Learning to Learn: Experimentation, Entrepreneurial Capital, and Development[*]

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Abstract

This paper models an entrepreneur's choice between investing in a safe activity or experimenting with a new risky one, and how much to invest in "entrepreneurial capital" that permits more effective use of arriving information on the latter- how much to learn how to learn. Optimal investment depends on the cost, the distance from the entrepreneurial frontier, and non-monotonically, on the expected return on the risky activity, leading to three learning regimes including a potential resource curse. The model is supported by historical evidence from Latin America and simulations of the relative decline of the Chilean versus US copper industries.

Keywords: Learning, Experimentation, Entrepreneurial capital, Development, Resource curse

JEL Codes: O31, O32, O13, D83

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1 Introduction

Entrepreneurship is experimentation in projects of uncertain payoff (Knight, 1921; Callander, 2011; Kerr et al., 2014; Manso, 2016; Braguinsky et al., 2020). More broadly, development can be thought of as a process of experimenting with a series of new projects ranging from adopting new technologies, to entering new industries, to experimenting with new and untried ways of organizing society. This paper models the entrepreneur's problem of whether to engage in such projects as not only one of acting on signals about their profitability, but critically, of how much to invest in the ability to learn from these signals, what we term "entrepreneurial capital."[1]

The idea that firms learn from experimentation is well-established in the literature: Rosen (1972) and Ericson & Pakes (1995) specifically model firm learning by doing.[2] Callander (2011) models agents learning about new products of varying complexity through a trial and error process and observing previous agents' experience. Most recently, Braguinsky et al. (2020), drawing on the case of Japan at the turn of the 20th century, see diversification as a risky process requiring new machines and technologies and hence firms first introduce innovative products on experimental basis. However, history suggests that some entrepreneurs are better at learning than others- as Rosen (1972) notes "...decision makers are 'made' as well as 'born' " and we model this by allowing for costly investment not in the precision of arriving information, which we take as a central but now well-explored problem, but in how much information of a given precision changes the beliefs on the relative payoffs- how well agents learn.

Our model is in the tradition of the literature on optimal investment in R&D. Roberts & Weitzman (1981) is among the earliest papers that study R&D from a learning perspective in a sequential context. There, the agent experiments to learn about the value of a project and optimally decides when to stop experimentation. Bolton & Harris (1999) and Moscarini

[1] The term entrepreneurial capital is also used in a related context by Gonzalez-Uribe & Leatherbee (2018) to distinguish start up skills from the "managerial capital" found in established firms.

[2] This said, Ericson and Pakes elsewhere argue that that learning by doing, an automatic or "passive" form of learning, differs from active experimentation although, as Braguinsky suggests, they may be difficult to distinguish empirically. We are grateful to Serguey Braguinsky for this clarification.

& Smith (2001) subsequently approach the problem in a bandit (slot machine) context in continuous time and the first part of our model draws on the former. Here, each agent chooses the frequency of playing (pulling) a risky arm whose payoffs follow Brownian motion, and a safe arm, and thus endogenizes the precision of an "aggregate signal." Pulling the risky arm helps learn the unknown drift of the risky arm but the cost of increasing the precision is the opportunity cost of not exploiting the safe arm.[3]

Entrepreneurship poses a similar problem in that agents need to decide how much to invest to find out whether a given idea or industrial project will prove profitable- how many experts should be hired, how many technical missions should be undertaken abroad, how much time should be spent trying to adapt a technology to a local context, or sell a new product to a local market. However, we go further to explore how efficiently this arriving information is used. We capture the "efficiency of learning" through the precision of the prior distribution, which we treat as inversely related to the level of accumulated entrepreneurial capital.

This capital could be anything that helps an entrepreneur understand the implications of newly arriving information for the profitability of a project such as business skills- ability to calculate likely return streams or judge and manage risks, or engineering or scientific capabilities to be able to judge technical feasibility. Hence, two individuals, one in Boston and one in Bogotá may receive identical information on the increasing use of steam engines in Manchester, but the first may have the accumulated technical and business background to conclude that, while not without risk, the expected pay off of the steam engine in the local context justifies experimenting with it, while the second can neither comprehend the technical parameters, nor assess the risk-return profile of the likely stream of benefits of the technology and hence his prior is unaffected by new information. The needed positive signal on return to induce experimentation is insuperably high- the entrepreneur is effectively blind to new opportunities and hence, stays with the known and 'safe' technology.

The less refined priors leading to engaging in new projects bears semblance to the class

[3]Keller et al. (2005) and Keller & Rady (2010) have explored the same issue but for exponential and Poisson bandits respectively.

of "reverse Bayesian" models in Karni & Vierø (2013), where priors become more diffuse with "increasing awareness," and heretofore unperceived possibilities for investment become visible. In particular, the increased awareness of consequences of actions could be seen as a dimension of our entrepreneurial capital that makes some projects appear feasible that were previously not considered so. However, our approach differs in that agents are always aware of the full state space of possible actions, higher entrepreneurial capital just increases the likelihood of choosing the risky project. Also, the probability of states does not change uniformly as their theory states, it depends on the variance of the prior and the distribution of signals.

The stickiness in updating priors in the absence of entrepreneurial capital is observationally equivalent to being more "risk averse" and in that sense we are providing an explanation for differences in observed risk taking across countries that does not rely on postulating different core parameters in the utility function. The impact is the same, however: If agents forego the risky project, they will also forego the knowledge that engaging in that task would bring, and hence they may not see the value of investing in how to learn about the profitability of new activities, with long term growth consequences.

The investment in entrepreneurial capital could take many forms. It might include straight up business or technical education, but it might include going abroad to work in more advanced industrial sectors, joint ventures with established entrepreneurs, and generally learning to learn by doing.

We show the decision to invest in entrepreneurial capital is affected by the perceived benefit from investing in it, which is non-monotonic in the expected returns to the risky project, the cost of acquiring it, and the distance from "frontier" levels of entrepreneurial capital. This raises the possibility of a new information-driven development trap: In a country which, for historical reasons comes late to modernity and begins with low entrepreneurial capital, and/or has very high costs of accumulating it, entrepreneurs cannot see the potential in the industrialization project because they cannot confidently assess it, do not experiment, and hence do not invest in the ability to interpret the signals associated with future new opportunities. Even worse, absent such investment, as modernization proceeds and new projects become more complex, the frontier-adjusted level of signal interpretation skills will fall, potentially leading entrepreneurs and countries to regress- abandoning even established industries as they become more sophisticated.[4]

The model identifies three equilibrium "learning regimes." In the first, if it is very costly to accumulate entrepreneurial capital and/or the expected return to risky projects is low, it will not pay to invest in better ability to process information about them. This is also true at the other extreme, the second regime, where returns to the risky project are expected to be far above those to the safe project thus obviating the need to invest in the ability to more finely compare between them. As a example relevant to our historical discussion, Adam Smith argued in the *Wealth of Nations* that investors had "absurd confidence" in exaggeratedly high returns to mining which, in our model, will discourage investment in entrepreneurial capital and pose a type of learning-displacing resource curse. Both regimes can lead to a development trap where entrepreneurs never gain the ability to assess the value of newly arriving technologies and products, and hence stay in low growth or even rent seeking sectors. The third regime occurs in the intermediate zone where the expected safe and risky returns are not too far apart, raising the benefit of being able to better use information on the latter, and leading to investment in entrepreneurial capital.

The model permits interpreting three central but heretofore understudied stylized facts surrounding entrepreneurship and industrialization in the Americas at the turn of the 20th century. This period comprises the Second Industrial Revolution and the initiation of the Great Divergence where the US surged ahead while most of Latin America fell behind.[5] First, despite facing the same institutional and business climate and similar access to finance, immigrants and foreigners were disproportionately the drivers of industrialization in Latin America, particularly in more complex sectors, suggesting the possession of a differentiating

[4]The same phenomenon captured in the models of Howitt (2000); Aghion et al. (2005); Howitt & Mayer-Foulkes (2005) where as the technological frontier shifts out, the skill level required to maintain the same level of absorptive capacity also increases, applies to management skills as well.

[5]Mokyr (1998) dates the second Industrial Revolution as taking place roughly 1870-1914 where there was an acceleration in innovation after a lull after the first phase, and an increased emphasis on more structured scientific inquiry such as laboratory based R&D.

entrepreneurial capital beyond basic human capital which presumably local elites also had. Second, there appears a substantial degree of variability in indigenous entrepreneurial zeal across regions, despite a purportedly prevalent anti-entrepreneurial cultural inheritance across Latin America, with some regions, such as Antioquia, Colombia, gaining fame as entrepreneurial hot beds. Further, this zeal varies over historically short time periods sometimes appearing as what we term *entrepreneurial retrogression* where once clearly dynamic regions or industries fall behind and then, in some cases, regain dynamism. Both are arguably more consistent with differential learning occurring amid a rapidly shifting technological frontier than slower moving cultural factors often postulated. Third, very similar economic structures, for instance a heavy presence of mining, generated very different development outcomes across countries, consistent with vastly differing complements of entrepreneurial capital. In particular, historical accounts are consistent with the high returns to copper extraction in Chile (and arguably mining across all of Latin America) making investments in entrepreneurial capital unnecessary in the moment, a decision which subsequently impeded both modernizing the sector and entering new ones. By contrast, in the US and Japan, mining of the same homogeneous good appeared to contribute a foundation for growth and diversification.

Having said this, we do not deny the import of culture-more entrepreneurial traditions implicitly lower the cost of acquiring entrepreneurial capital. Further, exclusionary institutions prevent large shares of the population from acquiring EC, and clearly better institutional and business climates raise the returns to all experiments.

In the final section, we show that the model is able to simulate the respective decline and boom in the Chilean and US copper industries at the turn of the century, arising either from initially high relative returns or low initial endowments of entrepreneurial capital in the latter, either of which would discourage investment in entrepreneurial capital in Chile, and impede upgrading and diversification. The patterns cannot be explained by the relative trajectories of human capital (literacy) that might simply raise the return to investment, or to aggregate capital accumulation.

The paper speaks to the importance of the emerging literature documenting the lag in managerial capabilities in developing countries (Bloom & van Reenen, 2007), where Latin America is shown to continue to lag the advanced countries, and the potential for policy to engineer their improvement (Bloom et al., 2013; Bruhn et al., 2010; Giorcelli, 2019; Iacovone et al., 2021). It contributes to the discussion of organizational capital (Atkeson & Kehoe, 2005; Lustig et al., 2011; Eisfeldt & Papanikolaou, 2013) -a type of unmeasured and non-transferable capital distinct from physical, and human capital that affects the technology of production- which Atkeson & Kehoe (2005) allow to encompass endogenous firm learning by doing such as that of Ericson & Pakes (1995) and Rosen (1972).

It also speaks to the literature stressing the choices entrepreneurs make between productive and unproductive (redistributive or rent seeking) activities. Baumol (1990, 2010) stresses the critical role of incentives in the emergence of a dynamic entrepreneurial class, including those embodied in social norms and culture and Murphy et al. (1991) model how the returns to entrepreneurial ability lead to sorting of talent into or out of entrepreneurship. In both cases, the overall business climate and institutional regime (see for example North, 1990; Robinson & Acemoglu, 2012) can alter the relative rewards and hence, the potential rate of growth. While acknowledging the importance of these factors, we argue for the quality of entrepreneurs as a necessary complement to the enabling environment, and that it is the endogenous outcome of cumulative entrepreneurial decisions. In a potential inversion of the logic above, below a certain level of entrepreneurial capital, entrepreneurs may not be able to identify or explore productive new opportunities and hence default to safer lower return activities, which might include creating rent seeking options.

Finally, the paper shares a kinship, albeit with a different mechanism, with the Schumpeterian literature stressing how different technological endowments can lead to different abilities to absorb or invent new technologies and hence to different growth convergence clubs (Howitt & Mayer-Foulkes, 2005), the empirical work on innovative capacity proxied by engineering as a determinant of growth (see, for example, Maloney & Valencia, 2022), as well as the broader literature on national learning (see, for example, Stiglitz & Greenwald, 2014).

2 Historical Evidence on the Importance of Entrepreneurial Capital

Clear measures of entrepreneurial capital are hard to come by- Few business school programs had been established and less formal ways of learning are by nature hard to quantify. Instead, we explore three features of entrepreneurship at the time of the second industrial revolution that are consistent with our framework.

2.1 The dominance of foreign entrepreneurs in the industrialization process

The fact that immigrants and foreign entrepreneurs play a disproportionate role in the industrialization process in Latin America despite facing an identical institutional and business climate and without enjoying especially favorable access to credit suggests that they embodied a cultural or human capital that local entrepreneurs lacked. Table 1 draws on collected data on firm ownership from detailed census data for Argentina, Mexico and the US, as well as other industrial source data from Brazil (Bresser Pereira, 1994; Birchal, 1999), Chile (Ortega, 1990), Colombia (Rincón et al., 2005; EAFIT, 2013; Becerra & Restrepo, 1987), and the US, at the turn of the 20th century (see Annex 1). Column 2 presents the share of firms owned or started by locals and immigrants for select countries and regions around 1900. Column 3 presents the share of immigrants in the population. Columns 4 and 5 standardize immigrant ownership by share in the population and can be interpreted as a measure of "comparative advantage in entrepreneurship" both relative to the total population and to the male population. Since in this period, most firms were started by men and most immigrants were men, the latter, while a lower bound for immigrant CA, is probably closer to the truth.

Looking first at the US, we find that roughly 30% of firm owners were immigrants which does suggest the importance of immigrants to the US growth process. That said, roughly 27% of the male population was immigrant so that overall, immigrants do not appear more or less entrepreneurial than native born. Another indicator is that of fortune 500 firms started by immigrants and here immigrants are slightly underrepresented.[6]

The picture from Latin America is dramatically different. In Argentina, the richest Latin country in our sample, 80% of owners/directors were immigrants (see Annex 1 for detail). However, it is also the case that 60% of the male population was comprised of immigrants so that overall they show perhaps 30% more propensity to start businesses than locals. The dominance of immigrants is supported by secondary sources that suggest that much of the dominant meat industry and the railroads, which were sponsored, financed, and constructed largely by nationals in Australia, Canada, and the United States, were undertaken by Europeans. The emblematic meat salting industry was started by two Englishman (Scobie, 1964), and more generally, the beef industry was spearheaded by recent arrivals who formed the *Sociedad Rural Argentina* in 1866 which led the transformation of the pampas, improving the quality of livestock, pastures, and methods of animal husbandry (Fogarty et al., 1985).

