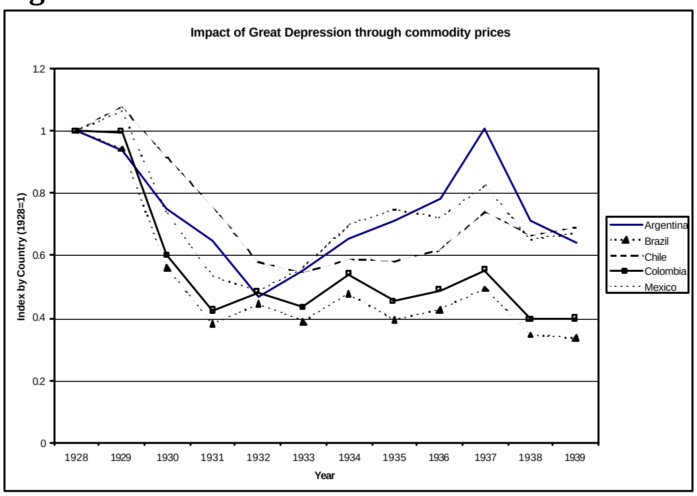

Figure 11*

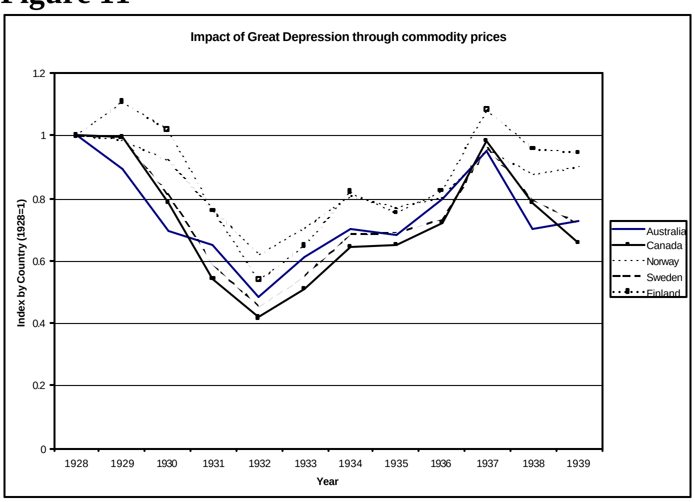

Figure 12*

***** *Source:* Elaborated by Author using Mitchell 1998a, 1998b and1998c.