

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

William F. Maloney[†] Andrés Zambrano[‡]

June 2, 2024

Abstract

This paper argues for “entrepreneurial capital” as a critical determinant of economic growth. It models an entrepreneur’s choice between investing in a safe activity or experimenting with a new risky one, and how much to invest in the ability to more effectively use arriving information on the latter, entrepreneurial capital. 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 the US and Latin America and simulations of the relative decline of the Chilean versus US copper industries across the 20th century.

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

JEL Codes: O31, O32, O13, D83

*Corresponding author Email: wmaloney@worldbank.org. This paper was partly supported by the regional studies budget of the Office of the Chief Economist for Latin America and the Caribbean, and the Knowledge for Change trust fund (KCP). We gratefully acknowledge comments from Nick Bloom, Serguey Braguinsky, Guillermo Caruana, Gerard Llobet, Javier Mejia, Ezra Oberfield, Andres Solimano, Jose Tessada and participants at the Harvard-MIT-Stanford Empirical Management Conference, 4th RIE Conference and the 6th EH-Clio Lab Conference at Universidad Catolica de Chile. We also thank the valuable assistance of Julian Gutierrez and Daniel Gomez. All remaining errors are ours.

[†]Chief Economist, Latin America and the Caribbean, The World Bank.

[‡]World Bank

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 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 We argue that the issue is central to understanding the differential growth trajectories of the past, and it has become increasingly relevant as how societies “learn to learn” has moved to center stage in discussions of industrial policies (Stiglitz, 1987; Stiglitz & Greenwald, 2015; Rodrik & Stiglitz, 2024).

The idea that firms learn from experimentation is well-established in the literature: Callander (2011) models agents learning about new products of varying complexity through a trial and error process and observing previous agents’ experience.² 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. Our model is in the tradition of the literature on optimal investment in R&D, where, for instance in Roberts & Weitzman (1981), agents experiment to learn about the value of a research project and optimally decide when to stop experimentation.³

¹The 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.

²Rosen (1972) and Ericson & Pakes (1995) specifically model firm learning by doing although Ericson and Pakes elsewhere argue that that learning by doing, an automatic or “passive” form of learning, differs from active experimentation.

³Bolton & Harris (1999) and Moscarini & Smith (2001) subsequently model agents choosing the frequency of playing (pulling) a risky arm in a bandit (slot machine) context 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. Keller et al. (2005) and Keller & Rady (2010) have explored the same issue but for exponential and Poisson bandits respectively.

However, history suggests that some entrepreneurs are better at learning from such experimentation than others. As Rosen (1972) notes “...decision makers are ‘made’ as well as ‘born’.” 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 entrepreneurial capital-the efficiency of learning- modeled as being inversely related to the precision of the prior, and thus how much new information changes the beliefs about uncertain payoffs.⁴

This capital could be anything that helps an entrepreneur understand the implications of newly arriving information for the profitability of a project: business skills, such as the ability to calculate likely return streams and manage risks; engineering or scientific capabilities to be able to judge technical feasibility; or the ‘openness to experience’ stressed by the psychology literature as a key trait of entrepreneurs (Kritikos, 2022). For an individual or society without these capacities, the needed positive signal to induce experimentation is insuperably high-the entrepreneur is effectively blind to new opportunities and hence, stays with the known and ‘safe’ technology. This 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.

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

⁴The less refined priors leading to engaging in new projects bears semblance to the class of “reverse Bayesian” models in Karni & Vierø (2013), where priors become more diffuse with “increasing awareness,” and heretofore unperceived possibilities for investment become visible. 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.

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.⁵

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 an 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, a surge in risky, complex higher return projects, and the initiation of the Great Divergence where the US moved ahead while most of Latin America fell behind.⁶ First, despite facing the same

⁵The 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.

⁶Mokyr (1998) dates the second Industrial Revolution as taking place roughly 1870-1914 where there

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 entrepreneurial capital.

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 the same homogeneous good appeared to contribute a foundation for growth and diversification.

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 former, 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 provides a mechanism through which to understand the creating of learning

was an acceleration in innovation after a lull following the first phase, and an increased emphasis on more structured scientific inquiry such as laboratory based R&D.

firms and societies and the interaction with government policy as discussed by Stiglitz (1987) and Stiglitz & Greenwald (2015). More concretely it speaks to 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; Eifeldt & 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. (1991a) 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, which is in turn the endogenous outcome of accumulated 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.

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), or the empirical work on innovative capacity proxied by engineering as a determinant of growth (see, for example, Maloney & Valencia, 2022).

Focusing on entrepreneurial capital does not obviate other explanations for growth performance in the literature: more business minded cultural traditions may lower the cost of acquiring entrepreneurial capital; exclusionary institutions prevent large shares of the population from acquiring it; better institutional and business climates raise the returns to all experiments.

2 An Information-Based Model of Entrepreneurial Choice

2.1 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. 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 $\tau + t$.

The precision of the signal t is a function of the number of signals that generated the aggregate average signal, as in the established R&D literature (Bolton & Harris, 1999). We interpret τ as a decreasing function of entrepreneurial human capital since a higher τ implies that the prior has a higher weight in the updated belief when the agent decides to experiment-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.⁷

The agent maximizes the discounted sum of profits over an infinite lifetime and each

⁷Alternatively, one could think on entrepreneurial capital as an increasing function of $\frac{t}{\tau}$, the relative weight of the signal on the posterior mean. However, we want to distinguish between the strength of the signal and the corresponding strength of the prior.

period chooses which project to pursue. The problem for the agent can be stated recursively as:

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

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 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:

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

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*

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

Proof. Following Stokey et al. (1989), there exists a unique solution to the problem given the constant returns to scale of the return and the discount on future payoffs. It is increasing in μ_r as the updated expected risky return μ'_r is increasing in μ_r and its probability distribution is ordered in the first stochastic dominance sense by μ_r . It is convex in μ_r and μ_s given the \max operator applied to linear functions. Since t (τ) increases (decreases) the variance of the probability distribution of μ'_r , its expected value function will be increasing (decreasing) in t (τ). In the limit, when τ approaches infinity, there would be no value for information and the distribution of μ'_r would be degenerate at μ_r .

□

The value of experimentation is the expectation of $v(\mu'_r, \tau + t)$. The greater the expected return to the risky project μ_r , the greater is the precision of the signal t and the lower is

the precision of the prior τ , the better off is the agent and the greater the willingness to experiment with the new project.

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^* .

Moreover, this threshold increases in τ since the value of information increases 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 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 threshold decreases and the agent will be more willing to experiment.

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 $\mathbb{E}_{\mu'_r} [v(\mu'_r, \tau_1)] > \mathbb{E}_{\mu'_r} [v(\mu'_r, \tau_2)]$, then the required threshold to experiment is lower in the first case. Thus the required positive signal to keep exploiting the risky project is higher the lower the entrepreneurial human capital, 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.

2.2 New projects and growth

In the growth process, each period a new risky project emerges and the entrepreneur decides to exploit it or stay with the safe project. If the agent chooses the risky project, s/he will update the distribution with the arrival of the new signal. If the updated risky mean is greater than the safe return, the risky project becomes the new safe project, and, for simplicity, we assume its distribution becomes degenerate at the posterior mean.

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 is drawn from a normal distribution with unknown mean μ'_r and precision t . The prior distribution of the unknown mean μ'_r will have mean μ_s and inherited precision τ , reflecting both the weight given to the prior but also shaping the unconditional distribution of the pool of new risky projects who would have mean μ_s and variance $t^{-1} + \tau^{-1}$. Therefore, an agent with lower entrepreneurial capital (higher τ) would not only assign less weight to signals, lowering its incentives to experiment, but would also draw new risky projects with returns closer to the updated safe return. Both mechanisms would reduce its capacity to grow and increase its likelihood for retrogression.

The problem can be expressed recursively as:

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

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.

2.3 Endogenous Entrepreneurial Capital

Introducing depreciation and investment in entrepreneurial capital yields richer growth dynamics. Now assume the precision of the new risky project is given by $\tau'(e) = \tau(1 + \delta(1 - e))$ where δ is the frontier-adjusted depreciation of entrepreneurial capital that occurs as technological progress increases the complexity of projects.⁸ Investing in entrepreneurial capital to offset depreciation, $e \in \{0, 1\}$, can be made at cost c after choosing the project but before observing the signal.⁹ If societies do not invest, depreciation makes experimentation more costly since entrepreneurs will give less weight to the arriving signals to evaluate them and the distribution of the new risky projects will have a smaller variance.

The problem can be expressed recursively as:

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

where

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

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

$$\mu'_s = \max \left\{ \mu_s; \frac{\tau'(e_r) \mu_r + tx}{\tau'(e_r) + t} \right\}$$

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

⁸A proportional increase in precision also generates a proportional decrease in variance, which is why we choose this specification for depreciation.