In São Paulo, Brazil 50% of large businesses were started by immigrants (70% if we include progeny), 50% more than would be expected given their share in the population. This was also the case in Rio de Janeiro and some parts of Minas Gerais. In the former, between 1878 and 1895, (Prado in Birchal (1999)) most textile mills were founded by foreigners, who owned 62% of wholesale textile trade in Rio, and foreigners soon dominated the manufacturing activities closely linked to their commercial activities. In both São Paulo and Rio, the first electricity generating companies were founded by foreigners. Birchal (1999) documents that Juis de Fora, Minas Gerais, a major steel and manufacturing area from 1858-1912, immigrants were responsible for 66% of industries (Birchal, 1999, p.26).

In Chile, 70% of steam powered businesses were started by immigrants, roughly 12 times their share in the male population. Again, this conforms with other historical accounts. Silva Vargas (1977a) notes that "the lack of entrepreneurs and of qualified national workers gave to the incipient Chilean industry, a markedly foreign air."(p 94)[7] Collier & Sater

[6]We are very grateful to Richard Sutch for the census sample data and to he and Larry Neal for extremely helpful discussions.

[7]... the lack of entrepreneurs and of qualified national workers gave to the incipient Chilean industry,

(1996) document that thirty-six of the forty-six dressmakers counted in 1854 were French, Americans installed the flour mills and Americans and British built the railroads. The port of Valparaiso became a major center of commerce dominated by foreigners. In 1860, of the 909 establishments surveyed by the government, 674 belonged to foreigners. For the country as a whole, the list of officers and members of the executive committee of SOFOFA, the principal organization of industrialists for the country, showed that that only three Spanish surnames accompanied those of the other 18 members of the directorate (Loveman, 1979, p. 193). Further, by 1920, as with mining more generally in Mexico, the vast copper enterprises were entirely foreign.

Two of Colombia's subregions also show very strong immigrant dominance: In the dynamic port of Barranquilla 64% of establishments were foreign owned, 3 times what would be predicted by the male immigrant share, and tax records suggest that, as in Mexico, they were largest ones. Further, as in Chile, foreigners introduced steam technology for manufacturing and transport, revolutionizing navigation from the port to the interior of the country. As Becerra & Restrepo (1987) note, "the entrepreneurs of foreign origin occupied an indisputable place as pioneers across the 19th century, in the emergence of Barranquilla as the primary port of the country."(p.35) High foreign participation is also notable in Santander where 50% of the most notable entrepreneurs were foreigners, roughly 8 times their representation in the population.

In Mexico, the industrial census shows that 50% of businesses were owned by immigrants or 26 times their share of the male population. As Annex 1 shows, the share of investment and production by foreigners is even greater, especially in mining, suggesting that our census data may be understating foreign influence in all countries. This is in line with Beatty (2015) who confirms the complete US domination of mining and Hansen (1971) who argues that industrialization was undertaken almost entirely by the resident foreigners. The French started the textile industries in Veracruz and Puebla, and foreigners also started Mexico's first

a markedly foreign air. Anwandter and Meschner (Beer), Poppe (cotton), Tiffou (tanneries) Rudlof and Benedetti (shoes), Gleisner (furniture, tanning, soap), Kuppfer (smelting), Reiche (spinning), Sciaccaluga (canning), Goeckel (soap), Osthaus (rigging), are some of the names linked to the earliest manufacturing activities....p. 94.

iron and steel plant in 1903, the Fundidora de Fierro y Acero de Monterrey, which would anchor what is now the premier industrial city in the country (Haber, 1997; Buffington & William, 1999). Though Mexican entrepreneurs emerged to play important roles, the census data, confirms the large foreign participation even deep into the 20th century. In fact, Haber (1995) notes about the post-revolution rise in the textile industry that "like the Porfirian giants, their owners were, for the most part, not Mexican. Indeed the most striking thing about this new group of entrepreneurs was that they were predominantly Eastern European Jews, Lebanese, and Syrians who had come to Mexico in the 1920s fleeing religious persecution" (P.187).

This outcome does not appear a result of access to finance. Accounts from São Paulo, Brazil (Bresser Pereira, 1994), Minas Gerais, Brazil (Birchal, 1999), Barranquilla, Colombia, Becerra & Restrepo (1987) and as discussed below, Chile, show that immigrant entrepreneurs were predominantly middle class or below and most of their ventures were self-financed. Haber (1995) notes that the refugees that built the textile industry began as petty traders in the cloth business selling socks and underwear door to door, but "by the 1930s had amassed enough capital that they were able to become owners of small mills." By 1938, foreign names dominated the tax registry for the textile industry.

Further, foreigners dominate across the product space, but especially in the more technologically advanced sectors. For Argentina, Annex Table A.1 selectively draws from a 200 sector disaggregation to show that in only a few sectors is there a high or dominant participation of locals and these are the traditional ones, such as sugar cane processing mills sugar refining, and wool fabric. Immigrants dominate in fields ranging from seemingly basic sectors (espadrilles, shoes, shirt-making, dressmaking carpentry, baking furniture making, tailoring and tanneries) to the most technically advanced sectors sectors (lumber mills, carriages and other vehicles, trolleys, iron works and mechanics shops). In Barranquilla, Colombia, foreigners again dominate all industries related to the new steam technologies-steam boats-the critical innovation for integration of the country via the Magdalena river-, steam sawmills, as well as insurance, telephones and trading houses. Colombians are most represented, although not always dominant, in brokerage, canned foods, retail, and hostelry.

In Mexican manufacturing, table A.2 does not suggest patterns as clear as those found in Argentina or Barranquilla. However, Table A.3 allows us to examine the extraction-related industries and reveals an overwhelming participation of foreigners in what was among the most technically advanced sectors of the age, mining as well as oil extraction, and refining, sectors in which Mexicans held under 2% of investment.

2.2 Learning to Learn

A long literature would explain these patterns by cultural inheritance. An overwhelming consensus exists among historians of virtually all countries of Latin America of an attitude of disdain for productive labor, derived from the colonial masters, and mainlined into the emerging societies across the social strata (see Lipset, 1967; Safford, 1976; Stein & Stein, 1970, for an overview and Annex 2).

We treat such cultural baggage as one of many possible costs of accumulating entrepreneurial capital, but do not see it as a sufficient explanation in itself. On the one hand, Table 1 shows that the dynamic industrialization process in Antioquia, Colombia, and to a lesser extent, Minas Gerais, Brazil, despite being steeped in the same Roman/Hispanic tradition, is domestically driven with even less than proportionate influence of foreigners. We offer an account of how Antioquians learned how to learn and hence dominate local industrialization in the next section. Second, as discussed below for Chile and then simulated in section 3.4, there are periods of entrepreneurial retrocession- a loss of entrepreneurial energy and activity which seems more consistent with a depreciation of entrepreneurial capital adjusted for an advancing technological frontier, than as an unexplained relapse to earlier cultural norms.

In fact, there is evidence of substantial latent entrepreneurial energy in the region, but also of impediments to learning posed by the business and institutional climate of the colonial period. Aspiring creole merchants were severely constrained by both the legal requirement to trade primarily with Spain, a country that came exceptionally late to the industrial revolution, and even this trade was prohibited except through peninsular intermediaries. Hence, local entrepreneurs would never see even the relatively backward port of Cádiz, let alone Manchester. However, the *demand* for greater commercial interaction was keen. In the 1720s and 1730s, the merchant classes of Peru and Mexico city, among the most developed in the region, sought direct trade with Spain but were rebuffed, and a vigorous contraband trade prevailed throughout the Caribbean (McFarlane, 2002). In Brazil, until the end of the 18th century even the establishment of industries was prohibited by the Portuguese colonial government, but they were latent, as in much of the region, emerging upon independence (Birchal, 1999). By contrast, the U.S. colonies were tightly integrated into England's industrialization process, sharing extensive trade and travel, engaging in industrial espionage, and accumulating knowledge and entrepreneurial capital.[8] Latin America also started with a far lower level of technological literacy: Maloney & Valencia (2022) show that Latin American, as the colonial mother countries, had one-tenth the presence of engineers that the US North had in 1900. Stronger industrialization efforts arguably failed to appear less because of indolence, and more because the costs of accumulating entrepreneurial capital were dramatically higher in Latin America than in the US.

2.2.1 The construction of indigenous entrepreneurial capacity in Antioquia, Colombia

The experience of Antioquia, Colombia shows a path where these disadvantageous initial conditions and high costs of investment in entrepreneurial capital were overcome by sustained exposure to foreign business practices and technologies and experience abroad that lowered the costs of accumulation and led a locally dominated industrialization process. As numerous studies have documented, the Antioquians developed a sui-generis spirit of capitalism with far reaching results. Rodriguez (1985) notes "...the Antioqueños played the role of modernizer assigned, in other societies, to foreign entrepreneurs...They showed to other regions the path for financial business, the modernization of commerce, and the creation of a manufacturing

[8] As an example, the fact that the Quakers started both Barclays and Lloyds Banks in England and then established Philadelphia as the nation's first financial hub may suggest a cultural link between the Friends' religion and high finance, but in our view, it is more likely that they gained substantial entrepreneurial capital and brought it to the new world.

industry (p 8).” The legendary entrepreneurs of the region seem so at odds with the Hispanic tradition that various cultural/genetic explanations have been invoked- a profusion of Basque immigrants, or the predominance of Jews fleeing the inquisition (Twinam, 1980).

However, a recent generation of scholars (Botero, 2007; Lopez, 2007) stresses instead the accumulation of business acumen and international experience through managing the entire production chain of gold, from extraction to marketing in London after Independence, in collaboration with a modest number of foreigners. As Meisel Roca (2011) observes, gold mining was one of the sectors that most benefited from the arrival of foreign entrepreneurs and technicians. Early descriptions of regional mining note a wild-catter mentality, consistent with Adam Smith’s characterization, with a short horizon and a yen to be landed gentry. The French engineer Amour argued that Antioquño entrepreneurs “would want almost immediate reimbursement of capital employed and, if there was the smallest obstacle or other accident, they would abandon the exploitation.” This corresponds to our second learning regime where perceived high returns, and high cost of entrepreneurial capital deter investment in it, and thereby the possibility of adopting technologies that might offer a medium term path around these obstacles. Fischer (1996) notes that “While the Colombian firms understood better the economic and political limitations of the country, it was the foreign firms were typified by the love of risk in the moment of discovering new gold deposits and then the experimentation with new technologies to explore them.” Our alternative casting is that they were more able to *assess* the risk and returns associated with this experimentation process necessary to bring a new project to fruition over the longer term.

But, critically, what emerges from the mining period is a dynamic interaction of local with foreign actors that sustained a process of learning to learn by the former. While in 1820 the region was backward and isolated even by Colombian standards (Lopez, 2007), in the next decade, Antioquia received an injection of technicians, mechanics and engineers that, while modest in number, was unlike in any other region of Colombia (Brew, 1977; Meisel Roca, 2011, and others).[9] The 1850s and 1860s were a period of modernization and

[9] “Names like Moore, Boussingault, White, Johnson, Paschke, de Greiff, Eastman, Jones are still found in the region. They were crucial in raising the technical quality. This system of exploitation of the mines, and

Botero notes from 1860-1870 "As processes of extraction and smelting became more complex, [local entrepreneurs] turned to a more modern administration and direction. Directors of mines with ample experience were partners with foreign engineers and Antioqueños with technical education." Poveda argues that this experience raised "the inventive capacity of entrepreneurs"(Poveda Ramos (1993) p. 49), an essential component of which is the ability to assess new projects. At the same time, Antioqueños dominated the national market for gold and became adept at managing financial transactions both locally and internationally. Travels to London and surroundings would have introduced them to industries and practices unknown to other regional elites. Finally, the Antioquia School of Mines, established by U.C. Berkeley graduates in 1895, is credited with radically modernizing and rationalizing the entrepreneurial outlook of generations of managers who dominated the ranks of Antioquian firms until the 1930s (Brew, 1977; Mayor Mora, 1984; Botero, 2007; Lopez, 2007).[10] Antioqueños would eventually sell most mining claims to foreigners- by regional standards, local mining was a difficult business and modestly profitable business- and, in line with the growth model laid out below, they used their accumulated entrepreneurial capital to enter new fields with higher returns, first coffee and then manufactures where they became one of the three celebrated industrialization poles of Latin America.

2.2.2 Entrepreneurial retrogression and recovery in Chile

Chile provides an example of entrepreneurial retrogression where a combination of high returns to mining, low initial entrepreneurial capital, and initially high costs of accumulating it led to a loss of industries it originally dominated, and an initial abdication of the industrialization project to foreigners and immigrants. Consistent with cultural explanations,

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particular empresarial relations led mining to be 'the seedbed of technical innovation.'" (Brew, 1977, p.126). Perhaps because of the small number of foreign engineers- on the order of 50 in the period- until the 1880s, the mining industry remained dominated by locals.

[10]Mayor Mora (1984) p. 21 argues: "If the School of Mines set out to endow the Antioqueño and national businessman with an economic rationality, namely, linking the entrepreneurial spirit with calculation, organization of the company to the expectations of a normal market, a rational responses of production techniques to forecasts, and, in the end, in the measurement of labor productivity, all this meant that the old practical rationality of Antioqueño , based on ingenious speculation, usury, or mere audacity, was no longer enough in the new era."

