NATURAL RESOURCES: UNAVOIDABLE CURSE OR MANAGEABLE ASSET?

EMILY LEVEILLE

This study examines the inevitability of the "natural resource curse" and tests two possible reasons for variations among countries that possess large endowments of natural resources in North and South America. Using evidence that policy choice is linked to a variety of theories on the mechanisms of the resource curse, I argue that the length of time between colonization and discovery of natural resources, as well as the category of metal produced, affects the degree to which a country suffers from a resource curse. Using quantitative and qualitative evidence from the year 1500 to the present, I show that the overall impact of resource output on GDP depends critically on institutions and policy, and that a greater length of time between colonization and resource production the stronger were the institutions that developed. Though type of mineral proves not to have a direct correlation with variation in GDP, further studies might reveal this characteristic to be influential on a country's stability and development.

I. Introduction

Scholars and economists of the Industrial Revolution underlined the possible benefits and potential for growth that large endowments of natural resources could bring to a country. However, since the late 1980's, the concept of the "curse of natural resources" has been supported by numerous case studies (Gelb, 1988; Maloney, 2002; Ross 1999, 2001) and cross-country empirical studies (Auty, 1993; Sachs and Warner, 1995, 2001, Busby et al., 2004).

The key unanswered question of the resource curse theory is why natural resource abundance has a negative effect on national economic growth rates. Five main effects have been indentified as being caused primarily by an abundance of natural resources, leading to growth stagnation: 1) the Dutch disease, 2) increased rent-seeking tendencies, 3) corruption and bloated bureaucracies, 4) a greater tendency towards closed economic policies, and 5) lack of labor-based learning and education. These theories attempt to explain what causes resource wealth to become a curse, as opposed to being beneficial to a countries growth.

Nonetheless, some countries (i.e. the United States, Canada, New Zealand, and Australia) seem

to have successfully avoided these policy blunders. These apparent exceptions to the theory have inspired a variety of studies to call into question the inevitability of the resource curse. These studies instead attempt to determine the effects that resource endowment might have on the policy choices made by governments (Gavin and Wright, 2001; Gavin and Czelusta, 2002; Robinson, Torvik, and Verdier, 2006; Maloney 2002). In his 2002 World Bank assessment of Latin American resource-based growth, Maloney emphasizes three key points that must be taken in to consideration when looking at the resource curse:

> "First, the time period where data permit reasonable analysis covers 25 years at the end of the twentieth century. This is probably not a representative period, including as it does the debt crisis and structural reforms… Second, the finding may not be robust to using different measures of resource abundance… Third, it is also important to know whether underperformance is intrinsic to natural resource-based sectors or a non-essential correlate, such as destructive political economy issues."

According to Gavin and Wright, historical evidence shows that there is reason to believe that successful resource-based development is primarily an endogenous, socially-constructed condition. In their study of the development of the U.S. mining industry, they explain that the country "underwent legal, institutional, technological and organizational adaptation in response to expanding international and industrial demands for minerals" (Gavin and Wright, 2003). Auty also concludes that although "most resource-abundant countries engender a political state that is factional or predatory, whose government distorts the economy in the pursuit of rents… there is nothing deterministic about these models and many resource-abundant economies grew very strongly during the First Golden Age of Economic Growth, 1870-1913 and again during the Second Golden Age, 1950-1973" (Auty, 2001).

Though it is generally accepted that the output of ore affects GDP, projections concerning the degree of this effect vary. This study looks at two possible reasons for this variation within resource-wealthy countries in North and South America: the difference in time between colonization and metal production, and the type of metal. In areas that were prosperous soon after colonization due to resource wealth, I argue that European colonialism established or continued the extractive institutions in place.[1] Conversely, in resource-poor areas, settlers developed systems of private property in order to increase investment incentives to sustain themselves. Consequently, I posit the longer it took settlers to discover resource wealth in a country, the greater the likelihood that a framework of rights and institutions would develop to mitigate massive wealth accumulation and dysfunctional policy manipulation by a small elite.