⁹Alternatively, a more natural timing would be to have the investment before choosing the project. In this case the investment would not be contingent to the project, but the solution would be the same since no information is revealed in between. On the other hand, our timing allow us to compare the investment made for each type of project. Also, we explored the case for a continuous e . Given that distributions are normal, the problem seems to be quasiconcave and, given the parameterization in subsection 3.3, the maximum would be around 1, as figure 2 suggests.

project is chosen whenever μ_r is greater than a threshold lower than 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, $e_s \leq e_r$.*

Proof. First note that, for any e :

$$E_{x, \mu'_r} \left[v(\mu'_s, \mu'_r, \tau'(e)) \right] \geq E_{\mu'_r} \left[v(\mu_s, \mu'_r, \tau'(e)) \right] \quad (1)$$

which is precisely why information has value. Both expressions are increasing and convex in μ_s and μ_r , decreasing 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 $\mu_r \in (a(c), b(c))$, where μ_s belongs to the interval and $a(\hat{c}) = \mu_s = b(\hat{c})$. Moreover, $a(c)$ and $b(c)$ 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 $e_s = 1$ it must be the case that $e_r = 1$ since the value of information is greater when the risky project is chosen. \square

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, investment in entrepreneurial capital is more productive and higher when the risky project is chosen and, conversely, 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.

Second, investment in entrepreneurial capital is more productive when the expected risky return is close to the safe return. At that point, new information is more important to distinguish between the value of the two projects. Optimal investment when the risky project is chosen is drawn in Figure 3 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, and is farther from them when the expected risky return is equal to the safe return. Thus, as shown in Figure 4, the marginal return of investment in entrepreneurial capital when the risky project is chosen is hump-shaped, and its maximum is at that point.

This result implies societies will not invest in entrepreneurial capital when agents have either very pessimistic or very optimistic priors on the risky project. The former case is self evident. In the latter case, agents will experiment with the risky project but will not invest in entrepreneurial capital because it is easy to parse the signal. However, this limits the ability to recognize newly arriving and more complex projects, restricting experimentation in new opportunities and limiting growth and diversification.

Even if this decision means losing future profitable opportunities, it is optimal from a single agent perspective. While investing in entrepreneurial capital increases future value functions, the sum of their discounted values may not be greater than the cost. Therefore, the more impatient a society is, the lower its prospective for growth. Figure 5 shows the case for the calibration for Chile in subsection 3.3, with successive investments in the first three periods. Note that successive investments increase subsequent value functions forever, but their differences are smaller over time.¹⁰

Third, the cost of investing in entrepreneurial capital is critical to experimentation and entrepreneurial capital investment choices. In the absence of a fixed cost it would be preferable to have more 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

¹⁰This result may not hold when there are multiple agents. If the technological frontier depends on investments made by other agents, as would happen in reality, multiple equilibria would arise and not investing in entrepreneurial capital could result in inefficient outcomes.

be decreasing in c , since the investment becomes more costly. Therefore, societies whose cost of investing in entrepreneurial capital is higher would experiment with new projects less frequently. Such costs may rise with prohibitions on trade, difficulty in visiting frontier industries/countries, the absence of business training or extension programs, or restrictions on opening new businesses.

3 Historical Evidence on the Importance of Entrepreneurial Capital

Clear measures of entrepreneurial capital are hard to come by at the time of the Second Industrial Revolution- 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 that are consistent with our framework.

3.1 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; Birchall, 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.¹¹

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 Birchall (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. Birchall (1999) documents that Juis de Fora, Minas Gerais, a major steel and manufacturing area from 1858-1912, immigrants were responsible for 66% of industries (Birchall, 1999, p.26).

In Chile, 70% of steam powered businesses were started by immigrants, roughly 12 times

¹¹We are very grateful to Richard Sutch for the census sample data and to he and Larry Neal for extremely helpful discussions.

their share in the male population. Again, this conforms with other historical accounts. Silva Vargas (1977) notes that “the lack of entrepreneurs and of qualified national workers gave to the incipient Chilean industry, a markedly foreign air” (p 94).¹² Collier & Sater (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

¹²... the lack of entrepreneurs and of qualified national workers gave to the incipient Chilean industry, 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.

data may be understating foreign influence in all countries. This is in line with Beatty (2015b) 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 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 (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.

For some immigrants, the observed greater learning ability may reflect previous familiarity with a sector of specialization in their home country. But, this is not always or even generally the case. The protean Andrew Carnegie arrived in the US with his hand-weaver father and first worked as a bobbin boy in a textile factory, and then messenger boy for the railroad, none of which are obviously helpful to recognizing the potential of the Bessemer process that revolutionized steel production. Instead, biographers cite his “keen eye for opportunity” as critical to his success in multiple sectors.¹³ Similarly, the founder of the Edwards dynasty in Chile, George Edwards, was the London-born son of a carpenter, and served as a surgeon and sailor on a British ship until deserting in Coquimbo. He worked as a doctor, but then became involved in mining. His sons would take over his silver smelter, develop copper and nitrate mines, start banks, build railroads, and eventually establish the country’s premier newspaper, none of which are obviously related to medicine. In both cases, the capability to recognize emerging new opportunities and evaluate their potential echoes the pattern we document in Antioquia, Colombia where local entrepreneurs began in mining, but then saw opportunities, first, in the coffee sector and then in manufactures.

3.2 Learning to Learn

A long literature would explain the relatively poor performance of local elites by cultural

¹³<https://www.carnegie.org/interactives/foundersstory/>

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 3.3, there are periods of entrepreneurial retrocession- a loss of previous sectoral advantage- which seems more consistent with high entrepreneurial capital investment costs causing a depreciation of entrepreneurial capital adjusted for an advancing technological frontier, than as an unexplained relapse to earlier cultural norms. The phenomenon of retrocession also allows identification between the importance of a lack of information, t , vs. the ability to use it, τ , given that information flows have increased over time.

In fact, there is evidence of substantial latent entrepreneurial energy in the region, but also of high costs of investment in entrepreneurial capital 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 northern 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.¹⁴ The South shows parallels to Latin America- much of its industry was started by foreigners or northerners and narratives point to the same counterproductive cultural values attributed to Latins, low technical and basic managerial capabilities, in addition to region specific factors. As suggestive examples, Wright (1986) notes that locals *with full knowledge* of gold or mineral deposits would respond more slowly than outsiders and "seemed to prefer backward methods to more capital-intensive and long term development" which he attributes to slave, not land appreciation being maximized. However, contemporary observers also talk of factors that are closer to a shortfall in entrepreneurial capital: southerners being "greatly disinclined to exact and careful reasoning"¹⁵ and "failing to see the opportunities within their grasp" that outsiders could.¹⁶ Likewise, Smith's (1980) canonical account of differential rates of technological adoption between the US armories in Springfield, Massachusetts and Harpers Ferry, Virginia paints a picture of free, even forced, information flows between the two government plants, but long lags in uptake by the latter. Though local power relations and cultural biases dampened receptiveness, the recurring dismissal of the new machinery and processes as proposals of "visionary theorists" (p. 208) and "visionary schemes and charlatanism" (p.139) point to problems in methodically "digesting the new technology" (p. 109) and judging its true economic potential for gain the way the New England management and workers enthusiastically did (Smith, 1980). These cases point to another potential source

¹⁴As 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.

¹⁵Frederick Law Olmstead, *The Cotton Kingdom* cited in Sowell (2009)

¹⁶Rupert Vance cited in Sowell (2009)

of lagging Southern development- not a lack of information, but of an inability to use it to modify priors, and a reluctance to invest in the capacity to do so.

As technical human capital is an ingredient in such ability, Latin America likely started with an even lower level of entrepreneurial capital: Maloney & Valencia (2022) show that Latin America had one-tenth the presence of engineers that the US North had in 1900 and one-third of that of the South. Stronger industrialization efforts arguably failed to appear less because of indolence, and more because the region entered the second industrial revolution with a low stock of entrepreneurial capital, and the costs of accumulating it were dramatically higher in Latin America than in the US. As the model shows, both these work against experimentation and the accumulation of entrepreneurial capital.

3.2.1 The construction of indigenous entrepreneurial capacity in Antioquia, Colombia

The experience of Antioquia, Colombia shows a path where these disadvantageous initial conditions 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 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 quickly become landed gentry. The French engineer Amour argued that Antioqueño 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 first type of retrocession where negative shocks in the absence of entrepreneurial capital lead to risky project abandonment. Fischer (1996) notes that "While the Colombian firms understood better the economic and political limitations of the country, it was the foreign firms that 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." As noted above, risk loving is observationally equivalent to possessing the entrepreneurial capital to assess project risk and returns and learn from this experimentation.

The dynamic interaction of local with foreign actors across this period lowered the cost of accumulating and engendered a process of learning to learn. 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).¹⁷ The 1850s and 1860s were a period of modernization 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."¹⁸ At the same time, Antioqueños dominated the national market for gold and became adept at managing financial transactions both locally and internationally. Finally, the Antioquia School of Mines, established by two exiles who graduated from U.C. Berkeley School of Mines in 1895, sought to, and is credited

¹⁷"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 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.

¹⁸Directors 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.

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).¹⁹

Antioqueños would eventually sell most mining claims to foreigners- by Latin American standards, local mining was a difficult and modestly profitable business- and, in line with our stylized growth model, 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 (Hirschman, 1968).