Encina (1911) in *Nuestra Inferioridad Economica* (Our Economic Inferiority) and Pinto (1959) in his *Chile, Un Caso de Dessarollo Frustrado* (A Case of Frustrated Development) 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. Yet, there is strong evidence of a formidable indigenous entrepreneurial presence across the first half of the 19th century(Encina, 1911; Pinto Santa Cruz, 1959; Villalobos et al., 1990; Nazer, 2000). Pinto is also clear that the elimination of Spanish restrictions on trade caused Chilean exports to boom immediately after independence, although entrepreneurial practices importantly lagged those of the advanced countries in every dimension.[11] Chilean entrepreneurs were the second largest presence in Peruvian nitrate fields, ahead of the British, and the nitrate industry there and in the *norte grande* elicited a strong response from Chilean entrepreneurs across the economy (Cariola & Sunkel, 1985). Locals pioneered and dominated copper mining during the period of Chilean global leadership from 1850-1880, agilely responding to a rise in price with a four-fold increase in production from 1844-1860, and seeding empires spanning railroads to banking under surnames that remain pre-eminent today.[12] In response to increased demand rising from the Gold rushes in California and Australia, Chilean wheat exports rose ten-fold in value from 1848-1850 (Conning, 2001) as hacendados borrowed heavily to clear lands on the southern frontier (Monteón, 1982). Up to 50,000 Chileans sailed to San Francisco to search for gold and brought new mining technologies to their Anglo counterparts (Monaghan, 1973).[13]

Hence, what alarmed contemporary observers sought to explain was the marked *decline* in entrepreneurial energy at the end of the 19th century as foreigners began to dominate all

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[11] Silva (1977b) notes "the surprising ignorance of established merchants techniques, accepted and in common usage in Europe for centuries, like letters of exchange, double entry bookkeeping, or banking operations" as well as the lack of "the basic theoretical knowledge of credit, simple and compound interest, amortization, capitalization, banks, etc. " (Silva 1977 p. 50).

[12] In 1871, two entrepreneurs alone Tomas Urmeneta and Maximiano Errazuriz accounted for 58% of total national production. Also building empires were entrepreneurs whose names remain pre-eminant today-Cousino, Edwards, Subercaseaux. Villalobos et al. (1990) asks "What would be Chile and what would it be now if there hadn't been in the 19th century a dynamic group of copper and silver miners in Atacama, pioneers of railroads and steam navigation, risk taking industrialists and active bankers. These were the ones who put together capital, invested, explored the territory, brought technicians and machinery, and and gained their fortunes in audacious businesses. Without this, we would imagine a country of rural and backward tone".

[13] The "Chili Mill" for breaking up rock displaced the Mexican *arrastre* and is on display at Sutter's Mill where gold was first discovered.

areas of the national economy, and much of the discussion revolved around entrepreneurial skills (Mac Iver, 1900; Encina, 1911; Pinto Santa Cruz, 1959). Despite continuing to be an "entrepreneurial people," Encina highlights that Chileans had"qualities little appropriate for industrial activities"-like the early Antioquians, they had an 'obsession for fortune at one blow, (ganada de un arretazo)' and lacked the technical and managerial skills to enter newly emerging sectors with longer horizons "taking little care about the exactitude of data and the legitimacy of the calculations based upon them."(Encina, 1911, p 195, 80-82n). Unlike Antioquia, as (Nazer, 2000, p.63) notes, the high concentration (ley) of copper ore and easy access to veins meant that, with some exceptions, there was little need to mechanize and extraction remained "artisanal, pre-capitalistic." This doomed the indigenous copper industry as it entered the second industrial revolution- (Nazer, 2000, p.66) cites a "lack of entrepreneurial capacity to innovate...the introduction of new technologies, forms of exploitation, and administration." Pinto Santa Cruz (1959) precisely sees this as a choice not to invest in entrepreneurial capital:

> The technological demands of the [earlier] 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 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 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." Pinto Santa Cruz (1959)(p 103n (59))(see also Sutulov (1975).

As we simulate in the next section, this can explain why the Chilean owned segment of the copper industry was effectively dead by 1920.[14] Similarly, although President Balmeceda in

[14]This appears not to be a question of the arrival of information *per se* since Chileans had a clear view of their own backyard over a long period: Sutulov (1975) asks "... if the foreigners have been able across 100 years to make this an excellent area of business, why cannot the Chileans do the same? It is here where a change of mentality and or processes or of both is urgently necessary." (p. 59)

1889 blamed the indolence, timidity and negligence of Chilean entrepreneurs for deferring to the British interests who were developing the vast nitrate fields recently conquered from Peru at the end of the 19th century, while other anguished critics, more aligned with our model, others saw the same absence of entrepreneurial and administrative capabilities, and deficient technical education, that led them to live from the rents instead (Pinto Santa Cruz, 1959; Meller, 1996; Monteón, 1982). This decision to not play the Schumpeterian midwife and invest in entrepreneurial capital allowed foreigners to dominate every field of endeavor.

In neither sector, nor in industry in general, is the Chilean abdication attributed predominantly to lack of capital much as it was not in Brazil or Colombia. A large Chilean literature notes the presence of vast wealth among the elites directed at conspicuous consumption,[15] but raises the possibility that these resources were not productively directed because they were not able recognize or exploit opportunities.

> It is important to note that the recent arrivals, frequently linked to important commercial houses, did not necessarily have a lot of capital, but they knew bookkeeping perfectly, and the possibilities of commerce and of investment over long periods...(Silva Vargas, 1977a, p. 45)

Villalobos et al. (1990) further notes that the foreign entrepreneurs arriving in Valparaiso after independence precisely had the entrepreneurial capital that Chileans had not built:

> 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* (italics ours) to develop or find 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 artesanal level (italics ours. 99).

Viewed through our model, Chileans lived off the safe returns of artisan copper mining

[15] Juan Jose Santa Cruz, 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 presence in 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 cloths, jewels, coaches, and statues exceeded those found anywhere else in America (Monteón, 1982). Pinto Santa Cruz (1959) cites 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, or 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."

and then rents from British nitrate exploitation while allowing their frontier adjusted entrepreneurial capital to depreciate, becoming technically and entrepreneurially dependent on foreigners who could identify and assess more complex new techniques and products as they appeared. (Encina, 1911, p. 292-293n) argues that this "manufacturing and commercial ineptitude"contributed to a "parasitism" of extensive and unproductive public employment and related professions, in an inversion the distorted incentives story where talent is diverted away from productive opportunities. Chileans would gradually learn to learn from the immigrants, whose influx, while increasing competition, also dramatically dropped the cost of investing in the necessary entrepreneurial capital(Silva Vargas, 1977b; Villalobos et al., 1990). Chileans increased their share in the nitrates industry, and by the 1960s major Chilean industrial groups were headed by families who were of the traditional landed aristocracy (Zeitlin & Ratcliff, 1988) and who might have deployed their capital earlier if they knew how to learn about the opportunities.

A similar story can be told of retrogression in Mexican mining where the pioneering local entrepreneurs who built the sector were unable to introduce the new technologies needed to rejuvenate it at the turn of the century and were displaced at every level of operation from ownership to technical workers by foreigners who could. (Beatty, 2015).

2.3 Identical products, different outcomes: the resource curse as a learning problem

Chile's trajectory is emphatically not intrinsic to either copper or nitrates and this brings us to our third stylized fact: identical products can lead to radically different development outcomes depending on the learning regime in place. While the high expected returns to copper, lower initial endowment, and higher costs of investment in EC may have led to a low learning regime in Chile, offering a new genre of resource curse, this was not the case elsewhere.[16] Not only does Wright (1999) argue that the US in the 19th century "parlayed its

[16]It does appear to be the case in Mexico where despite welcoming massive foreign investment in all sectors and particularly natural resources, President Porfirio Diaz, 'in his eagerness for industrial development, had failed to protect Mexican interests and to safeguard Mexican sovereignty. He had not insisted that Mexicans learn the new techniques;foreigners monopolized every responsible position..' Parkes (1969) p.309

[natural] resource based industrial prosperity into a well-educated labor force, an increasingly sophisticated science-based technology, and world leadership in scientific research itself" (p. 665), but he uses precisely the US copper industry as an example of national learning and of innovation as a network phenomenon. Japan also leveraged its position as a leading copper exporter for rapid and diversified national development.[17] Major zaibatsu, such as Furukawa and Sumitomo, began as copper mining companies (Yonekura & Shimizu, 2010), but then rapidly applied Western technologies and diversified. Furukawa gave birth to Fujitsu, the fourth largest information and computing firm in the world. The in-house unit that built motors for the Hitachi copper mine similarly developed into a global technology giant of the same name. To interpret Braguinsky et al. (2020) through our lens, firms that accumulated the entrepreneurial capital needed to identify new technology to upgrade vertically, were also able to use it to diversify into new areas. Relatedly, Braguinsky & Hounshell (2016); Agarwal et al. (2020) note that information on new technologies and processes was available to all firms in the emerging Meiji textile industry, but a few capable entrepreneurs, often with a strong engineering formation, and the skills their firms *acquired* drove the sector to global prominence. As one suggestive source of higher initial capabilities across the economies, Table 1 suggests that Japan, might have had a group playing the role of Latin America's immigrants. Odagiri & Goto (1996) note that nearly half of managers (those born before 1869) were lower class Shizoku (ex-samurais) who accounted for only 5 % of the population, partly because of the level and orientation of education they received during the pre-Restoration era.[18] But critical also was that the example of colonial domination of China made catching up and learning Western technologies imperative, dramatically raising the social return and spurring government efforts to lower the costs of learning how to learn.[19]

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[17] In the early 1800s, Japan was second only to England in copper exports before being displaced by Chile in the 1840s, a position it would regain behind the U.S. in the 1910s (Sutulov, 1975).

[18] Demobilized as warriors in the Tokugawa period, many Samurai studied and developed skills as administrators and in the mid 18th century *Bushi* (samurai) education gradually shifted its emphasis from classics to practical subjects including medicine, arithmetic and Western studies and new schools specializing in Western studies emerged in the early 1830s where many Meiji leaders were trained (Yasuba, 1987). Arguably, Japan had a base to begin from.

[19] Odagiri (1998) notes precisely the emphasis put on developing managerial and technical schools as critical to catch up and as knowledge networks. Pre-WWI management was dominated by graduates from

All three cases were among the global leaders in copper exporting across the 19th century, yet different learning regimes dictated radically different development outcomes. Annex 3 documents that the same retrocession found in Chile was seen in both the iron and electrical industry in Minas Gerais, Brazil, again due to inability to manage new risky projects, and the Antioquian textile industry, too, would stumble due to weak productivity and quality driven by lagging managerial capabilities (Morawetz, 1980).

3 An Information-Based Model of Entrepreneurial Choice

3.1 One agent and one risky project

We consider a risk-neutral agent who must decide between exploiting a new risky project whose expected return is unknown or continuing to exploit a safe project with known returns. As discussed in the literature on R&D, this is at once a decision to bet on a risky project as well as a decision to collect more information about it. There is learning by doing defined as refining the prior on the distribution of returns of the risky project by engaging in it and then observing its returns. The more the risky project is tried, the higher the number of observed returns, and the more precise the posterior on the distribution of returns.

In addition, there is process of learning about how to learn about projects- becoming better about processing new information to form a correct prior on a new product. We relate this ability with the notion of entrepreneurial capital, which is inversely related to the precision of the prior belief. When the prior belief is too precise (low variance), the arrival of new information will not shift the prior significantly and learning the correct distribution of the risky project becomes more difficult. We can think of a conservative agent, resistant to "newfangled" products and technologies for whom no amount of new information will shift him away from the traditional safe product. At the other extreme, we may see the Silicon Valley venture capitalist willing to bet on a new web product with very slim evidence on its

select schools with Hitachi being singled out as headed by engineering-managers from University of Tokyo.

eventual profitability. We see this as the same problem for the introduction of new industries in an economy and, at a more abstract level, the whole process of modernization.

The expected return of the safe project is μ_s, whereas the returns of the risky project y_r are drawn from a normal distribution with unknown mean u and known precision (inverse of the variance) t. The agent has a prior distribution over u given by a normal distribution with mean μ_r and precision τ. If the agent decides to undertake the risky project, s/he will observe a realization of its distribution in the next period that will later be used to update the agent's prior using Bayes rule. Therefore, a realization of profit x, will lead to the posterior of the unknown mean u to become a normal distribution with mean $\mu_r' = \frac{\tau\mu_r + tx}{\tau + t}$ and precision $\tau + t$. We interpret τ as a decreasing function of entrepreneurial human capital-some combination of managerial, technical, even linguistic skills- since a higher τ implies that the prior belief has a higher weight in the updated belief when the agent decides to experiment. This implies that realizations of the risky project will have a relatively smaller weight in the updated distribution, thus lowering the incentive to engage in the new project. On the other hand, we interpret the precision of the signal t as the number of signals that generated the aggregate average signal, as Bolton & Harris (1999) suggests. In our context it could be interpreted as the number of people (entrepreneurs) trying the new risky technology in the society. It is also linked to the number of migrants that had access to more advanced technologies in other societies or the strength of the ties with such societies, that make the realization of the risky signal more credible.

The agent maximizes the discounted sum of profits over an infinite lifetime and each period chooses which project to pursue. The problem for the agent can be stated recursively as:

$$v\left(\mu_r, \tau\right) = \max\left\{\mu_s + \beta v\left(\mu_r, \tau\right); \mu_r + \beta \mathbb{E}_{\mu_r'}\left[v\left(\mu_r', \tau + t\right)\right]\right\}$$

Note that choosing the safe project means that the agent will face the same problem the next period since no learning will have occurred and hence will continue to do so going forward as long as the process of the risky project does not change (Gittins, 1979). This strategy generates a lifetime utility of $\frac{\mu_s}{1-\beta}$ given the normalized payoffs. Hence the problem simplifies to:

$$v(\mu_r, \tau) = \max\left\{\frac{\mu_s}{1-\beta}; \mu_r + \beta \mathbb{E}_{\mu_r'}\left[v\left(\mu_r', \tau + t\right)\right]\right\}$$

Lemma 1. *There exists a unique solution to* $v(\mu_r, \tau)$. *Moreover, it is increasing and convex in* μ_r *and* μ_s, *increasing in* t, *decreasing in* τ, *and*

$$v(\mu_r, \tau) \geq \lim_{\tau \to \infty} v(\mu_r, \tau) = \max\left\{\frac{\mu_s}{1-\beta}; \frac{\mu_r}{1-\beta}\right\}$$

The expectation of $v(\mu_r, \tau)$ is often called the value of experimentation. The greater the expected return to the risky project and its precision t, the better off is the agent and the greater the willingness to experiment in the new project. Suppose any signal leads the agent to choose the safe project, then the value of experimentation would be equal to the discounted value of choosing the safe project forever. However, such case becomes uninteresting since there is no room for learning. Now, if for some signals the agent prefers the risky project, it means that the value of the risky project given that signal is greater than choosing the safe project forever. Therefore the value of experimentation (the ex-ante expectation before the signal is realized) is always greater than choosing the safe project since some signals will lead to a greater value whereas the others lead to the same value (the ones where the safe project is preferred to the risky one). Hence, we obtain $\beta \mathbb{E}_{\mu_r'}\left[v\left(\mu_r', \tau + t\right)\right] > \beta \frac{\mu_s}{1-\beta}$. Therefore, there exists a unique $\mu^* < \mu_s$ such that

$$\mu^* + \beta \mathbb{E}_x\left[v\left(\frac{\tau\mu^* + tx}{\tau + t}, \tau + t\right)\right] = \frac{\mu_s}{1-\beta}$$

This in turn implies that the agent will experiment with the risky project for any $\mu_r \geq \mu^*$- as long as the expected return is not "too much" lower than the safe return. It also implies that a bad realization x sufficiently lower than μ^* will lead the entrepreneur to stop investing in the risky project since the new updated expected mean would become lower than μ^*.