I will also test the category of mineral as a possible explanation for the variation of the effect of resources on GDP. I believe there may be a difference in the effect that the presence of precious metals resources, such as gold and silver, have on GDP versus the effect of industrial metals, such as iron and copper. Lack of labor-based learning and positive industry spillover are some of the mechanisms through which the resource curse is thought to affect GDP. Gyfalson states that in resource-based economies, "too many people become locked in low-skill intensive natural resource-based industries" (Gyfalson 2001). This statement may hold true for precious metals that have little value in the commercial sense,[2] especially those extracted during the colonial period with little mechanization.[3] On the other hand, I do not believe this is necessarily true in industrial metals-endowed nations. The main value derived from an industrial metal is its ability to be an input in other industries; therefore, industrial metals are intrinsically involved in these secondary industries' growth and expansion. Furthermore, the volume of industrial minerals demanded (beginning during the Industrial Revolution) incentivized large investments in information, technology, and exploration.

The aim of this study is not to argue that the resource curse does not exist, but to test whether the difference in time between colonization and resource production, as well as the category of metal, influences the extent to which the resource curse affects a country. I do not contend that these variables are the sole determinants of this effect, but I hope that this study will determine whether these are two sources of exogenous variation within resource-rich countries.

II. Literature Review

Five Main Theories of the Mechanisms of the Resource Curse

Below I present a summary of the main theories presented by economists and political scientists that seek to explain the primary mechanisms through which the resource curse affects an economy. These theories serve as background and context for my hypothesis. Though aspects of each are valid and robust, three facts remain of primary importance. First, each theory attributes importance to policy choices; secondly, no one theory can conclusively explain every situation nor do they address variations of development within resource-wealthy countries; finally, most of the studies that support these theories only examine data dating back as far as the 1960s, a small period of time relative to the 500-year span of resource production in the Americas. I emphasize that I do not attempt to prove or disprove any one of these theories specifically; instead, my objective is to identify which countries exhibit variations in predicted outcome, and then attempt to explain these deviations

Again, the mechanisms through which a large abundance of natural resources lead to slowed growth that are most often cited are 1) the Dutch disease, 2) increased rent-seeking tendencies, 3) a greater tendency towards closed economic policies, 4) corruption and bloated bureaucracies, and 5) lack of labor-based learning and education.

The Dutch disease assumes the economy is divided in to three sectors: the tradable natural resource, tradable non-resource (manufacturing) sector, and the non-traded sector. This theory argues that economies with larger natural resource sectors create a higher demand for non-tradable goods. As a result, there is less allocation of labor and capital to tradable manufacturing, and a disproportionately high allocation of labor and capital to tradable natural resources. The shrinking of the manufacturing sector increases economic dependence on resources, and exposes nations to the volatility of commodity prices. The Dutch disease does not account for the fact that in many economies, the resource and manufacturing sectors are not mutually exclusive. Manufactured products frequently contain raw resource inputs, and the excavation of these natural resources requires the use of manufactured products such as machinery and refining plants as well.

A second argument is that resource-rich nations are frequently afflicted by high levels of rent-seeking behavior. Because of the large profits and taxes that are typically derived from commodities, governments often do not need to enact or enforce property or income taxes on their people. Instead, they allocate profits from the resource sector to a variety of private and public endeavors. This can lead to unproductive battles concerning how to best allocate the profits, in turn promoting a cycle of inefficiency, bloated bureaucracies, corruption, and cronyism that stunts growth. Auty writes that natural resources "engender a political state that is factional or predatory and whose government distorts the economy in the pursuit of rents that are deployed to force industrialization and this leads to a staple trap" (Auty, 2001). However, this theory fails to acknowledge the fact that some governments do not derive large profits from commodity taxes. For example, the U.S. government did not establish a tax collection and enforcement structure for mineral profits; after repeated failures, they dropped efforts to use mineral policies as a direct source of tax revenue (Gavin and Wright, 2001).