3.2.2 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, Encina (1911) in *Nuestra Inferioridad Economica* (Our Economic Inferiority) and Pinto (1959) in his *Chile, Un Caso de Desarrollo 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 energy 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 he notes entrepreneurial practices importantly lagged those of the advanced countries in every dimension. Chilean entrepreneurs were the second largest presence in Peruvian nitrate fields, ahead of the British (Cariola & Sunkel, 1985). Locals pioneered and dominated copper mining during the period

¹⁹Mayor 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."

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.²⁰ 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).²¹

Hence, what alarmed contemporary observers sought to explain was the marked *decline* in local entrepreneurial activity at the end of the 19th century as Chile lost industries where it once excelled, and foreigners began to dominate all areas of the national economy (Mac Iver, 1900; Encina, 1911; Pinto Santa Cruz, 1959). Their arguments are consistent with a low level of entrepreneurial skills that depreciated with a shifting frontier. Like the early Antioquians, Chileans had an ‘obsession for fortune at one blow, (ganada de un arretazo),’ had “qualities little appropriate for industrial activities” and took “little care about the exactitude of data and the legitimacy of the calculations based upon them” (Encina, 1911, p 195, 80-82n). 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).

Unlike Antioquia, and consistent with our second learning regime, 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,” and the result was a

²⁰In 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-eminent 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”.

²¹The “Chili Mill” for breaking up rock displaced the Mexican *arrastre* and is on display at Sutter’s Mill where gold was first discovered.

“lack of entrepreneurial capacity to innovate...the introduction of new technologies, forms of exploitation, and administration...” when confronted with the second industrial revolution (Nazer, 2000, p. 63-66). This depreciation of Chile’s entrepreneurial capital was a choice-not a problem of finance or information-²² that not only caused domestic mining to retrocess and die by 1920, but foreclosed entry into new industries as the frontier moved. Pinto precisely describes the dynamics of our model:

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).

Similarly, anguished critics saw the country’s abdication of the role of Schumpeterian midwife in the development of the recently conquered nitrate fields, subcontracting to British interests and living from a share of the rents, as foreclosing the building of necessary capabilities to move into new sectors. (Pinto Santa Cruz, 1959; Meller, 1996; Monteón, 1982).

In no case is this 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,²³ but raises the possibility that these

²²This 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)

²³Juan 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

resources were not productively directed precisely because entrepreneurs were not able to recognize or exploit opportunities.²⁴ Villalobos et al. (1990) note “that 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)” and who “brought a greater tradition of information” (p.99). By contrast, (Encina, 1911, p. 292-293n) argues that the local “manufacturing and commercial ineptitude” contributed to a “parasitism” of extensive and unproductive public employment and related professions, in an inversion of the Murphy et al. (1991b) view of talent being diverted away from productive opportunities by distortions.

Historical accounts and patenting evidence document the same retrogression in Mexican mining and manufactures. The introduction of the MacArthur-Forrest cyanide separation process in 1903 led to an explosion of patents for new techniques related to the refining of gold and silver ores that was wholly the result of foreigners, and not the local miners and engineers who, for 300 years until the 1880s, had directed the nation’s mining and refining capacity, but were now uncompetitive (Beatty, 2015a). As Beatty (2015b) discussion of Mexico’s struggle to manage new technologies documents, this retrogression extended to many sectors beyond mining.²⁵

These examples confirm that industrial retrogression was emphatically not intrinsic to copper or nitrates and establish 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

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.”

²⁴“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, 1977, p. 45)

²⁵Parkes notes that 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.

in entrepreneurial capital may have led to a low learning regime in Chile, offering a new genre of resource curse, this was not the case elsewhere. Not only does Wright (1999) argue that the US in the 19th century “parlayed its [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. Japan also leveraged its position as a leading copper exporter for rapid and diversified national development.²⁶ Major zaibatsu such as Fujitsu, Hitachi, and Sumitomo began as copper mining companies but then rapidly applied Western technologies and diversified. All three countries were among the global leaders in copper exporting across the 19th century, yet different learning regimes, arising from different initial endowments of and cost of accumulating entrepreneurial capital dictated radically different development outcomes.²⁷ Annex 3 documents that the same retrocession can be found in other sectors-both the iron and electrical industry in Minas Gerais, Brazil, again due to inability to manage new risky projects.

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

This section shows that with plausible parameters our model can generate these divergent time paths of the Chilean and US copper industries across the 1850 to 1920 period. As a proxy for the entrepreneurial skills, we follow Murphy et al. (1991a) in using engineering density (engineers per 100.000 inhabitants) derived from Maloney & Valencia (2022) and

²⁶In 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).

²⁷As discussed, the US started with UK level entrepreneurial capital and accumulation costs were low. As one suggestive source of higher initial capabilities in Japan, 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. 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. But critical also was that the example of colonial domination of China made catching up and learning Western technologies imperative, raising the social return and spurring government efforts to lower the costs of learning how to learn. Odagiri (1998) notes precisely the emphasis put on developing managerial and technical schools as critical to catch up. Pre-WWI management was dominated by graduates from select schools with Hitachi being singled out as headed by engineering-managers from University of Tokyo.

census data. Figure 6 shows the evolution of the logarithm of copper revenue by Chilean nationals, and US nationals in the US, and Figure 7 the evolution of the number of domestic engineers for both countries. Note Chile has higher initial revenues, but is overtaken by the US within the first decades. On the other hand, US has higher initial entrepreneurial capital and keeps investing in it at a higher pace than Chile.

For each country, we begin 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 100 which reproduces the average adoption lag estimated by Comin & Mestieri (2018). The depreciation parameter δ is set to 0.3 and the cost of investing in entrepreneurial capital c is set to 0.2 for both countries to match the growth of revenues.

We use the same seed for the realized returns of the risky project for both countries. Table 2 summarizes the descriptive statistics of the model and the data to evaluate its fit. It successfully replicates the revenues (returns) from copper as seen by comparing Figure 8 to Figure 6. Further, it simulates the increased path of entrepreneurial capital in the US and its stagnation in Chile as seen by comparing Figure 9 to Figure 7, although the assumed linearity of its accumulation does not allow the model to replicate the path quantitatively. As with the data, the simulations show that despite Chile having a higher initial return, US quickly surpasses it because of a higher initial entrepreneurial capital and a lower initial expected risky return.

To clarify which parameters are driving the results, we assign the U.S. initial value to each as a base and then vary them individually. First, we simulate the case where both countries have the same initial entrepreneurial capital and the same safe return, but Chile has a higher initial expected risky return. As described in the model, this setup discourages Chile to invest in entrepreneurial capital, lagging behind US as shown in Figure 11. Even with more moderate returns, the resulting lag in entrepreneurial capital implies that it is no longer profitable to invest further and the frontier-adjusted stock continues to depreciate. As

a result, revenues slow and end up lower than the ones in US (Figure 10). The US overtakes Chile somewhat later than previously given the latter's higher initial stock of entrepreneurial capital.

Setting returns equal, but allowing different initial levels of entrepreneurial capital implies a 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 as Figures 12 and 13 show. In sum, both the higher initial expected risky return and low initial entrepreneurial capital contribute to the decision to invest in further entrepreneurial capital.

However, having a higher initial safe return, while shutting down differences in initial entrepreneurial capital, does not generate diverging paths. Figure 14 shows the evolution of the returns for the case where both countries have the same initial entrepreneurial capital. In this case, both countries always invest in entrepreneurial capital (Figure 15) and the higher initial safe return of Chile generates an almost constant advantage over time.

3.3.1 Robustness

One concern is that engineering density may be simply picking up human capital more generally that might be increasing the return to investments in new technologies and hence may not capture 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 16 shows that literacy was already high in the US, while engineering density almost tripled across our period. On the other hand, Chile's literacy rate and engineering density followed a similar low path, where literacy stagnated a decade earlier. These dynamics in literacy rates could not generate the observed evolution of copper revenue in the US.

As a second robustness test, we remove the effects that aggregate physical capital accumulation may have had from copper revenue to avoid conflating it with the effects we model. 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 (Figure 17). 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 18 shows the resulting copper labor revenue, which behaves very similarly to copper revenue. Table 3 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 investment in turn depends on the cost, the initial distance from the frontier and, non-monotonically, on the expected return to the new 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.