The value of information is also increasing in entrepreneurial capital. In the limit, where τ tends to infinity and there is no entrepreneurial capital, prior beliefs are too strong and there will be no learning. In that case the expected value function is simply the discounted value of the greatest expected return. As τ decreases, the value of information becomes less convex since more weight is given to the information yet to be realized. Since the boundary values remain equal, the lower convexity implies that the value of information increases with more entrepreneurial capital.

This optimal behavior is illustrated in Figure 1 for $\tau_1 < \tau_2$, where the blue line represents the first case and the red line the second case. Since $\mathbb{E}_{\mu_r'}\left[v\left(\mu_r', \tau_1\right)\right] > \mathbb{E}_{\mu_r'}\left[v\left(\mu_r', \tau_2\right)\right]$, then the required threshold to experiment is lower in the first case; formally, μ^* is increasing in τ. Thus the required positive signal is higher the lower the entrepreneurial human capital to keep exploiting the risky project and if not high enough, we may see abandonment of the project or "retrogression". In other words, if two societies with different levels of entrepreneurship were to observe the same signal x such that $x^* < x < x^{**}$, then the society with lower entrepreneurial capital will experience retrogression whereas the other will continue exploiting the risky project. We present a longer term mechanism for retrogression below.

3.2 New projects arising and growth

To introduce growth, we assume that a new risky project emerges each period. Now, the entrepreneur decides each period whether to exploit the safe project or the risky one. If the agent chooses the risky project, the next period a signal will be observed, the entrepreneur will update the distribution of the risky project, and will choose definitely between the previous safe and risky project with the updated distribution. If the entrepreneur chooses the risky project, it will become the new safe project, and, for simplicity, we assume its distribution is degenerate at the posterior mean of the risky project. At the same time a new risky project will arise and the entrepreneur will face the same problem.

Let μ_s' be the safe return of the next period, that is $\mu_s' = \max\left\{\mu_s, \frac{\tau\mu_r + tx}{\tau+t}\right\}$. The new risky project has an unknown mean whose prior is also a normal distribution with mean μ_r' and inherited precision τ. The unconditional mean μ_r' will be random with some known distribution. For simplicity, we assume that this distribution does not depend on the rest of the parameters of the model. The problem can be expressed recursively as:

$$v\left(\mu_s, \mu_r, \tau\right) = \max\left\{\mu_s + \beta E_{\mu_r'}\left[v\left(\mu_s, \mu_r', \tau\right)\right]; \mu_r + \beta E_{x,\mu_r'}\left[v\left(\mu_s', \mu_r', \tau\right)\right]\right\}$$

where $\mu_s' = \max\left\{\mu_s; \frac{\tau\mu_r + tx}{\tau+t}\right\}$

Using the results from the previous section we know that the value function will be increasing and convex in μ_s and μ_r, increasing in t and decreasing in τ. As before, an agent will experiment with the risky project, as long as its prior mean is greater than some threshold that is lower than the safe mean μ_s. However, the observed signal from the risky project must be larger than before to continue with the risky project since there is only one stage of experimentation. It also implies that societies with lower entrepreneurial capital (higher τ) face lower incentives to experiment since they give more weight to their prior and less weight to their signals. Hence, we are more likely to observe retrogression in societies with less entrepreneurial capital, which also implies that they have less capacity to grow over time.

3.3 Endogenous Entrepreneurial Capital

Introducing depreciation and investment in entrepreneurial capital yields richer growth dynamics. It allows us to model a moving technological frontier and to understand retrogression cases where having high initial returns lowers incentives to invest in entrepreneurial capital.

We now assume that the precision of the new risky project is given by $\tau + \delta\left(1 - e\right)$. δ is interpreted as the frontier-adjusted depreciation of entrepreneurial capital that occurs as technological progress increases the complexity of projects and hence the necessary entrepreneurial capital to process signals. The depreciation in a given period can be offset by investing in entrepreneurial capital $e \in \{0,1\}$, at a cost c. If societies do not invest, depreciation makes experimentation more costly and entrepreneurs will give less weight to the arriving signals to evaluate them. We can think of the Second Industrial Revolution as introducing projects with new levels of complexity that countries that had progressively invested in entrepreneurial capital could evaluate and bet on, while others became progressively less able to evaluate these projects and hence did not take up industrialization.

The problem can be expressed recursively as:

$$v(\mu_s, \mu_r, \tau) = \max \left\{ v_s(\mu_s, \tau); v_r(\mu_s, \mu_r, \tau) \right\}$$

where

$$v_s(\mu_s, \tau) = \max_{e_s} \left\{ \mu_s + \beta E_{\mu_r'} \left[v\left(\mu_s, \mu_r', \tau + \delta(1 - e_s)\right) \right] - c \cdot e_s \right\}$$

$$v_r(\mu_s, \mu_r, \tau) = \max_{e_r} \left\{ \mu_r + \beta E_{x, \mu_r'} \left[v\left(\mu_s', \mu_r', \tau + \delta(1 - e_r)\right) \right] - c \cdot e_r \right\}$$

$$\mu_s' = \max \left\{ \mu_s; \frac{\tau \mu_r + t x}{\tau + t} \right\}$$

The value function $v(\mu_s, \mu_r, \tau)$ is the maximum of the value function when the safe project is chosen, v_s, and the value function when the risky project is chosen, v_r. In the first case the agent will choose investment e_s; in the second case it will choose e_r. As before, the risky project is chosen whenever μ_r is greater than a threshold lower that μ_s. The following lemma characterizes the optimal investments e_s and e_r.

Lemma 2. *The optimal investments are decreasing in c. Moreover, e_r^* is decreasing in μ_r for $\mu_r > \mu_s$ and increasing for $\mu_r < \mu_s$, whereas e_s is independent of μ_r. Moreover, $e_s \leq e_r$ for $v_s \leq v_r$.*

Proof. First note that, for any e:

$$E_{x,\mu_r'}\left[v\left(\mu_s',\mu_r',\tau+\delta\left(1-e\right)\right)\right]\geq E_{\mu_r'}\left[v\left(\mu_s,\mu_r',\tau+\delta\left(1-e\right)\right)\right] \tag{1}$$

which is precisely why information has value. Both expressions are increasing and convex in μ_s and μ_r, increasing in τ, and have the same pasting and value matching conditions at the boundary points. Therefore, as long as $c\leq\hat{c}$, $e_r=1$ if $\mu_r\in\left(a\left(c\right),b\left(c\right)\right)$, where μ_s belongs to the interval and $a\left(\hat{c}\right)=\mu_s=b\left(\hat{c}\right)$. Moreover, $a\left(c\right)$ and $b\left(c\right)$ are decreasing and increasing in c, respectively. On the other hand, v_s is independent of μ_r, thus $e_s=1$ for sufficiently low c, otherwise it will be zero. Moreover, if $e_s=1$ and $v_r\geq v_s$ it must be the case that $e_r=1$ since the value of information is greater when the risky project is chosen. □

A central finding is the complementarity of betting on risky projects and investing in entrepreneurial capital. Having a lower precision of the prior increases the value of experimentation as discussed before. Therefore, the investment in entrepreneurial capital is more productive when the risky project is chosen rather when the safe project is preferred. This implies that the agent invests more in entrepreneurial capital when the risky project is preferred. A corollary is that countries with lower entrepreneurial capital, those less likely to bet on risky projects, will also invest less in additional capital. This dynamic generates a new type of growth trap- societies with low entrepreneurial capital are more likely to choose the safe project, which in turn also implies a lower investment in entrepreneurial capital, locking them into progressively less profitable projects.

The model also suggests that the investment in entrepreneurial capital is more productive when the risky mean prior is close to the safe return since that is the point where new information is more important given the close indifference between the projects. Therefore we show that societies will not invest in entrepreneurial capital when agents have pessimistic priors on the risky project or very optimistic. This implies that societies where the risky prior is high enough will experiment with the risky project but will not invest importantly in entrepreneurial capital. As new projects arise and its complexity increases, these societies will remain exploiting those old risky projects (now safe ones) and will not grow as more entrepreneurial societies. Note this low growth arises from an endogenous decision of not investing in offsetting the depreciation in entrepreneurial capital after observing a very profitable project.

The cost of investing in entrepreneurial capital is also critical to the set of choices. Optimal investment when the risky project is chosen is drawn in Figure 2 for $c_1 < c_2$. The black line is the case where agents do not invest in entrepreneurial capital (note the similarity with Figure 1), whereas the red and blue lines depict the cases where there is investment at a high and a low cost, respectively. Note that the black line is more convex than the other two, since entrepreneurial capital is lower, whereas the other two lines have the same convexity. In the absence of a fixed cost it would be preferable to have higher entrepreneurial capital (lower τ) as shown in Figure 1. A positive cost implies that investing in entrepreneurial capital makes sense only for prior beliefs that see information as more valuable which is where the expected risky return is close to the safe return. Formally this happens in the interval $[a_i, b_i]$ for cost c_i, which is where the less convex (red and blue) lines are above the more convex (black) line. As expected this interval must be decreasing in c, since the investment becomes more costly. Therefore, societies whose cost of investing in entrepreneurial capital is higher, will incur these costs only if the risky return is expected to be very similar to the safe return. However, if the cost is sufficiently high, they will never invest in entrepreneurial capital. Such costs can be associated to institutions that disincentivize entrepreneurship such as prohibitions on trade or restrictions to opening new businesses such as was the case in Latin America or, incentivize them, such as was the case with the Meiji national imperative to learn western technologies.

Another way to summarize the previous lemma is to examine the marginal return of investing in entrepreneurial capital. Figure 3 shows such marginal return for the calibration we described in the next subsection. Note the marginal return when the risky project is chosen is highest for intermediate values of the expected risky return. However, even though the expected return exceeds just staying in the safe product, the cost of the investment represented by the dotted horizontal line, makes investment prohibitive. Consistent with Figures 1 and 2 above, a higher initial level of entrepreneurial capital will also shift up the return to investment at every level of the expected return to the risky asset, leading to a wider range of expected returns to the risky asset and costs of investment where investment will occur.

3.4 Validation of the model: Chile and US experience in copper

In this section, we show that plausible parameters can generate the distinct time paths of the Chilean and US copper industries across the 1850 to 1920, the period that Chile's industry declined and the US rose. As a proxy for the entrepreneurial skills we model, we follow Murphy et al. (1991) in using engineering density (engineers per 100.000 inhabitants) derived from Maloney & Valencia (2022) and census data. Figure 4 shows the evolution of the logarithm of copper revenue by Chilean nationals, and US nationals in the US, and Figure 5 shows the evolution of the number of domestic engineers for both countries. Note Chile has a higher initial revenues, but is overtaken by the US within the first decades. On the other hand, US has a higher initial entrepreneurial capital and keeps investing in it at a higher pace than Chile.

To replicate the observed data with our model we start, for each country, with an initial τ_0 equal to the inverse of the number of engineers in the population in 1850, and an initial μ_s equal to the logarithm of copper revenue in US in 1850. The initial μ_r is also set equal to the initial μ_s, the second μ_r is set equal to the initial logarithm of copper revenue for each country, and t is set to infinity, that is the signal reflects the true expected return of the risky project. The depreciation parameter δ is set to 8 and the cost of investing in entrepreneurial capital c is set to 0.5 for both countries. The process for the risky projects arising each period follows a normal distribution with mean equal to μ_s and variance equal to the inverse of τ given the perfect informativeness of the signals.

We use the same seed for the realized returns of the risky project for both countries. Table 1 summarizes the descriptive statistics of the model and the data to evaluate its fit. The model successfully replicates the returns from copper, and although it simulates the increased path of entrepreneurial capital in US and its stagnation in Chile, the assumed linearity of its accumulation does not allow the model to replicate the path quantitatively. Figure 6 shows the generated evolution of copper revenue, while Figure 7 shows the implied evolution of entrepreneurial capital. Note the numerical exercise replicates the observed paths in Figures 4 and 5. Despite Chile having a higher initial return, US quickly surpasses it because of a higher initial entrepreneurial capital and a lower initial return.

To gain further clarity, we decompose the effect of each by assigning the U.S. initial value to each as a base and then varying them individually. Figures 8 and 9 show the evolution of the returns and the entrepreneurial capital, respectively, for the case where both countries have the same initial entrepreneurial capital, but a higher initial return for Chile reduces the incentives to invest further. Even when returns moderate, the resulting lag in entrepreneurial capital implies that it is no longer profitable to invest further and frontier adjusted stock continues to depreciate. The model implies a similar path as the previous figures, except that the US overtakes Chile later given the latter's higher initial stock of entrepreneurial capital.

Figures 10 and 11 show that relative trajectories could also be generated by having the exact same returns in both countries, but different initial levels of entrepreneurial capital. The greater initial facility in recognizing new opportunities in the US leads to investment in riskier projects, more investment in entrepreneurial capital, and a higher long run growth trajectory. In sum, both the higher initial return and low initial entrepreneurial capital plausibly contribute to the decision to invest in further entrepreneurial capital.

3.4.1 Robustness

One concern is that engineering density is just picking up human capital more generally that might be increasing the return to investments in new technologies and hence really is not capturing anything particular about entrepreneurial capital. As a proxy for the former that would not be sufficient to undertake the risky project evaluations we describe, we examine the behavior of literacy at the time. Figure 12 shows that literacy was already high in the US, while its engineering density almost tripled. On the other hand, Chile's literacy rate and engineering density followed a similar path, where literacy stagnated a decade earlier. These dynamics in literacy rate could not generate the observed evolution of copper revenue in the

US.