The third theory argues that economic policies are the mechanism through which resource endowment leads to slower growth, more specifically open trade policies. Open trade policies are believed to have a very significant correlation with growth. Sachs and Warner (1995, 1997) posit that resource-rich nations are more prone to enact closed trade policies in an attempt to protect infant manufacturing sectors. This tactic raises price levels and renders the economy less competitive in the global markets, leading to slower growth rates. These studies are limited in that their data only dates as far back as 1960s. Given that resource production in the Americas began more than 500 years ago, the policies of the last 40 years may instead be viewed as an outcome rather than a root cause. Furthermore, wide variations still persist within resource-rich countries that have had or continue to have closed economic policies during this period.[4]

Another theory is that resource-wealthy economies engender bloated bureaucracies and corruption. This argument is not dissimilar to the theory that resource rents are the main cause of slowed growth in resource rich nations. Auty (2001) states that natural resources "engender a political state that is factional or predatory

and whose government distorts the economy." Large profits from taxes and exports of resources create an incentive for corruption and consolidation of power among a small powerful segment of the population.

The last theory is that resource-wealthy economies neglect industry-based learning and education in general. W.F. Maloney concludes that missed opportunities for rapid resource-based growth in Latin America are a result of low investment in human capital and scientific infrastructure (Maloney, 2002). Gyfalson et al. (1999) and Gyfalson (2000) argue that there is lack of focus on education in general in resource-rich economies. Resource-rich governments often neglect the development of human resources because primary production does not require a high level of education. This effect is frequently exacerbated by inefficient allocation of resource profits. These arguments are contingent on the observation that education directly causes growth and that the resource industry is inherently low-skill. Despite attributing lack of resource-based growth in Latin America to low investments in human capital, Maloney also states in response to Gyfalson that "concerns that the resource-based sectors intrinsically lack dynamism have probably been exaggerated" (Maloney, 2002). In many cases, resource production can be highly skill-intensive; moreover, these industries frequently require a large amount of technological innovation in order to remain competitive.

While some countries have clearly been unable to develop their resource wealth effectively, we cannot conclude that the relative success of other countries was not fueled by natural resources. This study focuses on possible explanations for these variations, assuming that policy choice is clearly being instrumental in determining a country's development.

III. Qualitative Background

The following section is an explanation of the qualitative data that provides evidence for my hypothesis. One limitation of studies is the relatively limited scope of time they examine; therefore, this study seeks to examine each country from colonization to present. In many cases, data for many early years is somewhat limited, but I believe it is sufficient to determine the presence of the correlations in my hypotheses when supplemented with qualitative analysis. I examine the countries of study in greater detail in the context of the aforementioned theories and my own hypotheses for causes of variations between their respective national incomes. This section also contains the simple quantitative association between these variables and GDP that initially motivated my study.

The importance that I ascribe to the length of time that a country was allowed to develop before resources were discovered is closely associated with the evidence[5] that the initial resource wealth (or lack thereof) of the colonies affected the policies and institutions that developed therein. Acemoglu et al. contend that countries that started as wealthy colonies have undergone a "reversal of fortune" and now have less income than those colonies that were initially poor.[6] The divergence in development within countries in the Americas has recently attracted attention from economists and historians (Acemoglu, Johnson and Robinson, 2000; Sokoloff and Engerman, 2000; Gavin and Wright, 2002), whose explanations focus on the importance of institutions and policies relevant to growth such as security of property rights, corruption, and investment and infrastructure. Consequentially, I argue that colonies forced to develop for a longer period of time as "poor" colonies may avoid—or at least more skillfully manage—the negative effects on long-term development associated with resource extraction.

The association between the time of colonization and the time of the first boom of natural resources (defined by change in rate of production and by historical accounts; this criterion is clarified later in the study) is the initial observation that led to my first hypothesis. A graph using data from Angus Maddison's 1990 G-K$ study shows a simple positive correlation between the difference in time and GDP.