References

- Aghion, P., Mayer-Foulkes, D., & Howitt, P. (2005). The Effect of Financial Development on Convergence: Theory and Evidence. *Quarterly Journal of Economics*, 120, 173–222.
- Atkeson, A. & Kehoe, P. J. (2005). Modeling and measuring organization capital. *Journal of political Economy*, 113(5), 1026–1053.
- Azevedo, F. d. (1944). *A Cultura Brasileira : Introducao ao Estudo da Cultura no Brasil*. Companhia Editora Nacional, Sao Paulo, 2 ed. edition.
- Baumol, W. J. (1990). Entrepreneurship: Productive, Unproductive, and Destructive. *Journal of Political Economy*, 98(5), 893–921.
- Baumol, W. J. (2010). *The Microtheory of Innovative Entrepreneurship*. Princeton: Princeton University Press.
- Beatty, E. (2015a). Globalization and technological capabilities: Evidence from mexico’s patent records ca. 1870-1911. *Estudios de Economía*, 42(2).
- Beatty, E. (2015b). *Technology and the search for progress in modern Mexico*. University of California Press.
- Becerra, M. R. & Restrepo, J. R. (1987). *Los Empresarios Extranjeros de Barranquilla, 1820-1900*. Facultad de Administracion Universidad de los Andes.
- Becker, S. O. & Woessmann, L. (2009). Was Weber Wrong? A Human Capital Theory of Protestant Economic History. *The Quarterly Journal of Economics*, 124(2), 531–596.
- Benjamin, H. R. (1965). *Higher Education in the American Republics*. McGraw-Hill, New York ; Sydney.
- Birchal, S. d. O. (1999). *Entrepreneurship in Nineteenth-century Brazil: the formation of a business environment*. London.
- Bloom, N., Eifert, B., Mahajan, A., McKenzie, D., & Roberts, J. (2013). Does management matter? evidence from india*. *The Quarterly journal of economics*, 128(1), 1–51.
- Bloom, N. & van Reenen, J. (2007). Measuring and explaining management practices across firms and countries. *Quarterly Journal of Economics*.
- Bolton, P. & Harris, C. (1999). Strategic experimentation. *Econometrica*, 67(2), 349–374.
- Botero, M. (2007). *La Ruta del Oro: una Economía Primaria Exportadora: Antioquia, 1850-1890*. Universidad Eafit.
- Brading, D. A. (1971). *Miners and Merchants in Bourbon México, 1763-1810*. University Press, Cambridge.
- Braguinsky, S., Ohyama, A., Okazaki, T., & Syverson, C. (2020). *Product Innovation, Product Diversification, and Firm Growth: Evidence from Japan’s Early Industrialization*. Technical report, National bureau of economic research.

- Bresser Pereira, L. C. (1994). Empresários, suas origens, e as interpretações do brasil. *Revista Brasileira de Ciências Sociais*, 9, 25.
- Brew, R. (1977). *El Desarrollo Económico de Antioquia desde la Independencia hasta 1920*, volume 38. Banco de la República Bogotá.
- Bruhn, M., Karlan, D., & Schoar, A. (2010). What capital is missing in developing countries? *The American Economic Review*, (pp. 629–633).
- Buffington, R. & William, F. (1999). *The Culture of Modernity*. In *The Oxford History of Mexico*, edited by Michael C. Meyer and William Beezley. Oxford University Press.
- Callander, S. (2011). Searching and learning by trial and error. *American Economic Review*, 101(6), 2277–2308.
- Cariola, C. & Sunkel, O. (1985). The growth of the nitrate industry and socioeconomic change in Chile, 1880-1930. In I. R. C. Conde & S. J. Hunt (Eds.), *The Latin American Economies*. Holmes and Meier.
- Collier, S. & Sater, W. F. (1996). *A History of Chile, 1808-1994*. Cambridge University Press. 1996.
- Comin, D. & Mestieri, M. (2018). If technology has arrived everywhere, why has income diverged? *American Economic Journal: Macroeconomics*, 10(3), 137–178.
- Conning, J. (2001). Latifundia economics.
- EAFIT (2013). *Fuentes Documentales para la Historia Empresarial, Tomo II*. Fondo Editorial Universidad EAFIT.
- Eisfeldt, A. L. & Papanikolaou, D. (2013). Organization capital and the cross-section of expected returns. *The Journal of Finance*, 68(4), 1365–1406.
- Encina, F. A. (1911). *Nuestra Inferioridad Económica, sus Causas, sus Consecuencias*. Santiago: Colección Imagen de Chile.
- Ericson, R. & Pakes, A. (1995). Markov-perfect industry dynamics: A framework for empirical work. *The Review of Economic Studies*, 62(1), 53–82.
- Fischer, D. H. (1989). *Albion's Seed : Four British Folkways in America*. Oxford University Press, New York.
- Fischer, T. (1996). Empresas extranjeras en el sector del oro y de la plata en Colombia, 1870-1914: La free standing company como modelo aplicado por inversionistas extranjeros. *Boletín Cultural y Bibliográfico*, no 39.
- Fogarty, John Di Tella, G., Platt, D. C. M., & of Americanists, I. C. (1985). Staples, Super-Staples and the Limits of Staple Theory: The Experiences of Argentina, Australia and Canada Compared. In *Argentina, Australia, and Canada : studies in comparative development, 1870-1965*. D.C.M. Platt and Guido di Tella.

- Gallman, R. E. (1986). The united states capital stock in the nineteenth century. In *Long-term factors in American economic growth* (pp. 165–214). University of Chicago Press.
- Galor, O. & Michalopoulos, S. (2009). *The Evolution of Entrepreneurial Spirit and the Process of Development*. Carlo Alberto Notebooks 111, Collegio Carlo Alberto.
- Giorcelli, M. (2019). The long-term effects of management and technology transfers. *American Economic Review*, 109(1), 121–52.
- Gonzalez-Uribe, J. & Leatherbee, M. (2018). The effects of business accelerators on venture performance: Evidence from start-up chile. *The Review of Financial Studies*, 31(4), 1566–1603.
- Haber, S. (1995). *Industry and underdevelopment: the industrialization of Mexico, 1890-1940*. Stanford University Press.
- Haber, S. (1997). *Financial Markets and Industrial Development: A Comparative Study of Government Regulation, Financial Innovation and Industrial Structure in Brazil and Mexico, 1840-1930*. Stanford, CA:Stanford University Press.
- Hansen, R. D. (1971). *The Politics of Mexican Development*. Johns Hopkins Press Baltimore,.
- Hirschman, A. O. (1968). The political economy of import-substituting industrialization in latin america. *The Quarterly Journal of Economics*, 82(1), 1–32.
- Howitt, P. (2000). Endogenous Growth and Cross-country Income Differences. *American Economic Review*, (pp. 829–846).
- Howitt, P. & Mayer-Foulkes, D. (2005). R&d, Implementation, and Stagnation: A Schumpeterian Theory of Convergence Clubs. *Journal of Money, Credit and Banking*, 37(1), 147–77.
- Hurtado, O. (2007). *Las Costumbres de los Ecuatorianos*. Quito: Editorial Ecuador FTB.
- Iacovone, L., Maloney, W., & McKenzie, D. (2021). Improving Management with Individual and Group-Based Consulting: Results from a Randomized Experiment in Colombia. *The Review of Economic Studies*.
- Karni, E. & Vierø, M.-L. (2013). ” reverse bayesianism”: A choice-based theory of growing awareness. *American Economic Review*, 103(7), 2790–2810.
- Keller, G. & Rady, S. (2010). Strategic experimentation with poisson bandits. *Theoretical Economics*, 5(2), 275–311.
- Keller, G., Rady, S., & Cripps, M. (2005). Strategic experimentation with exponential bandits. *Econometrica*, 73(1), 39–68.
- Kerr, W. R., Nanda, R., & Rhodes-Kropf, M. (2014). Entrepreneurship as experimentation. *The Journal of Economic Perspectives*, 28(3), 25–48.
- Knight, F. H. (1921). *Risk, uncertainty and profit*, volume 31. Houghton Mifflin.

- Kritikos, A. S. (2022). Personality and entrepreneurship. *Handbook of Labor, Human Resources and Population Economics*, (pp. 1–20).
- Lipset, S. (1967). Values, Education and Entrepreneurship. In *Elites in Latin America*. Lipset and Aldo Solari.
- Lopez, J. C. (2007). Minas de Oro y Plata, Origen del Espírtu Empresarial Antioqueno. *Revista Gestion y Region*.
- Loveman, B. (1979). *Chile, the Legacy of Hispanic Capitalism*. Oxford University Press.
- Lustig, H., Syverson, C., & Van Nieuwerburgh, S. (2011). Technological change and the growing inequality in managerial compensation. *Journal of Financial Economics*, 99(3), 601–627.
- Mac Iver, E. (1900). Discurso sobre la crisis moral de la república (1900). *Biblioteca La Revista de Chile, Santiago: Imprenta Moderna*.
- Maddison, A. et al. (1994). *Standardised estimates of fixed capital stock: a six country comparison*. Technical report, Groningen Growth and Development Centre, University of Groningen.
- Maloney, W. F. & Valencia, F. (2022). Engineering Growth. *Journal of the European Economic Association*.
- Manso, G. (2016). Experimentation and the returns to entrepreneurship. *Review of Financial Studies*, (pp. hhw019).
- Mayor Mora, A. (1984). *Ética, trabajo y productividad en Antioquia: una interpretación sociológica sobre la influencia de la Escuela Nacional de Minas en la vida, costumbres e industrialización regionales*. Ediciones Tercer Mundo.
- McCleary, R. M. & Barro, R. J. (2006). Religion and Economy. *Journal of Economic Perspectives*, 20(2), 49–72.
- McFarlane, A. (2002). *Colombia before independence: economy, society, and politics under Bourbon rule*, volume 75. Cambridge University Press.
- Meisel Roca, A. (2011). Costos y beneficios de la independencia. In E. P. Carbo (Ed.), *Colombia. Crisis imperial e independencia. Tomo I (1808-1830)*. Taurus.
- Meller, P. (1996). *Un siglo de economía política chilena (1890-1990)*. Editorial Andrés Bello Santiago.
- Mokyr, J. (1998). *The Second Industrial Revolution, 1870-1914*. Northwestern University Manuscript. Evason, 1st edition.
- Monaghan, J. (1973). *Chile, Peru, and the California gold rush of 1849*. Univ of California Press.
- Monteón, M. (1982). *Chile in the Nitrate Era: The Evolution of Economic Dependence, 1880-1930*. University of Wisconsin Press Madison, Wisc.