As a second robustness test, we discount from copper revenue the effects that aggregate physical capital accumulation may have had. To do this, we use the physical capital series for each decade in our period found in Tafunell (2013) for Chile, and in Gallman (1986) for US from 1840 to 1900 and in Maddison et al. (1994) from 1900 onward. The capital series are illustrated in Figure 13. Then we assume the copper production follows a Cobb-Douglas specification, where the share of physical capital is 0.3 and discounted it from the copper production. Figure 14 shows the resulting copper labor revenue, which behaves very similarly to the copper revenue. Table 2 provides the goodness of fit for the exercise. The results are not qualitatively different from the main calibration.

4 Conclusion

The ability to productively experiment with new technologies and products, and learn from that process is essential to development. This paper argues that the divergence in growth dynamism within the Western Hemisphere can be seen as the result of differential investment in the entrepreneurial capital that permits more efficient use of arriving information about new technologies and products- more advanced countries have learned better how to learn. Our model shows that that investment in turn depends on the cost, the distance from the frontier and, non-monotonically, on the expected return to the risky project. Together these factors lead to three learning regimes which aid in interpreting key features of the industrialization process in Latin America: the disproportionate role of immigrants and foreigners in industrialization, the emergence of some poles of entrepreneurial dynamism, and entrepreneurial retrocession in others; and the differing development outcomes of identical industries. We show that, under reasonable parameters, the model is able to simulate the differential experiences with copper in Chile and the US.

These findings confirm the salience of the emerging literature that documents the gap in a range of managerial and technological practices between advanced and developing countries and provides an additional rationale for the substantial efforts of industry upgrading agencies across the advanced world.

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5 Figures and Tables

Figure 1: Optimal experimentation as a function of μ_r and τ: $\tau_1 < \tau_2$

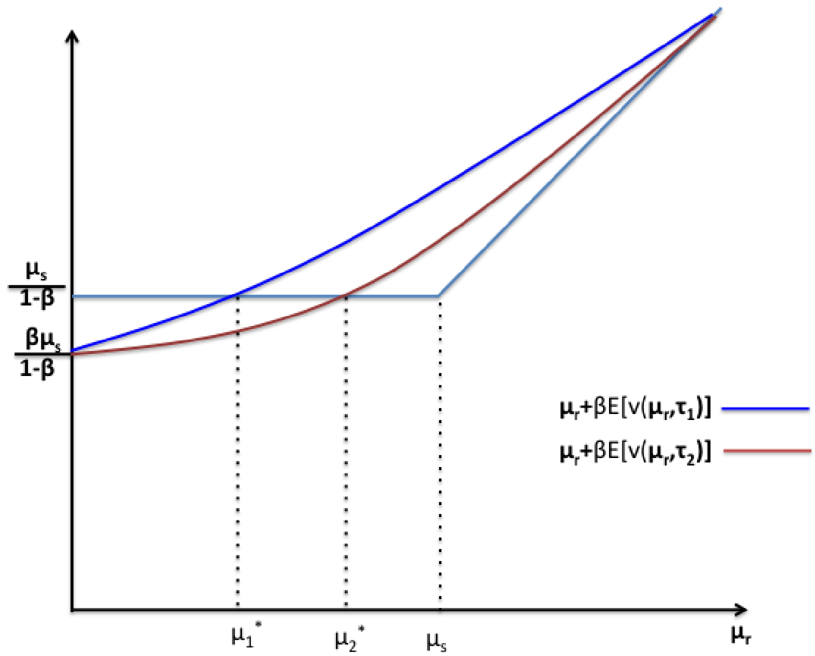


Figure 2: Optimal investment when the risky project is chosen: $c_1 < c_2$

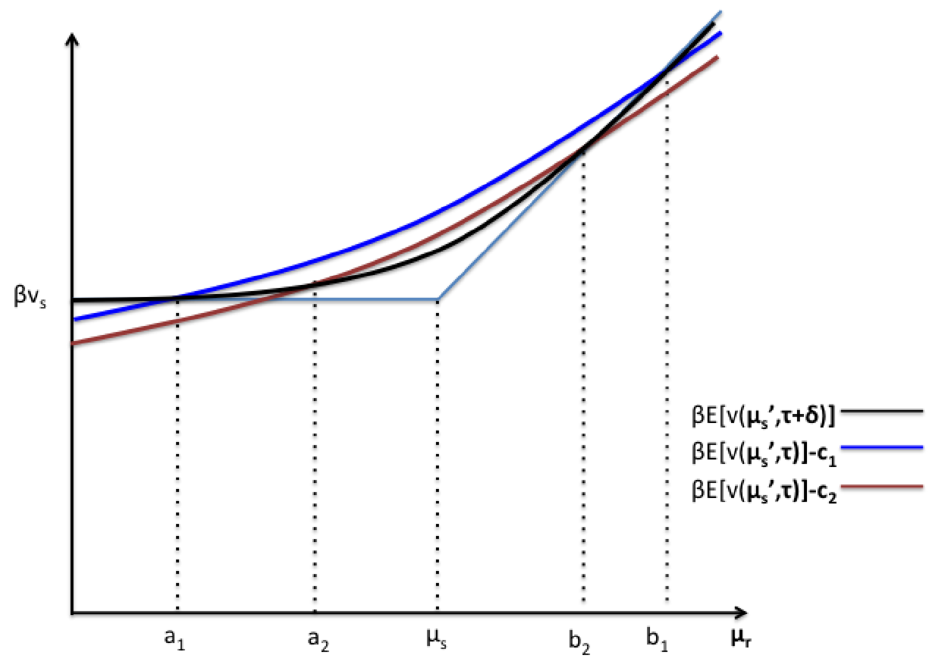


Figure 3: Marginal return to entrepreneurial capital as a function of the expected risky return

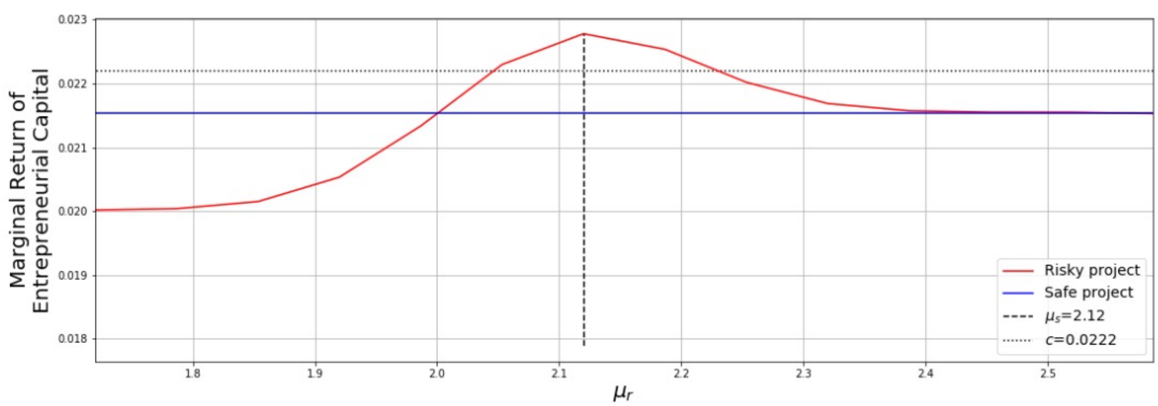


Table 1: Results

height	observed		simulation	
model	**US**	**Chile**	**US**	**Chile**
Log return				
mean	6.43	5.88	6.42	6.32
std	1.73	0.45	2.36	0.54
max	9.69	7.11	10.64	7.21
min	2.96	4.99	2.9	5.3
Engineering Density				
mean	72.19	10.86	90	11.71
std	78.53	7.51	41.27	1.27
max	282	23.71	160	12
min	8.91	2.11	20	4

Figure 4: Logarithm of Copper revenue by Chilean nationals in Chile and US nationals in US: 1850-1920

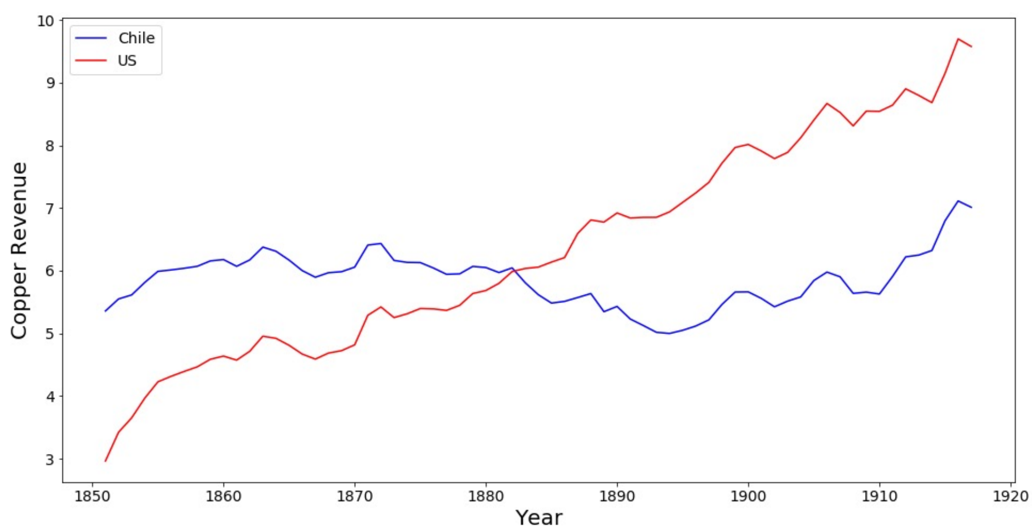


Figure 5: Entrepreneurial capital: Number of domestic engineers in Chile and US per 100.000 inhabitants: 1850-1920

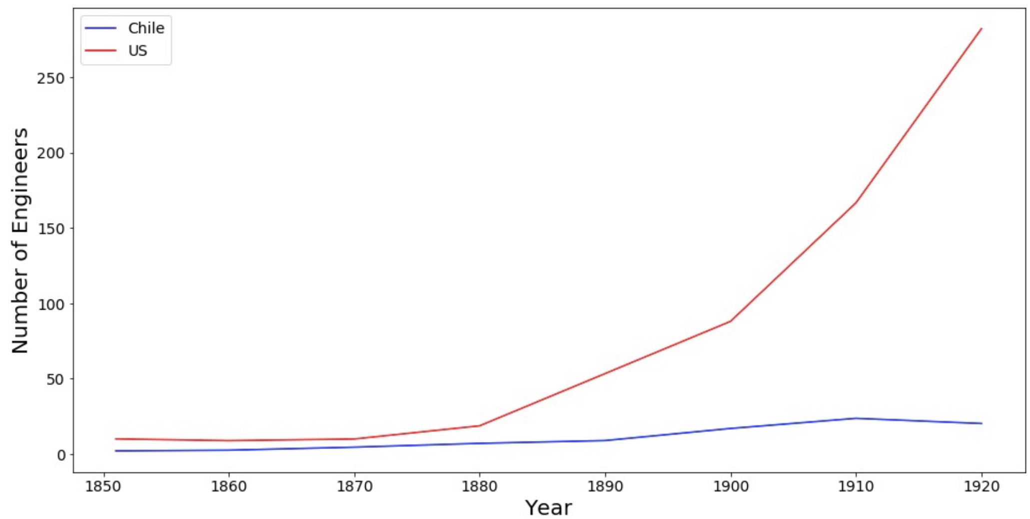


Figure 6: Replicated returns for Chile and US

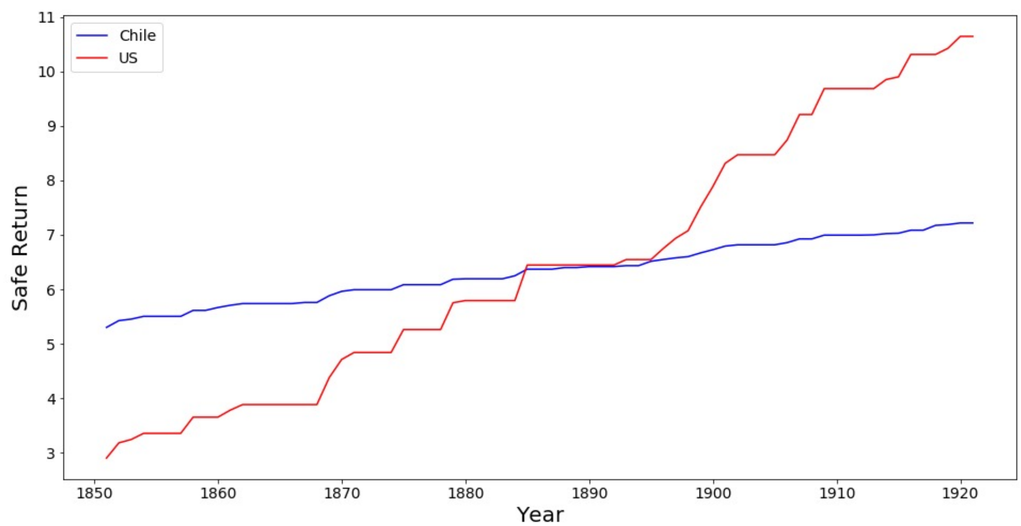


Figure 7: Replicated evolution of entrepreneurial capital in Chile and US

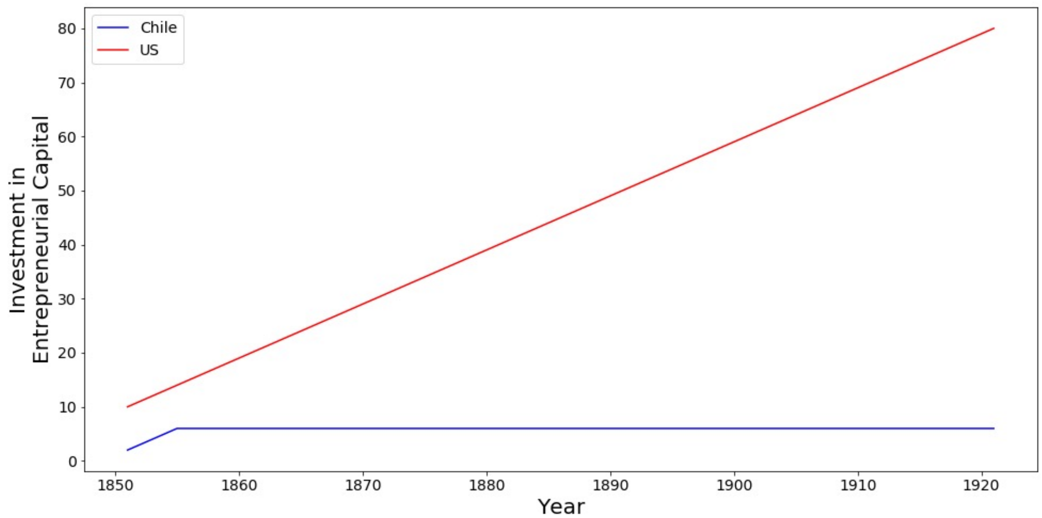


Figure 8: Counterfactual returns for Chile and US: same initial entrepreneurial capital, higher initial return to risky project in Chile