A basic time series analysis of GDP from the earliest available data to 2006 shows the association that grounds the second hypothesis: that the type of metallic resource is significant in determining the extent to which a country was affected by the resource curse. Chile, the United States, and Canada (those countries with noticeably higher GDP and growth rates after 1900) are all primarily producers of industrial metals. Maddison's data also shows that these three countries had the largest difference in time between colonization

and the first boom of their natural resources as well as had a large amount of industrial metal production as opposed to precious metal production.

Acemoglu et al. present two classes of institutions that existed in colonial America: institutions of private property and institutions of extracation. Because these institutions are partially determined by the level of wealth in the colony, the level of resources present may have partially determined what type of institutions developed. Institutions of private property ensured secure property rights for broad swathes of society and were essential to promote investment and long-term economic growth and stability. Conversely, extractive institutions concentrate power in the hands of a small elite and created a high risk of expropriation for the majority of the population. This discouraged economic development because citizens could not be guaranteed any return on investment. Elites in situations with large resource rents were less likely to want to transition to democratic republics, as they risked losing massive amounts of power and wealth to institutional development or and also would no longer be direct beneficiaries of economic growth, and consequently attempted to retain control through government. In summary, extractive colonial institutions were designed to maximize rents to Europeans, not to promote long-term growth.

Countries that were initially perceived as lacking natural resource wealth were largely ignored by Europe and forced to develop these property rights institutions in order to promote investment and economic prosperity for their own sustainability. Acemoglu et al. add that "relatively poor regions were sparsely populated, and this enabled or induced Europeans to settle in large numbers and develop institutions encouraging investment" (2001).[7] For example, the small amount of agriculture and mineral production in colonial North America, combined with low population density, suggests relatively low income; from this lack of development we can infer that European powers did not view North America as valuable. Voltaire famously described the conflict between the French and the British over Canada during the Seven Years War (1756-63) as two countries "fighting over a few acres of snow." Aside from a few coastal areas, most of North America was of marginal economic interest relative to Europe's colonies in the West Indies and Latin America. Canada's initial urbanization level in 1500 was essentially zero and resources in Canada did not become an important economic factor until 1848, almost 350 years after its discovery. Had more mineral wealth been discovered upon arrival, the level of urbanization and wealth would have been higher and the institutions that developed probably would have been more focused towards extractive policy as opposed to developing private property.

The United States also benefitted from a long-term focus on developing property rights. Ben Franklin stated in 1790 that "gold and silver are not the produce of North America, which has no mines." Mineral development in the United States indeed remained unimpressive until the last third of the nineteenth century. But by the year 1913 mineral production far exceeded its comparative endowed share of the world's reserves. Gavin and Wright assert that there is "an important element of truth in the assertion that the United States' rise to world mineral leadership was facilitated by the legal environment." Instead of promoting rent issues and economic disarray, high returns to early investments encouraged further investments through effective policies.

In the United States, the government claimed no ultimate legal title to the nations minerals, permits were easy and cheap to attain, and prospecting was free.[8] Furthermore, the government did not have an established tax collection and enforcement structure for mineral profits, policies that most likely resulted from infeasibility as opposed to ideology. After repeated failures, the government dropped efforts to use mineral policies as a direct source of tax revenue. This is an important distinction when compared to countries like Peru, Colombia, and even Chile.[9] Most notably, during the California gold rush of 1849—a period in which where there was no regulation at all—local miners drew up basic rules for recording, enforcing, working and transferring claims. Many of these rough guidelines ultimately became federal law, illustrating the endogenous rise of property rights[10] in the absence of effective government authority.

Private incentive structures, rules of access, and the character of property rights were key to securing payoffs for investments. The government's ability to supply infrastructure and guarantee return on investments through property rights were key in determining the expansion and success of a country's mining industry.