- Moscarini, G. & Smith, L. (2001). The optimal level of experimentation. *Econometrica*, 69(6), 1629–1644.
- Murphy, K. M., Shleifer, A., & Vishny, R. W. (1991a). The allocation of talent: Implications for growth. *The Quarterly Journal of Economics*, 106(2).
- Murphy, K. M., Shleifer, A., & Vishny, R. W. (1991b). The allocation of talent: Implications for growth. *The Quarterly Journal of Economics*, 106(2), 503–30.
- Nazer, R. (2000). El surgimiento de una nueva elite empresarial en Chile: 1830-80. *Minore e Culture Imprenditoriali*, (pp. 59–84).
- North, D. C. (1990). *Institutions, institutional change and economic performance*. Cambridge university press.
- Odagiri, H. (1998). Education as a source of network, signal, or nepotism. *Networks, Markets, and the Pacific Rim: Studies in Strategy*, (pp. 141).
- Odagiri, H. & Goto, A. (1996). *Technology and Industrial Development in Japan: Building Capabilities by Learning, Innovation, and Public Policy*. Oxford University Press.
- Ortega, L. (1990). El proceso de industrialización en Chile 1850-1930. *HISTORIA*, 26, 1991–1991.
- Parkes, H. B. (1969). *A History of Mexico*. Houghton Mifflin.
- Pinto Santa Cruz, A. (1959). *Chile, un Caso de Desarrollo Frustrado*. Santiago : Universitaria, 1959.
- Poveda Ramos, G. (1993). *Historia Social de las Ciencias en Colombia: Ingeniería e historia de las técnicas, Vol. IV y V*. Colciencias.
- Putterman, L. & Weil, D. N. (2008). *Post-1500 Population Flows and the Long Run Determinants of Economic Growth and Inequality*. NBER Working Papers 14448, National Bureau of Economic Research, Inc.
- Ramirez, S. E. (1986). *Patriarchs: Land Tenure and the Economics of Power in Colonial Perú*. University of New Mexico Press, Albuquerque, 1st edition.
- Rincón, G., Antonio, A., & Nieves, M. A. (2005). La elite empresarial de Santander (1880-1912). *Empresas y empresarios en la historia de Colombia. Siglos XIX y XX*, (pp. 141–178).
- Roberts, K. & Weitzman, M. L. (1981). Funding criteria for research, development, and exploration projects. *Econometrica*, 49(5).
- Robinson, A. & Acemoglu, R. (2012). Why nations fail. *The Origins of Power, Prosperity and Poverty*, Nueva York.
- Rodrik, D. & Stiglitz, J. (2024). A new growth strategy for developing nations. *Universidad de Harvard [en línea] <https://drodrik.scholar.harvard.edu/publications/new-growth-strategy-developing-nations>*. José Manuel Salazar-Xirinachs y Marco Llinás.

- Rogers, E. (1962). The Iron and Steel Industry in Colonial and Imperial Brazil. *The Americas*, 1(2), 172–184.
- Rosen, S. (1972). Learning by experience as joint production. *The Quarterly Journal of Economics*, (pp. 366–382).
- Safford, F. (1976). *The Ideal of the Practical : Colombia's Struggle to Form a Technical Elite*. University of Texas Press, Austin.
- Scobie, J. R. (1964). *Argentina : A City and a Nation*. Oxford University Press, New York.
- Silva Vargas, F. (1977). Comerciantes, habilitadores y mineros: una al estudio de la mentalidad empresarial en los primeros años de chile republicano (1817-1840). *Empresa Privada*.
- Smith, M. R. (1980). *Harpers Ferry armory and the new technology: The challenge of change*. Cornell University Press.
- Sowell, T. (2009). *Black rednecks & white liberals*. Encounter Books.
- Spolaore, E. & Wacziarg, R. (2009). The Diffusion of Development. *The Quarterly Journal of Economics*, 124(2), 469–529.
- Stein, S. J. & Stein, B. H. (1970). *The Colonial Heritage of Latin America : Essays on Economic Dependence in Perspective*. Oxford University Press, New York.
- Stiglitz, J. E. (1987). Learning to learn, localized learning and technological progress. *Economic policy and technological performance*, (pp. 125–153).
- Stiglitz, J. E. & Greenwald, B. C. (2015). *Creating a learning society: A new approach to growth, development, and social progress*. Columbia University Press.
- Stokey, N. L., Lucas, R. E., & Prescott, E. C. (1989). Recursive methods in economic dynamics. (*No Title*).
- Sutulov, A. (1975). Antecedentes históricos de la producción de cobre en chile. *El Cobre Chileno*, edited by A. Zauschquevich and A. Sutulov, (pp. 1–115).
- Swank, J. M. (1965). *History of the Manufacture of Iron in all Ages, and Particularly in the United States from Colonial Times to 1891*. B. Franklin New York,, [2d ed.] edition.
- Tafunell, X. (2013). Capital formation in latin america: one and a half century of macroeconomic dynamics. *CEPAL Review*.
- Taylor, A. (2001). *American Colonies: The Settling of North America the Penguin History of the United States, Volume 1*. Penguin History of the United States. New York, N.Y: Penguin Books.
- Telles, P. C. d. S. (1994). *História da Engenharia no Brasil, Séculos XVI a XIX*. Clavero, Rio de Janeiro.
- Tortella Casares, G. (2000). *The Development of Modern Spain : An Economic History of the Nineteenth and Twentieth Centuries*. Harvard University Press, Cambridge, Mass. .:

- Twinam, A. (1980). From jew to basque: ethnic myths and antioqueno entrepreneurship. *Journal of Interamerican Studies and World Affairs*, 22(1), 81–107.
- Villalobos, S. R., , & Beltrán, L. (1990). *Historia de la Ingeniería en Chile*. Hachette. Santiago.
- Will, R. M. (1957). *Some Aspects of the Development of Economic Thought in Chile (ca. 1775-1878)*. Technical report.
- Wood, G. S. (1992). *The Radicalism of the American Revolution*. A.A. Knopf, New York, 1st ed. edition.
- Wright, G. (1986). *Old South, New South : Revolutions in the Southern Economy since the Civil War*. Basic Books, New York.
- Wright, G. (1999). Can a Nation Learn? American Technology as a Network Phenomenon. In *Learning by doing in markets, firms, and countries* (pp. 295–332). University Of Chicago Press.
- Yasuba, Y. (1987). The tokugawa legacy: a survey. *The Economic Studies Quarterly*, 38(4), 290–308.

5 Figures and Tables

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

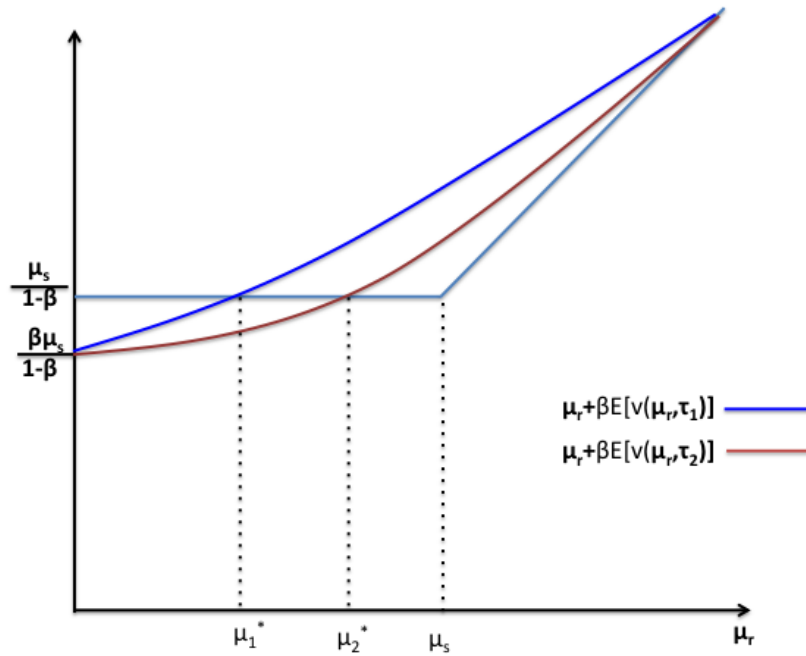


Figure 2: Quasiconcavity of $v_i(\mu_s, \mu_r, \tau)$ on e_i for $i = s, r$.