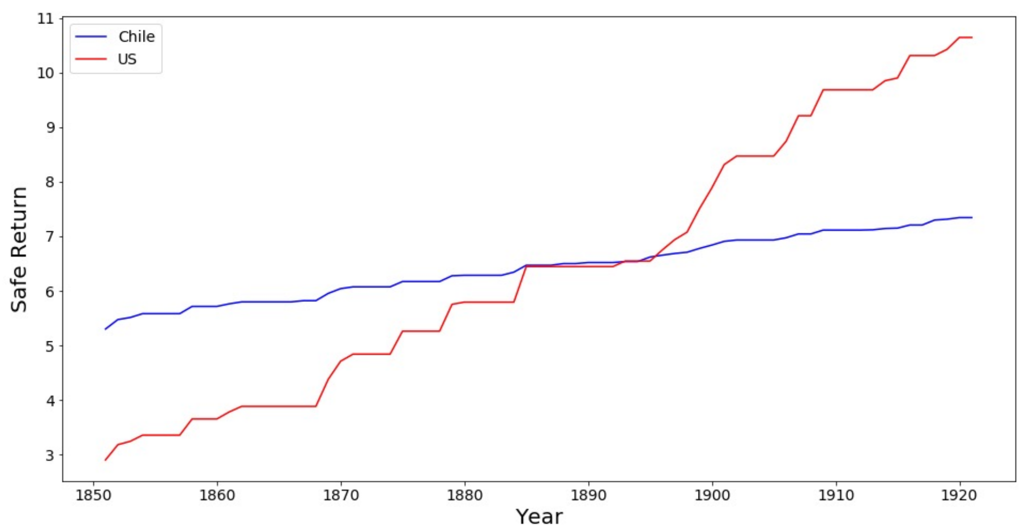


Figure 9: Counterfactual evolution of entrepreneurial capital in Chile and US: same initial entrepreneurial capital, higher initial return to risky project in Chile

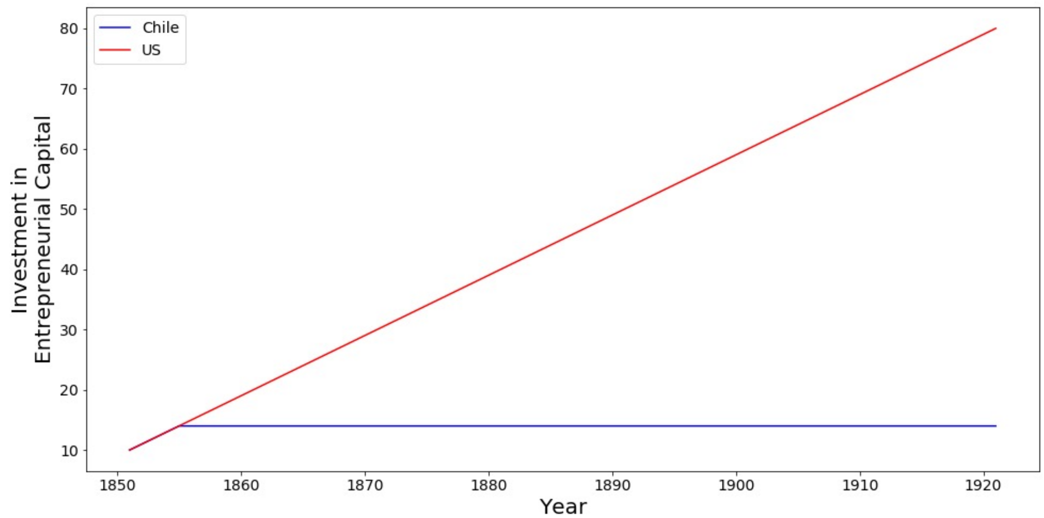


Figure 10: Counterfactual returns for Chile and US: same initial return, higher initial entrepreneurial capital in US

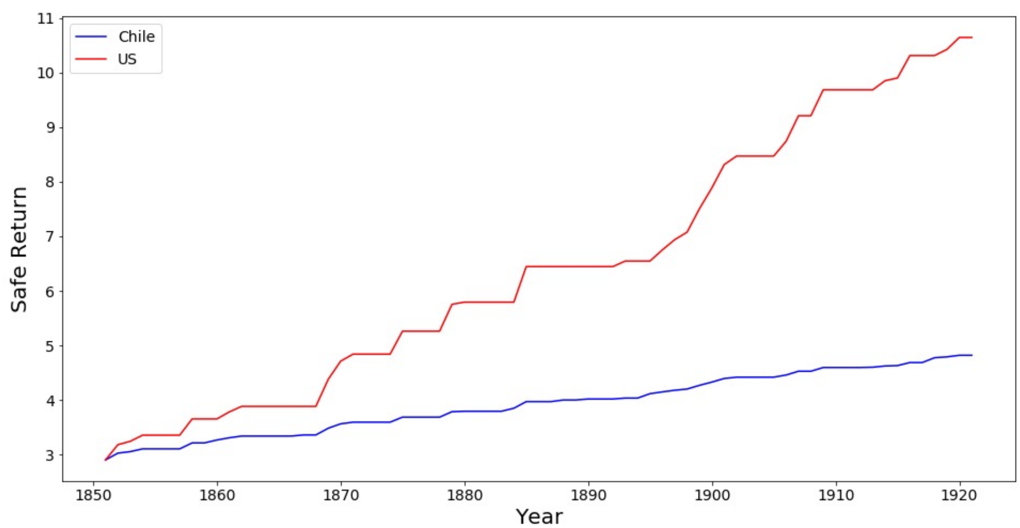


Figure 11: Counterfactual evolution of entrepreneurial capital in Chile and US: same initial return, higher initial entrepreneurial capital in US

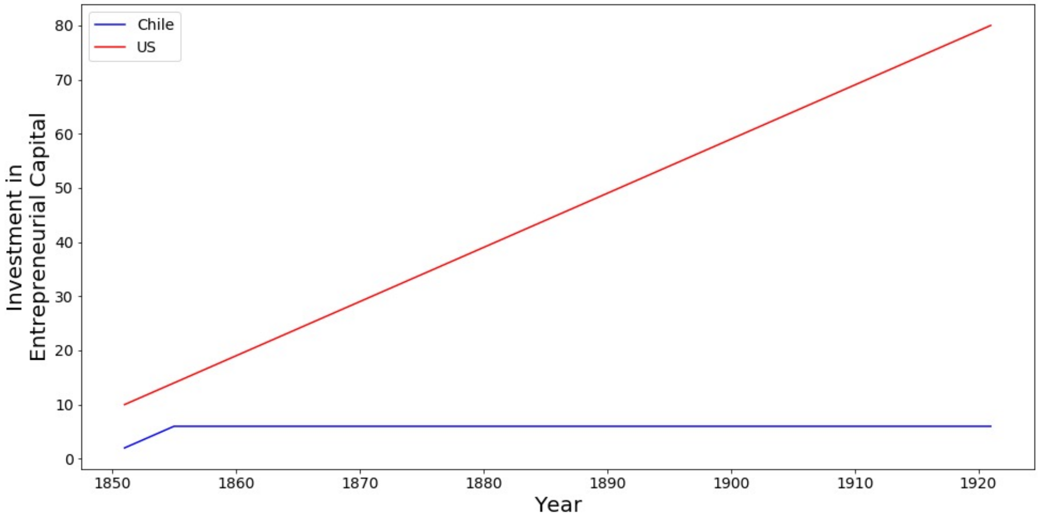
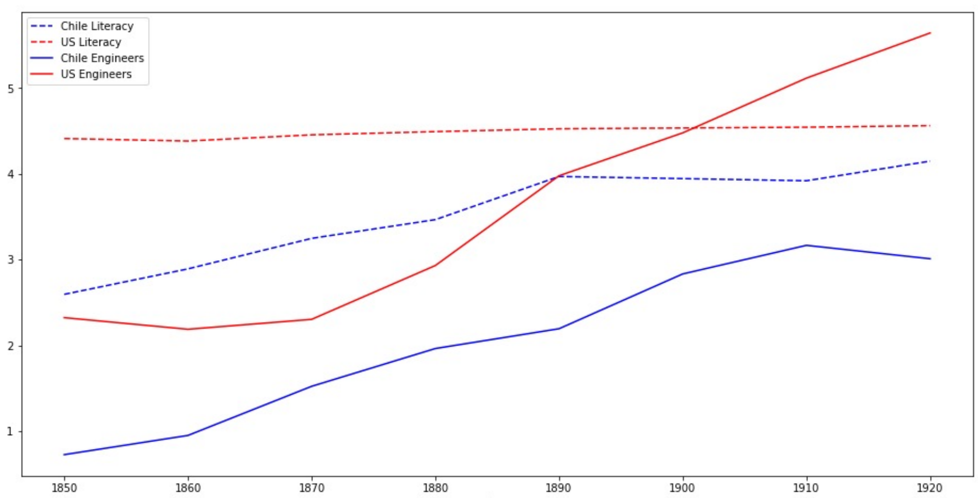
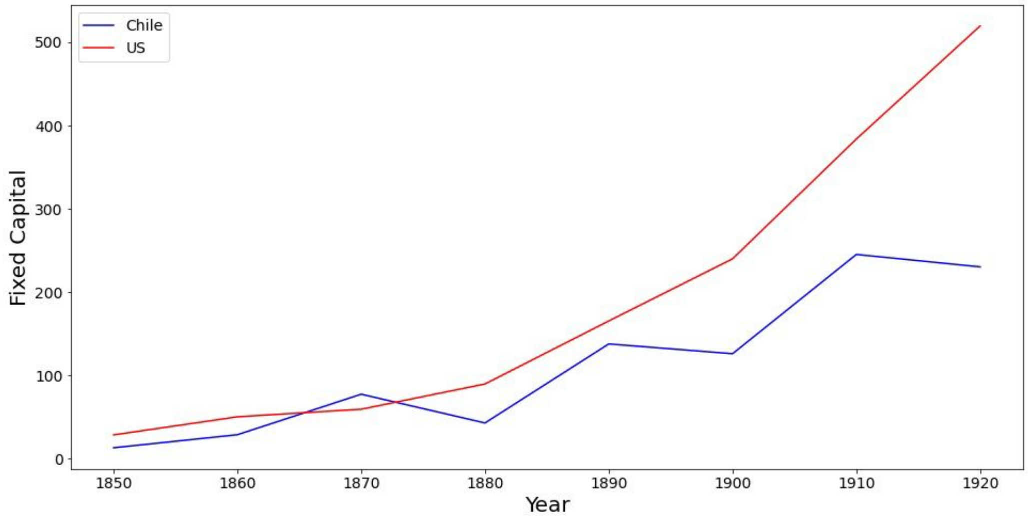


Figure 12: Literacy rate and engineering density in Chile and US: 1850-1920



Sources: Literacy rate for Chile was obtained from EH-Clio Lab UC (http://cliolab.economia.uc.cl/BD.html). Literacy rate for US was obtained from the National Center for Education Statistics (https://nces.ed.gov/naal/lit$_h$*istory.asp*).

Figure 13: Capital in Chile and US:1850-1920



Sources: From 1840 to 1900 we use Tafunell (2013) for Chile, and Gallman (1986) for US. From 1900 onward we use Maddison et al. (1994).

Figure 14: Copper Labor Revenue in Chile and US:1850-1920

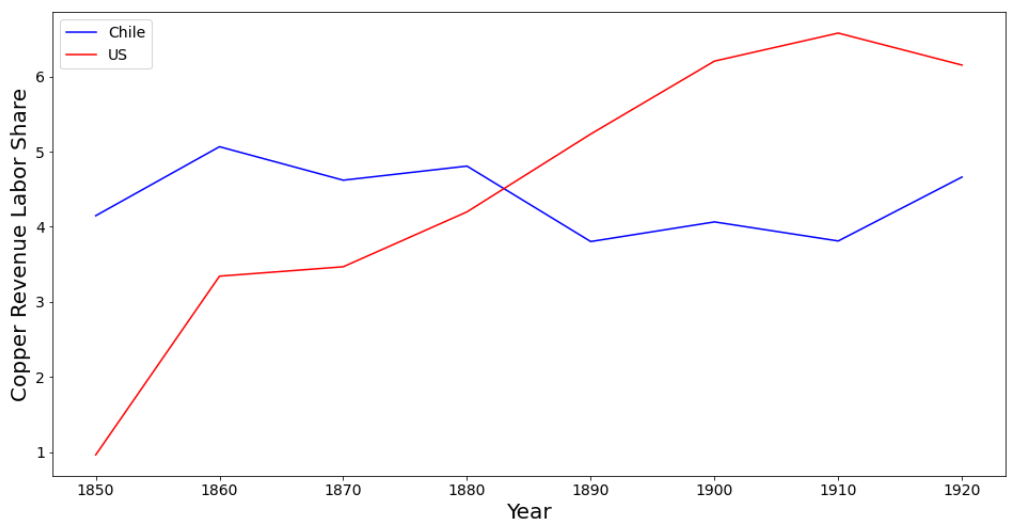


Table 2: Results

	observed		simulation	
model	**US**	**Chile**	**US**	**Chile**
Log return				
mean	4.5181	4.3731	4.9764	4.4869
std	1.9077	0.4779	2.3973	0.4721
max	6.5778	5.0658	8.6454	5.7415
min	0.9655	3.8040	0.9	4.1
Engineers				
mean	72.19	10.86	91	11.7222
std	78.53	7.51	41.8569	1.2696
max	282	23.71	162	12
min	8.91	2.11	20	4

Table 3: Relative Contribution to Industrialization of Locals vs. Immigrants and Shizoku

Country	Year	% Owners	% Pop.	Ratio	
		Immigrants	Immigrants	All	Men
Argentina	1900	80	30	2.7	1.3
Brazil (Sao Paulo)	1920-1950	50	16.5	3.0	1.5
Brazil (Minas Gerais)	1870-1900	3.6	1.5	2.4	1.2
Chile	1880	70	2.9	24.1	12.1
Colombia (Antioquia)	1900	5	4.7	1.1	0.5
Colombia (Barranquilla)	1888	60	9.5	6.3	3.2
Colombia (Santander)	1880	50	3	16.7	8.3
Mexico	1935	50	0.97	51.5	25.8
US (5% census sample)	1900	31	13.6	2.3	1.1
US (Fortune 500)	various	18	10.5	1.7	0.7
Relative contribution of Ex-Samurai (Shizoku)					
Japan	1868-1912	50	5	10	5

Notes: Table tabulates the share of industries owned by immigrants, their share in the population, their contribution relative to their share in the population and their contribution assuming all immigrants and entrepreneurs are male. Source: Industrial Surveys, both official and academic. See text. Tabulations for Japan are of ex-Samurai as entrepreneurs and their relative share of the populationOdagiri & Goto (1996).

6 Annexes

6.1 Annex 1: Data on immigrant firm ownership.

Subsubsectiondata on industrial ownership The paper draws together data on the firm ownership from census and other industrial source data from Argentina, Brazil, Chile, Colombia, Mexico and the US at the turn of the 20th century. The most extensive data is drawn from the available Industrial Censuses: both Argentina 1900 and Mexico (1935) have detail on origin of owners, and sector of operation. For comparison we draw on the 1% sample from the US 1900 census. Most other countries of the region began their surveys substantially later and those available from Ecuador (1957), Peru (1955), and Colombia (1943) do not include measures of ownership. For Chile, Ortega (1990) tabulates the ownership of industries using steam power in 1880.

For other countries, we have data on specific sub-regions. In Brazil, the most detailed data emerges from a 1962 retrospective survey by Bresser Pereira (1994) of 36% of firms of over 100 employees in the core 4 municipalities of the São Paulo industrial zone. São Paulo was cited by Hirschman as one of the three growth poles of Latin America along with Antioquia, Colombia and Monterrey, Mexico. The period 1930 to 1966 effectively covered by the survey is termed the Brazilian Industrial Revolution and hence, this sample of now large firms is central to understanding the development of the country. Birchal (1999) also offers a historical survey of ownership in the other center of autonomous industrialization, Minas Gerais.

For Colombia, firm registration records for the 19th and 20th century are available for the industrial center Antioquia that includes the sector and the principal shareholders in each firm as compiled and annotated by EAFIT (2013). Becerra & Restrepo (1987) offer data for for Barranquilla in 1888 which, at the time it was the principal port and major center of economic activity for the country, and Rincón et al. (2005) on the most notable entrepreneurs in the capital Bucamaranga 1880-1912 for Santander department, one of the earliest in manufactures in the Colonial period. Though the observations are fewer in these cases, they are closer to censuses than samples.

6.1.1 The concentration of immigrants in technologically advanced sectors

Also of importance, foreigners dominate across the product space, but especially in the more technologically advanced sectors.

For Argentina, Table 2 selectively draws from a 200 sector disaggregation to show that in only a few sectors is there a high or dominant participation of locals and these are the traditional ones, such as sugar cane processing mills sugar refining, and wool fabric. Local participation is also high, but not dominant in flour mills, and tobacco manufacture. Immigrants dominate in fields ranging from seemingly basic sectors (espadrilles, shoes, shirt-making, dressmaking carpentry, baking furniture making, tailoring and tanneries) as well as the most technically advanced sectors (lumber mills, carriages and other vehicles, trolleys, iron works and mechanics shops). The provision of electricity, and gas show a large component of not specified ownership, but sole Argentine ownership appears under 20%.

In Barranquilla, Colombia, foreigners again dominate the most sophisticated industries. All industries related to the new steam technologies-steam boats-the critical innovation for integration of the country via the Magdalena river-, steam sawmills, as well as insurance, telephones and trading houses are foreign dominated. Colombians are most represented, although not always dominant, in brokerage, canned foods, retail, hostelry.

In Mexican manufacturing, table 3 does not suggest patterns as clear as those found in Argentina or Barranquilla. However, Table 4 allows us to examine the extraction-related industries and reveals an overwhelming participation of foreigners in what was among the most technically advanced sectors of the age. In mining, Mexicans own a minority of 39% of plants and represent 30% of directors. Among the foreigners, the US here is the big gorilla with 28% of plants 40% of directors and 77% of investment (compared to Mexico's 2%). In Metallurgic processing, foreigners control 77% of firms with the US accounting for 46%. However, again, the US controls 83% of total investment compared to the Mexican 1%. In oil extraction the US shares dominance with Anglo-Dutch partnership with 68% and 31% of total investment compared to Mexico's 1.3%. In refining, the English dominate with 86% of investment compared the US 28%, and the Mexicans .4%. Foreign dominance of the sectors that made New Spain the jewel in the Spanish Empire is total. This pattern is echoed throughout the hemisphere.

6.1.2 What did immigrants bring?

What emerges is a picture where, with two regional exceptions, immigrants disproportionately laid the foundation of industrialization across the southern hemisphere, often at very large multiples of their representation in the general population. This echoes findings for the American South where Wright (1986) among others, documents the heavy role for Northern firms in the establishment of Southern industry.[20] These findings sit uncomfortably with the notion that the investment or institutional climate is the dominant explanation for Latin America's sluggish growth performance, at least during the critical Second Industrial Revolution. Foreigners were arriving on a regular basis and opening new firms across the industrial spectrum, but often in the more challenging ones. We could argue that more would have come under better circumstances, but the question remains of why there were so few local entrepreneurs developing these industries first?

[20]These findings may be consistent with **?** that Latin American had excessively homogeneous populations and hence were less able to identify and take advantage of new opportunities until immigrants arrived.

Table A1: Argentina 1910. Establishments by Nationality of Ownership

Establishments	**Argentine**	**Foreign**	**Joint**	**N.S**	**Total**	**Foreign Share**
Sugar Mills	23	11	1	2	37	0,30
Sugar Refining	1	0	0	0	1	0,00
Flour Mills	117	141	28	44	330	0,43
Tobacco	60	96	6	9	171	0,56
Wool Fabric	19	13	0	1	33	0,39
Clothes Vending	6	69	2	8	85	0,81
Espadrilles	7	138	3	22	170	0,81
Footwear	20	199	9	26	254	0,78
Shoe Making	185	1531	11	236	1963	0,78
Dress Making	34	171	7	28	240	0,71
Beer	8	11	2	3	24	0,46
Fruit Vending	10	27	0	17	54	0,50
Lumber Mills	59	163	24	37	283	0,58
Sacks Cloth	5	11	2	2	20	0,55
Shirt Making	9	75	3	4	91	0,82
Meat Processing Plant	4	4	0	0	8	0,50
Foundries	18	65	8	7	98	0,66
Designers	97	377	7	57	538	0,70
Meat Preserves	2	4	0	0	6	0,67
Baking	439	1876	72	213	2600	0,72
Glass	2	11	1	3	17	0,65
Furniture Making	82	647	12	53	794	0,81
Brickmaking	245	854	9	173	1281	0,67
Printing	318	302	21	98	739	0,41
Carpentry	457	1989	55	313	2814	0,71
Carriages/Vehicles	117	690	33	36	876	0,79
Trolleys	0	1	0	0	1	1,00
Tanneries	35	157	6	29	227	0,69
Saddlry	256	417	9	65	747	0,56
Wool Cleaning	0	1	0	0	1	1,00
Tailoring	246	1922	19	218	2405	0,80
Electricity	9	29	2	16	56	0,52
Gas	2	4	0	6	12	0,33
Mechanics Shops	50	234	16	35	335	0,70
Iron Works	464	2085	45	338	2932	0,71
Tin Work	91	614	8	87	800	0,77
All	5750	21957	612	3669	31988	0,69

Table A2: Mexico 1935, Manufacturing Establishments by Nationality of Ownership

Sectors	Mexico	Germany	Spain	US	France	England	Italy	Poland	Siria	Russia	Others	Total	Foreign Share
Textiles	761	14	215	32	49	16	2	32	21	38	62	1242	0,39
Metalurgy and Manufactured													
Metal Products	277	23	46	34	4	17	5	3	2	5	18	434	0,36
Construction Materials	140	1	32	5	1	4	8	0	0	1	5	197	0,29
Construction of Vehicles	12	0	1	0	0	0	0	0	0	0	0	13	0,.08
Clothes Factory	573	10	108	10	38	2	5	18	23	53	147	987	0,42
Food Products	1828	30	510	52	21	2	21	1	2	5	88	2560	0,29
Wood and Furniture	227	5	59	23	6	7	0	0	0	7	14	348	0,35
Ceramics	7	2	0	0	0	0	0	7	0	0	0	16	0,56
Leather	148	10	14	6	5	1	1	0	1	13	11	210	0,30
Light, Power, Heat	21	2	0	5	0	0	0	0	0		1	29	0,28
Chemicals	296	19	63	23	12	4	5	0	0	7	29	458	0,35
Paper	44	4	20		5	0	0	0	0	2	2	77	0,43
Graphics, Photography	195	3	49	1	1	1	1	0	0	2	10	263	0,26
Tobaco	49	1	5	4	2	0	0	0	0	0	1	62	0,21
Glass	22	0	4	0	0	0	0	1	0	0	1	28	0,21
Jewelry	20	2	2	1	0	1	1	0	0	1	3	31	0,35
Other	168	33	47	21	9	3	0	0	3	3	22	309	0,46
Total	4788	159	1175	217	153	58	49	154	52	137	414	7356	0,35
Share of Total	0,65	0,02	0,16	0,03	0,02	0,01	0,01	0,02	0,01	0,02	0,06	1,00	0,35
Workers	15966	222	1239	212	148	67	26	26	9	40	243	18198	0,12
Share of Total	0,88	0,01	0,07	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,01	1,00	0,12

Table A3: Mexico 1935, Establishments, Directors, Investment and Production by Nationality

Extraction Related Establishments	**Mexican**	**US**	**French**	**Italian**	**Spanish**	**German**	**English**	**Anglo-Dutch**	**Other**	**Total**	**Foreign Share**
Manufacturing											
Units	4653	151	140	41	978	122	43	0,000	788	6916	0,33
Share of Units	0,673	0,022	0,020	0,006	0,141	0,018	0,006	0,000	0,114	1	
Directors	4475	253	190	51	1166	143	65	0,000	1013	7356	0,39
Share of Directors	0,608	0,034	0,026	0,007	0,159	0,019	0,009	0,000	0,138	1	
Investment	207,738	53,406	37,372	1,065	87,239	8,946	11,485	0,000	48,461	455,712	0,54
Share of Investments	0,456	0,117	0,082	0,002	0,191	0,020	0,025	0,000	0,106	1,000	
Production	455,272	96,611	97,261	2,347	205,138	21,769	14,959	0,000	95,550	988,906	0,54
Share of Production	0,460	0,098	0,098	0,002	0,207	0,022	0,015	0,000	0,097	1	
Extractive Industries											
Mining											
Units	86	62	7	4	6	3	0,000	0,000	49	217	0,60
Share of Units	0,396	0,286	0,032	0,018	0,028	0,014	0,000	0,000	0,226	1	
Directors	90	128	7	4	5	6	0,000	0,000	67	307	0,71
Share of Directors	0,293	0,417	0,023	0,013	0,016	0,020	0,000	0,000	0,218	1	
Investment	2,479	87,705	1,896	0,196	0,125	0,019	0,000	0,000	21,610	114,030	0,98
Share of Investments	0,022	0,769	0,017	0,002	0,001	0,000	0,000	0,000	0,190	1	
Metallurgic proc.											
Units	26,0	51,0	3,0	3,0	28,0	0,000	0,000	0,000	0,000	111,0	0,77
Share of Units	0,234	0,459	0,027	0,027	0,252	0,000	0,000	0,000	0,000	1	
Directors	28	63	3	2	32	0,000	0,000	0,000	0,000	128	0,78
Share of Directors	0,219	0,492	0,023	0,016	0,250	0,000	0,000	0,000	0,000	1	
Investment	1,003	73,226	3,666	0,229	10,018	0,000	0,000	0,000	0,000	88,143	0,99
Share of Investments	0,011	0,831	0,042	0,003	0,114	0,000	0,000	0,000	0,000	1	
Oil extraction											
Units	15	18	0,000	0,000	0,000	0,000	0,000	2	9	44	0,66
Share of Units	0,341	0,409	0,000	0,000	0,000	0,000	0,000	0,045	0,205	1	
Directors	21	53	0,000	0,000	0,000	0,000	0,000	56	10	140	0,85
Share of Directors	0,150	0,379	0,000	0,000	0,000	0,000	0,000	0,400	0,071	1	
Investment	2,774	146,924	0,000	0,000	0,000	0,000	0,000	66,882	0,438	217,019	0,99
Share of Investments	0,013	0,677	0,000	0,000	0,000	0,000	0,000	0,308	0,002	1	
Refiining											
Units	2	4	0,000	0,000	0,000	0,000	3	0,000	0,000	9	0,78
Share of Units	0,222	0,444	0,000	0,000	0,000	0,000	0,333	0,000	0,000	1	
Directors	5	13	0,000	0,000	0,000	0,000	29	0,000	0,000	47	0,89
Share of Directors	0,106	0,277	0,000	0,000	0,000	0,000	0,617	0,000	0,000	1	
Investment	0,505	27,613	0,000	0,000	0,000	0,000	85,856	0,000	0,000	113,973	1,00
Share of Iestments	0,004	0,242	0,000	0,000	0,000	0,000	0,753	0,000	0,000	1	

Table A4: Barranquilla, Colombia 1888. Establishments by Nationality of Ownership