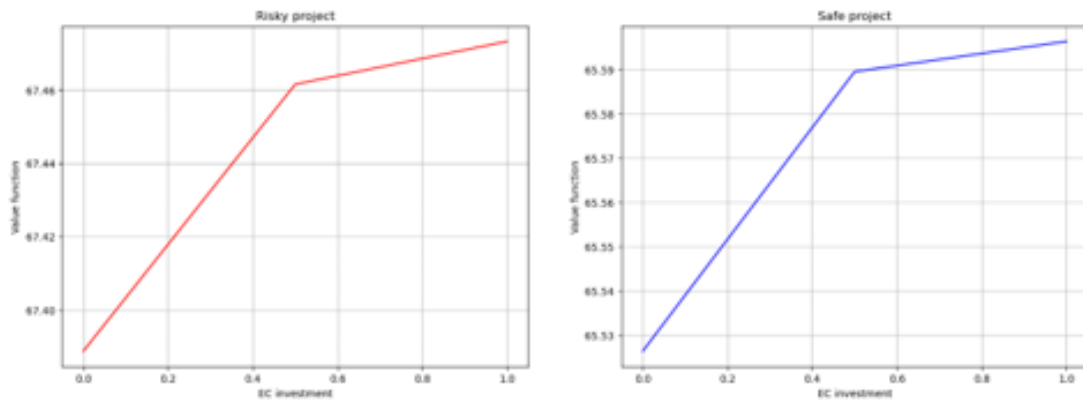


Figure 3: Optimal investment when the risky project is chosen: $c_1 < c_2$

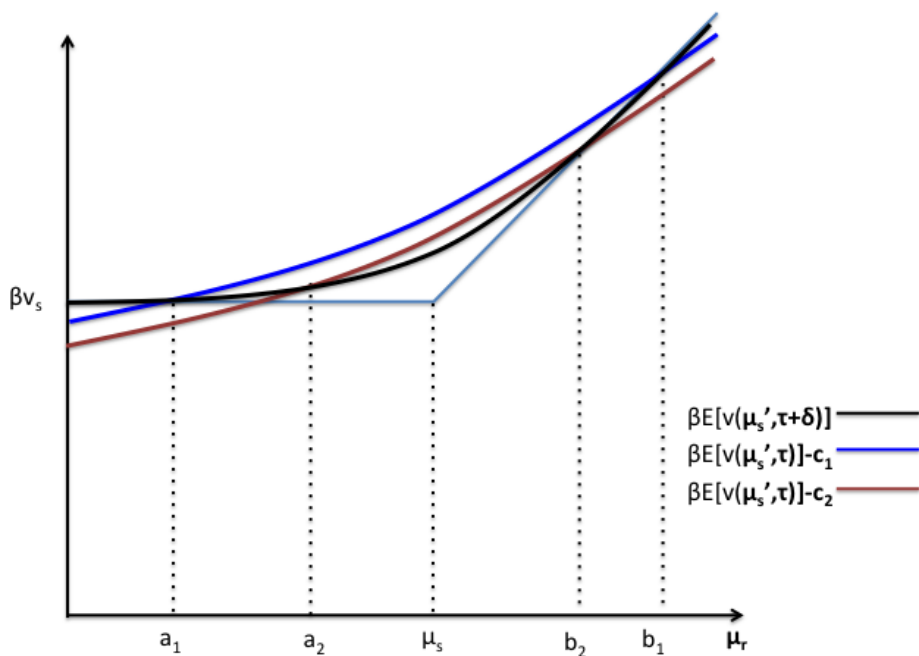


Figure 4: Marginal return to entrepreneurial capital as a function of the expected risky return

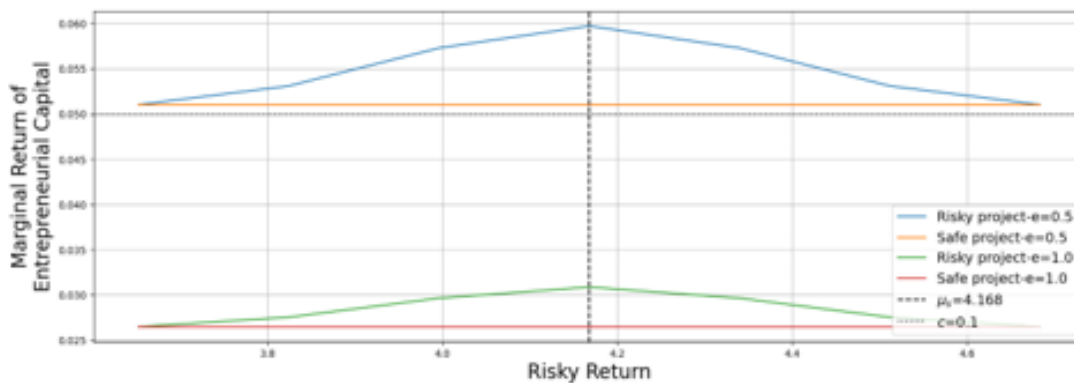


Figure 5: Evolution of the value function with investment

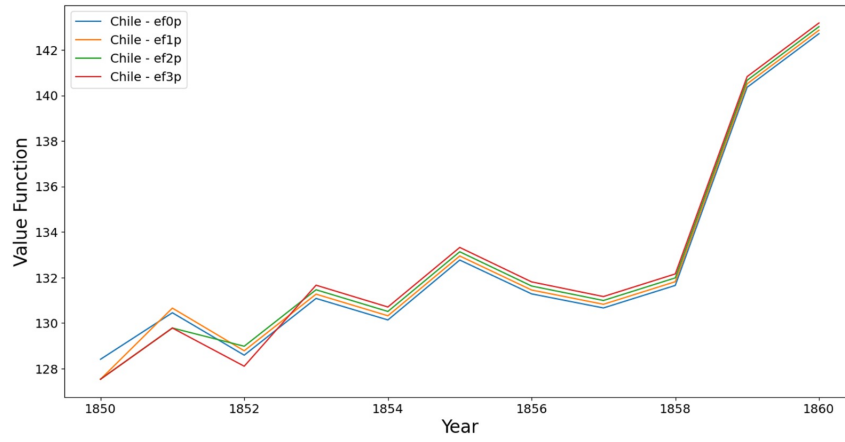


Table 1: Relative Contribution to Industrialization of Locals vs. Immigrants and Shizoku

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 population Odagiri & Goto (1996).

Table 2: Results

model	observed		simulation	
	US	Chile	US	Chile
Log return				
mean	6.43	5.88	5.13	5.80
std	1.73	0.45	2.22	0.88
max	9.69	7.11	8.77	7.23
min	2.96	4.99	0.9	4.1
Engineering Density				
mean	72.19	10.86	90	4
std	78.53	7.51	41.28	0
max	282	23.71	160	4
min	8.91	2.11	20	4

Figure 6: Logarithm of Copper revenue by Chilean nationals in Chile and US nationals in US: 1850-1920

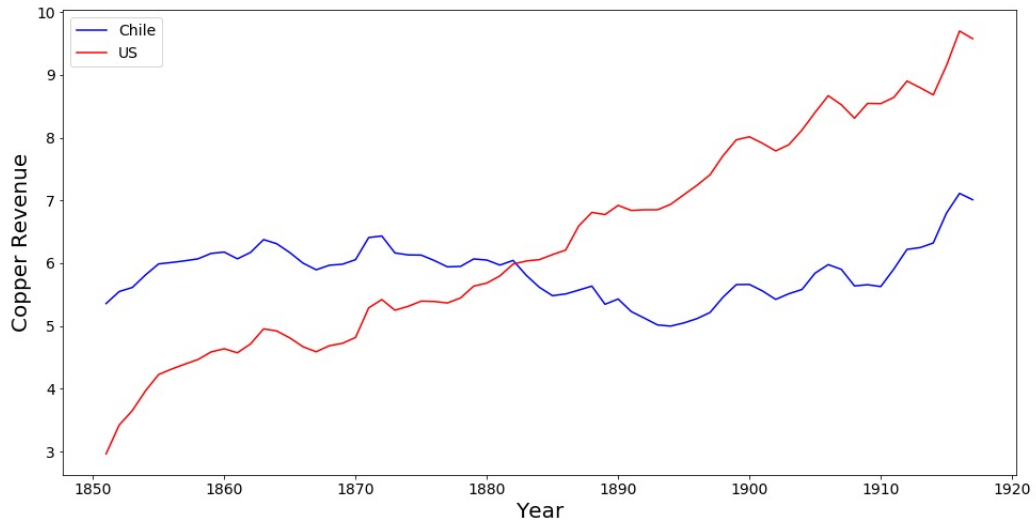


Figure 7: Entrepreneurial capital: Number of domestic engineers in Chile and US per 100.000 inhabitants: 1850-1920