Sectors	**Colombia**	**Germany**	**Spain**	**US**	**France**	**England**	**Italy**	**Holland**	**Cuba**	**Foreign N.S.**	**Total**	**Foreign Share**
Banks	1	0	0	0	0	0	0	0	0	2	3	0,67
Cotton Packing and Cleaning	0	3	0	0	0	0	0	0	0	0	3	1,00
Brokers	4	4	0	0	0	0	0	0	0	0	8	0,50
Dry Dock	0	1	0	2	0	0	0	0	0	0	3	1,00
Canned Food Wholesaler	4	3	0	0	0	0	0	2	0	0	9	0,56
Canned Food Retailer	15	0	0	0	0	0	0	0	0	16	31	0,52
Stores	15	0	0	0	0	0	0	0	0	17	32	0,53
Insurance Company	1	0	0	3	0	1	0	0	0	0	5	0,80
Steam Sawmill	0	1	1	0	1	4	0	0	0	0	7	1,00
Metallurgical Workshop	1	1	0	0	0	2	0	0	0	0	4	0,75
Steamboat Sawyer	2	1	0	0	0	0	0	0	0	0	3	0,33
Soap Factory	3	0	0	0	0	0	0	0	2	0	5	0,40
River Navigation Steam Vessels	0	0	0	0	0	0	0	0	0	14	14	1,00
Steam Transport Boats	0	0	0	0	0	2	0	0	0	0	2	1,00
Bakeries	0	0	0	0	2	0	2	0	0	0	4	1,00
Boutiques	0	0	0	0	2	0	0	0	0	0	2	1,00
Hardware Retail	0	1	0	0	0	0	0	2	0	0	3	1,00
Warehouse Furniture	2	1	0	0	0	0	1	0	0	0	4	0,50
Hotels	3	0	0	0	2	0	0	0	0	0	5	0,40
Tipography	2	0	0	1	0	0	0	0	0	0	3	0,33
Shoes Retail	3	0	0	0	0	0	2	0	0	0	5	0,40
Newspapers	2	0	0	1	0	0	0	0	0	0	3	0,33
Telephone Company	0	0	0	1	0	0	0	0	0	0	1	1,00
Total Establishments	58	16	1	8	7	9	5	4	2	49	159	0,64
Share of Total	0,36	0,10	0,01	0,05	0,04	0,06	0,03	0,03	0,01	0,31	1,00	0,64

6.2 Annex 2: Cultural Roots of Weak Latin American Entrepreneurship

An overwhelming consensus exists among historians of virtually all countries of Latin America of an attitude of disdain for productive labor, derived from the colonial masters, and mainlined into the emerging societies across the social strata. See Safford (1976), Stein & Stein (1970) for an overview. (Lipset, 1967, p.8) argues "Almost everywhere in Latin America, the original upper class was composed of the owner of latifundia and these set the model for elite behavior to which lower classes, including the businessmen of the towns, sought to adapt. He argues that the continuation of pre-industrial values in much of Latin America can be linked in large part to the persistence of rural social structure which originally fostered these [21].

Scobie (1964) argues with reference to the Spanish legacy to Argentina "Basic to this golden era of Spain's empire was the ambition to become a lord over others, a dream which bore fruit in the disdain of future generations for manual labor." In Brazil "the disdain for technical, or any practical work" was a "value transferred from the metropolis [Portugal],ï¿½: for many people, work was synonymous with servile activity." (Telles, 1994, p.584). Azevedo (1944) argues that "This disdain had very old roots: coming from the times of the colony and was a product of an era and conditions of social life in the metropolis, transferred to the Colony, like customs, the use of religion, the mentality that liberty became a synonym with laziness (ociosidade) and work was the equivalent of servitude (Cited in Telles). It was the arrival of rich and respected British immigrants who helped shift attitudes toward practical activities and technical professions. In nineteenth-century Colombia "Individuals with pretensions to social status shunned manual labor. And the upper sector tended to seek patents of social honor through the pursuit of legal, political, or literary careers." (Safford, 1976). As (Hurtado, 2007, p. 83) relates, the US ambassador to Ecuador in the 1850s confirmed observations by foreign visitors over the previous three centuries that the elite considered work "shameful," "would rather die of hunger than engage in manual labor," and that "business, consonant with the Spanish tradition, was considered 'incompatible with nobility'," attitudes, he argues, that were shared by all classes. Applicants to San Gregorio university during the colonial period had to legally demonstrate "the purity of their blood and prove that none of their ancestors had engaged in trade" (Benjamin, 1965, p. 16). In Mexico, (Brading, 1971, p. 50) notes how Mexican mining was only seen as "a stepping stone to landowning: the role of the capitalist had little appeal." In Chile "The economic ideal of the nineteenth century remained that of a

[21] A recent literature has attempted to put the influence of such inherited colonial characteristics on a firmer empirical basis. Spolaore & Wacziarg (2009) have found that the distance from the technological frontier captured by genetic characteristics, proxying for "customs, habits, biases, conventions etc. that are transmitted across generations-biologically and/or culturally-with high persistence" is correlated with economic performance. (p. 471). Putterman & Weil (2008) demonstrate that backgrounds of the ancestors migrating to a country are correlated with economic performance. Weber's assertion of a link between religious belief or religiosity and entrepreneurial qualities is re-argued by McCleary & Barro (2006) and Becker & Woessmann (2009) have argued the "very long-lived (centuries) economic consequence of the emergence of Protestantism," although through its impact of human capital accumulation (literacy) rather than through work effort and thrift. Galor & Michalopoulos (2009) take a genetic point of view that the failure of the landed aristocracy to lead the risky process of industrialization could be attributed to the effect of Darwinian selection on the low representation of entrepreneurial, risk tolerant individuals within the landed gentry, and the prevalence of risk tolerant individuals among the middle and even the lower classes.

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' (**?**, pg. 14). For Peru, (Ramirez, 1986, pg. 225-226) argues that "The tradition of the gentleman farmer, which had reached its ultimate expression during the second half of the seventeenth century, and the fear of tainting their respectability, prevented many from engaging actively in commerce...The prosperity of the previous period ..reinforced old prejudices against such work inherited from Spain."

As Baumol notes, this attitude appears in Rome where commerce and manufacturing were relegated to manumitted slaves, and it was perpetuated through the middle ages. Safford notes that "The [Spanish] nobility's special position was codified in the thirteenth-century Siete Partidas, [the unifying legal code of Spain, based, in some cases verbatum, on the Roman Code of Justinian] which cautioned Spanish nobles against defilement in commerce" (Safford, 1976, pg.6) and which remained central to Spanish law into the 20th century. Roman influence reemerged in Spain after the re-conquest with the revival of the study of Roman law in the 13th Century. The Partidas remained an integral part of Spanish law through the centuries and the basis of the reform of the civil code in 1889.

Tortella Casares (2000) devotes a chapter of his Economic History of Spain, to how this attitude across all strata undermined entrepreneurship and contributed to the scarce economic progress in Spain from 1500 to 1850, the "miscarriage" of the Industrial Revolution there, and the lack of a "competitive, dynamic, entrepreneurial class" (pp. 73, 224).Tortella Casares (2000) acknowledges that it

> would be naive to attribute the economic backwardness of Spain solely to the mediocre caliber of its business entrepreneurs. But neither can one deny that social attitudes, difficult as they are to grasp, were very pervasive... My principal hypothesis... has been that a society which from the sixteenth century onwards was, intellectually speaking, frozen solid into an orthodoxy that systematically repressed original thought and freedom of action in the search of earthly happiness, finished up three centuries later without a competitive, dynamic, entrepreneurial class. The social attitudes, the accepted norms, I repeat, have been very persistent (p.227).

And, indeed, historical evidence suggests that Spain had the same problems with entrepreneurship and managing technological progress, domination by foreign firms across industries, and shared a similar penchant for monopolistic structures and trade protection (Tortella Casares, 2000). The experience of the Spanish mining industry, for example, follows the same template discussed earlier in Mexico and Chile (see Maloney & Valencia (2022) for more details). Spanish mines were rich, and, some minerals, mercury for example, had been worked for a thousand years. However, lack of technical capacity and capital, and slow growth of domestic metallurgical know how led Spanish entrepreneurs to work close to the surface and then sell out to foreigners once easy veins had been exhausted. As Tortella Casares (2000) summarizes "extraction and processing constitute a classic example of the failure of Spanish entrepreneurs to confront the problems of developing an industrial sector with complex technology, intensive use of capital, [and] a fast-expanding horizonï¿½" (p. 96, 213-215). Given the similarities in symptoms, it seems reasonable that some elements of the disease-institutions, productive structures, and social attitudes- were imported with colonization and retained influence in the interaction with the local environment.

Similar attitudes have been documented among Southern US elites as well. However, they had long been diluted in much of England and both the Puritans, and the Quaker colonizers of Delaware, New Jersey and Pennsylvania, valued both the productive use of time and the skilled trades, in the latter case, to the point that even those who rose to great wealth maintained their original occupational identification (Fischer, 1989). The fact that the Quakers started both Barclays and Lloyds Banks in England and established Philadelphia as the nation's first financial hub suggests the importance of imported human/entrepreneurial capital in that area. Taking a view of the country as a whole, Wood (1992) argues the colonies imported the English contempt for authority, high level of religious tolerance, and relative support for equality. Building on these, and critically facilitated by an abundance and relatively egalitarian distribution of land, he argues that the most radical achievement of the period of the American Revolution was the overturning the ancient tradition of aristocratic leisure and leadership and installing in its place, a celebration of work and commerce unparalleled in the Western world.

The character of this evolution interacted with the great availability of land more generally, the nature of the frontier, and huge migratory flows of both non English and those from parts of England with little attachment to the present order. Two thirds of Americans at the time of the revolution owned land compared to 1/5th in England (Wood, 1992, p. 123). Wood argues that it is "under-appreciated the degree to which early-nineteenth century Americans were overturning the ancient tradition of aristocratic leisure and leadership and celebrating in its place what Emerson called 'the dignity and necessity of labor to every citizen"(286) "The secret to American prosperity," said one foreign visitor, "was its celebration of work" "What most astounded Tocqueville was that Americans thought not only that work itself was 'honorable' but that 'work specifically to gain money' was 'honorable' (Wood, 1992, p. 285).

Hence, some differences in latent preferences have been argued to interact with different distribution of land to lead to a very different set of attitudes toward entrepreneurship. This is not to say that more formal institutions did not critically shape entrepreneurial incentives. Taylor argues that a bureaucratic distrust of commerce and aggressive self interest hobbled the Spanish empire."Despite their long head start in the Pacific, the Spanish lost much ground (and more water) to their many rivals at the end of the eighteenth century. They lacked the commitment to entrepreneurial commerce that drove the European penetration of the Pacific after Cook and his scientists showed the way. Wedded to Catholic absolutism, economic monopolies, and a highly bureaucratic and hierarchical government, the Spanish authorities simply did not trust independent merchants and their aggressive pursuit of self-interest. By contrast, the British and especially their spawn the Americans dedicated their governments to promoting commerce". (Taylor, 2001, p. 476).

6.3 Annex 3: Retrocession in Minas Gerais, Brazil

Minas Gerais, the other self-starting region in our sample, offers an example of the reverse process: how industrial retrogression, which we define as a loss of competitiveness of locally driven viable industry can occur if the frontier-adjusted level of entrepreneurial capital slips. Mining also defined Minas Gerais (General Mines) but the learning partnership occuring in Antioquia was arguably short circuited. "During the first decades of the nineteenth century, the primitive and disordered gold-mining activity of the end of the eighteenth century was replaced by foreign mining companies using 'state of the art' technology..." The British-owned Saint John del Rel Mining Company was the largest single industrial employer in Minas Gerais until the 1930s and the only one to survive among the nine Brazilian and foreign-owned gold-mining companies active in 1900. A similarly truncated learning process appeared in the textile and iron industries. Largely financed by the traditional landed elites, both industries grew significantly across the 19th century. However, while particularly the northern US colonies engaged in a sustained process of learning by doing and innovation in both iron and steel (Swank, 1965) from the early 18th century on, from 1830 to 1880 Brazil actually experienced a "retrogression in technique"(Rogers, 1962, p. 183).[22] Birchal (1999) argues that the underlying debility was difficulty in selecting new technologies, in our model, assessing the viability of a new project.

> Metallurgy for most of the nineteenth century was still essentially an empirical activity so that the selection of a method of production of iron depended largely on the technical knowledge of workers and/or entrepreneurs/managers. Success in the productive process was affected by variation in resource inputs in ways that could not be predicted or understood, and the best mix of resource inputs was found by trial and error. Therefore, not surprisingly, the most successful Mineiro foundries in the first three-quarters of the century were set up by foreigners with extensive knowledge of metallurgy. p 153

His description corresponds tightly to the learning process we model: success in the iron industry required experimentation to learn about processes and this, in turn, required the accompanying entrepreneurial capital. Foreigners had extensive knowledge of metallurgy precisely because they did this experimentation and invested in the entrepreneurial capital to get the most out of it. Similarly, in the 1880s there was potential for Minas to enter the electrical industry before foreigners moved the frontier too far to catch up (local entrepreneurial capital depreciated relative to the frontier). However, there was insufficient investment in entrepreneurial capital, in this case of both managerial and technical bent. Birchal (1999) concludes

> Mineiro firms relied strongly on foreign technologies and skilled personnel... The existing informal and spontaneous technological innovation system was not developed enough to take the process of technological assimilation farther in the direction of a profound modification of existing foreign technologies or to create a more complex indigenous technological alternative. The narrowness of the capacity of the nineteenth (sic) century Mineiro economy to absorb and refine imported

[22]Most Mineiro firms used the very primitive cadinho methodology which required neither complex facilities nor skilled workers but allowed little room for technological advance (Birchal, 1999, p. 117). But even though some foundries experimented with the more advanced Italian and Catalan methods, one engineer noted "The national industry was not prepared to compete against foreign products since it did not apply scientific industrial techniques or the new techniques developed in Europe, in particular the Bessemer process for manufacturing steel and then Seimens-Marin process open hearth method."[23]

> technology was due to a lack of skills and entrepreneurship which was confirmed by the failure to develop a capital goods industry. (p. 183).

The capital goods industry would be, in our terms, the next risky activity that would require investment in entrepreneurial capital. That did not happen. Hence, Minas Gerais offers a case of the reverse dynamic found for Antioquia- a retrogression where local entrepreneurs were active, in this case in new industries, but then abandoned them to foreigners as their frontier adjusted entrepreneurial capital eroded and they were unable to evaluate and adopt the new technologies that would keep them competitive.