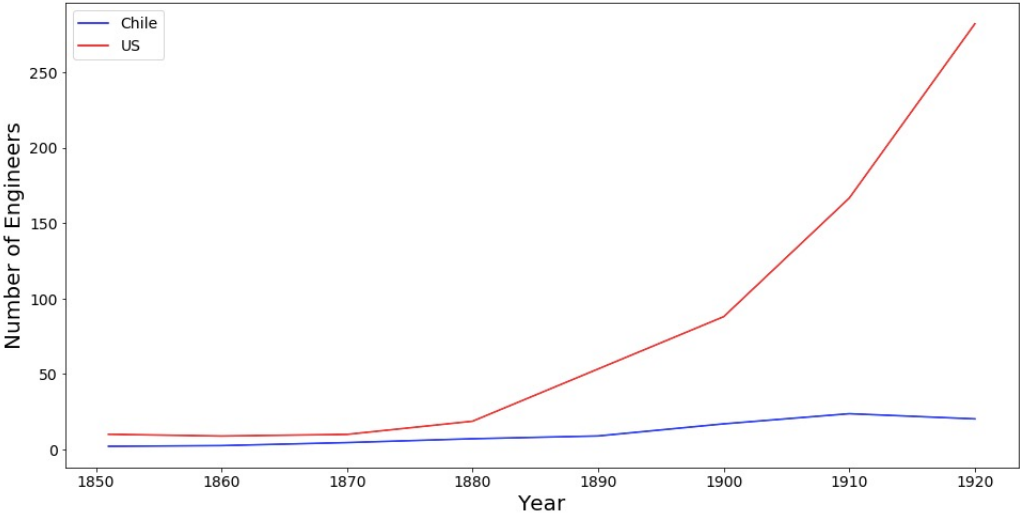


Figure 8: Replicated returns for Chile and US

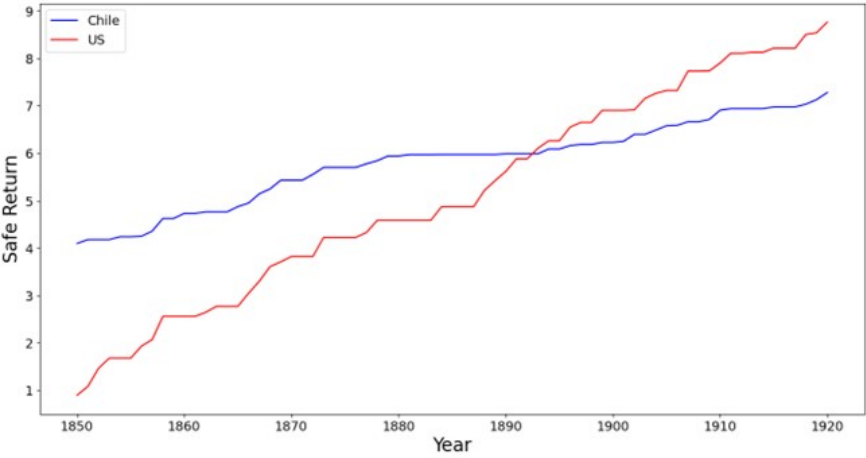


Figure 9: Replicated evolution of entrepreneurial capital in Chile and US

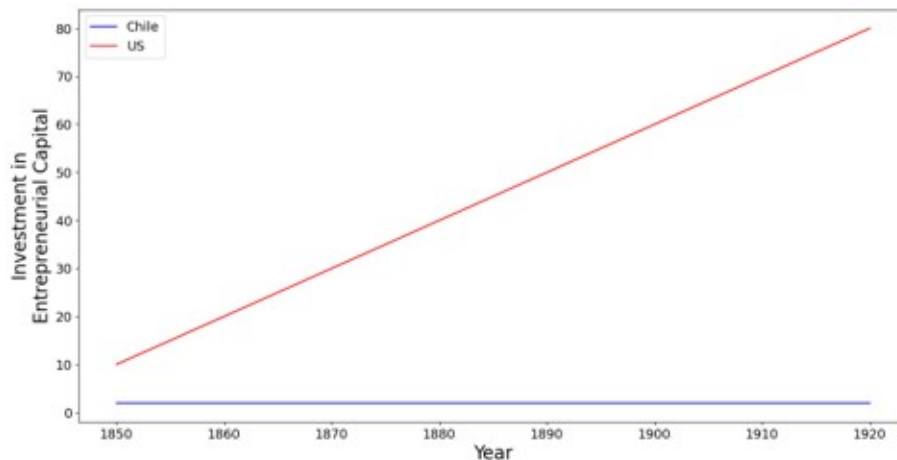


Figure 10: Counterfactual returns for US: same initial entrepreneurial capital and same safe return, higher initial expected return to risky project

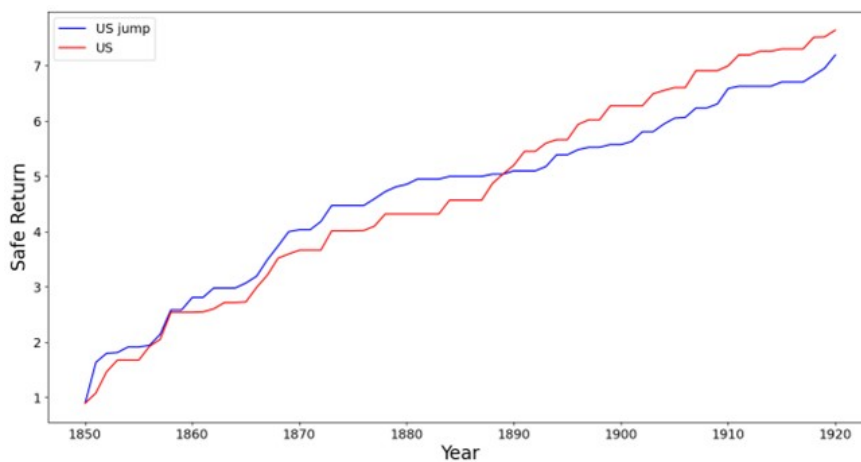


Figure 11: Counterfactual evolution of entrepreneurial capital in US: same initial entrepreneurial capital and same safe return, higher initial expected return to risky project

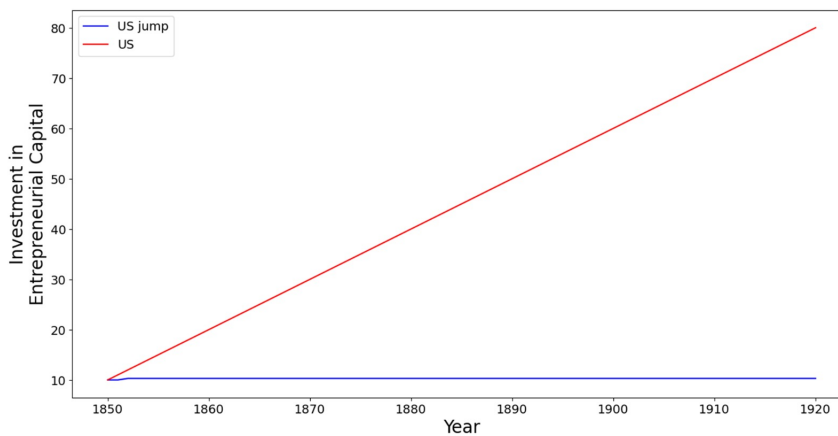


Figure 12: Counterfactual returns for Chile and US: same initial return, higher initial entrepreneurial capital in US

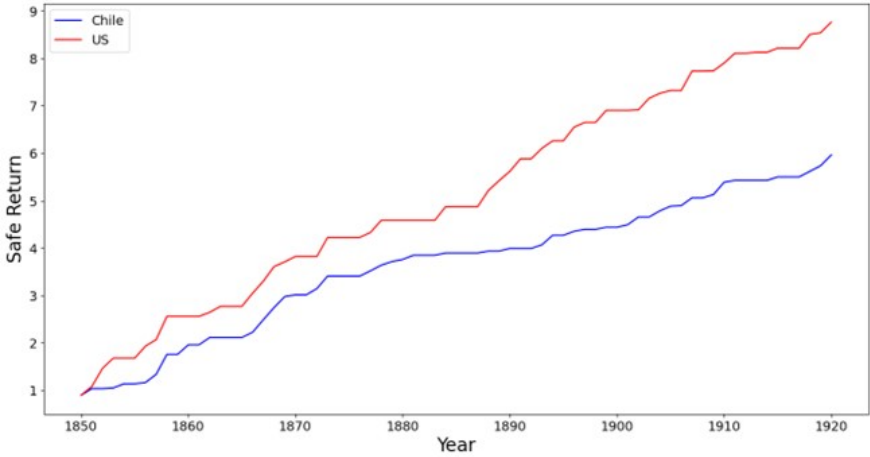


Figure 13: Counterfactual evolution of entrepreneurial capital in Chile and US: same initial return, higher initial entrepreneurial capital in US

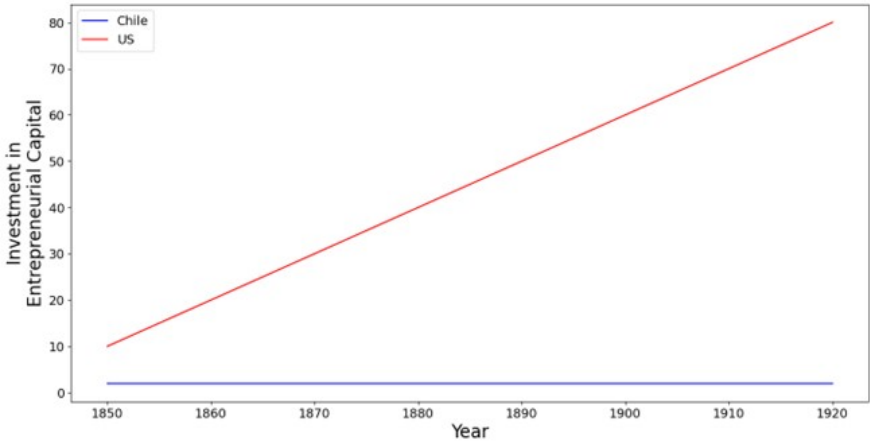


Figure 14: Counterfactual returns for Chile and US: same initial entrepreneurial capital, higher initial safe return

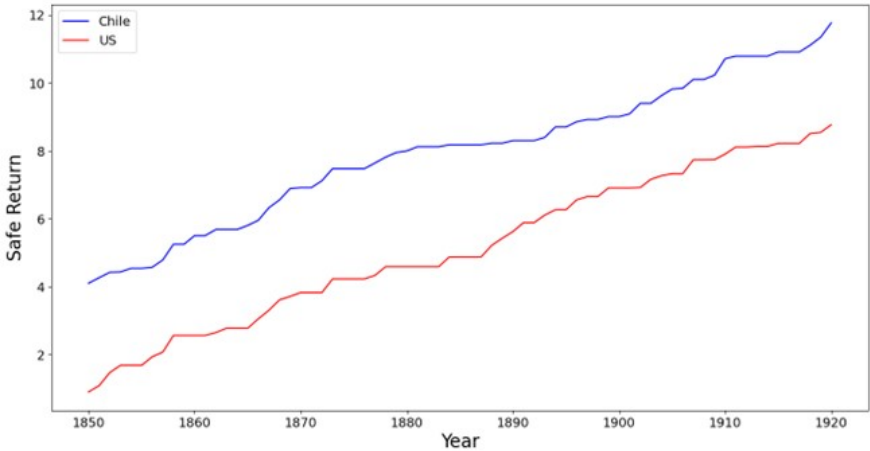


Figure 15: Counterfactual evolution of entrepreneurial capital in Chile and US: same initial entrepreneurial capital, higher initial safe return

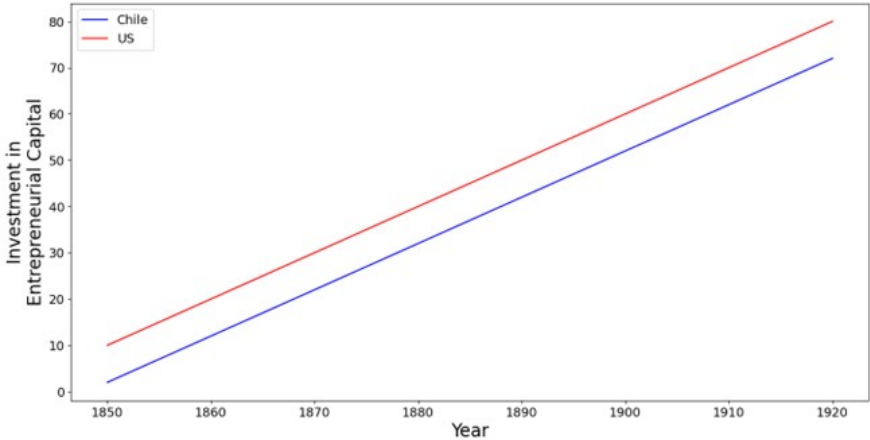
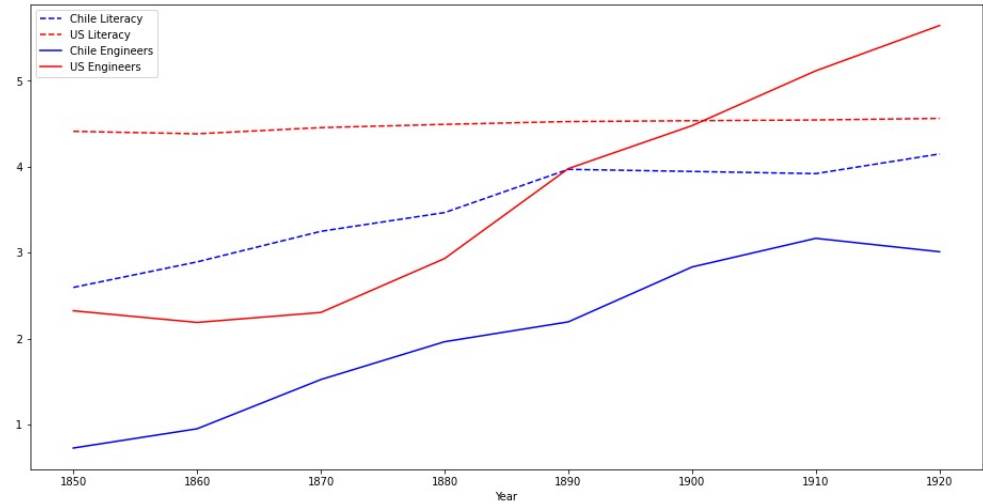
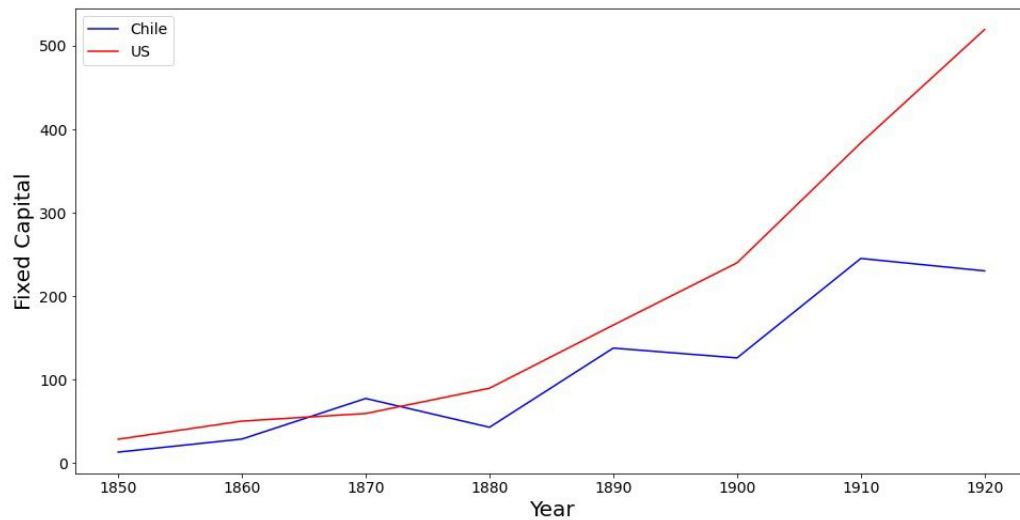


Figure 16: Literacy rate and engineering density in Chile and US: 1850-1920



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_history.asp).

Figure 17: 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 18: Copper Labor Revenue in Chile and US:1850-1920

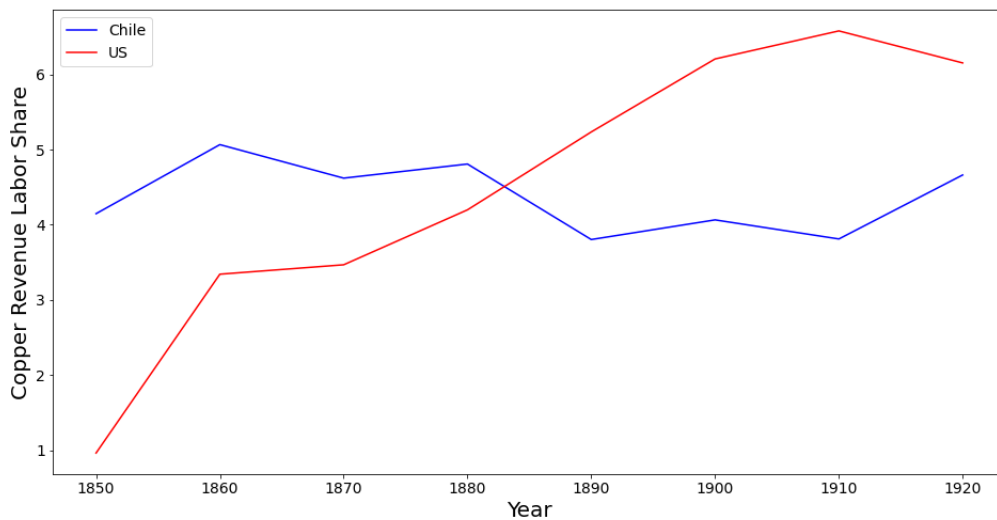


Table 3: Results

model	observed		simulation	
	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

6 Annexes

6.1 Annex 1: Data on immigrant firm ownership.

Subsubsection data 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. Birchall (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 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 Bucaramanga 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.²⁸ 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

²⁸These 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.

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?

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	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	
Refining											
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 Investments	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	2	0	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	0	0	0	0	0	0	0	0	0	0	1,00
Warehouse Furniture	2	1	0	0	0	0	2	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 ²⁹.

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], i.e. 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

²⁹A 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 verbatim, 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 horizon” (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 occurring 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 Rei 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).³⁰ 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

³⁰Most 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.”³¹

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.