Some have ascribed the divergence in growth between North and South America to differences in national heritage (North 1988), presuming that the success of the U.S. and Canada is a result of British institutions being more conducive to growth than those of Spain or Portugal. However, although most people associate only the U.S. and Canada with the New World colonies of Britain, Sokoloff and Engerman (2000) point out that Barbados, Jamaica, Belize, and Guyana were all British colonies that have lagged in terms of industrialization and development. Also, the highest per-capita incomes during colonial periods were in the Caribbean, regardless of British, French or Spanish origin. Furthermore, the variations among resource-rich economies are not limited to North and South America. Not all colonies were treated equal by Spain or Portugal[11] and variations are apparent within countries in South America as well.

The former Spanish conquests of what is today Argentina and Chile exemplify how initially-low resource wealth (or perceived resource wealth) shaped and determined the way in which Europe developed its colonies in South America. The Spanish arrived at the la Plata River in the middle of the sixteenth century. They founded Buenos Aires but were unable to sustain themselves, and quickly retreated to Paraguay. Argentina was eventually developed many years later with a higher proportion of European settlers and little forced labor. Similarly, Chile was discovered by Diego de Almagro in 1535. Immediately disappointed by the lack of mineral wealth, Almagro left after only two years. Finding only minimal amounts of gold as well, the settlers determined that Chile would have to be a primarily agricultural state. Ironically, Chile would later become one of the world's largest copper producers, but not until almost 300 years after its initial colonization. Following Acemoglu et al.'s theory, the two countries had urbanization rates of zero, and today Chile and Argentina are two of the most industrialized and least corrupt nations in South America.

In wealthier colonies where resources were already abundant or became so early on, the Spanish set up—or took over—existing extractive institutions in order to directly extract resources, develop plantation and mining networks, and collect taxes. These institutions produced very different outcomes for their colonies. Spain "used its…fantastic returns from gold and silver mines in the New World to purchase all that was needed, thus developing a rentier mentality" (Maloney 2002). In these situations where there was a high return from minerals for a few individuals, there was an incentive to deter the distribution of wealth and power through institutional property rights. This seems to have persisted through what Isham et al. (2003) calls the "entrenched inequality" effect, whereby dysfunctional government policies persisted after independence, allowing a politically powerful elite to continue to act exploitatively.

Peru makes for an interesting comparison to Chile. The two countries sit side by side and share relatively similar topography, size, population, and climate. In addition, while these countries were colonized within 10 years of one another by the Spanish crown, Peru's early economy was characterized by extractive economic policies, and the country still hasn't managed to shake the legacies of colonialism that continue to be detrimental to growth and increased equality. While Chile was being effectively ignored by Spain and thus left to create its system of institutions, Peru became the focal point of the Spanish Empire and a prime example of the implementation of extractive policies.[12]

Lima became the axis of Spanish wealth and power, and consequently Spain actively sought to prevent its decentralization. In 1550, Spain abolished the *encomienda* system,13 allowing only a few powerful elites to control the huge haciendas, and also restricted development to Lima. Most structures of the colonial government were funded by taxes of what Mirow attests was the "primary function of the colonies, silver mining" (Mirow, 31). The Spanish government received between 16 and 20 percent of mined precious metals declared to inspectors. Acemoglu et al. point out that "in resource wealthy colonies, high population density provided more labor and larger population to tax" (Acemoglu, 2001). Subsequently, Lima was also the location of the most important audencia, or tax revenue courts, "the key institution that worked in tandem with the royal official" (Mirrow, 22).[14] While law in Chile was developed mostly by local elites, in Peru it was characterized by the Spanish government's interference and seizure of gold and silver.

Countries that established private property institutions (for example the U.S., Canada, and Chile) before the discovery and exploitation of natural resources seem to exhibit similarities with each another and differences with countries like Peru. Chile's dependence on nitrate revenue from 1890 to 1924 contributed

to financial instability, and the country was one of the hardest hit countries during the depression due to its dependence of revenue from copper. Nonetheless, Chile was also extremely independent from the crown. It developed a number of townships and ports in the South that became of were important to the economy, diversifying economic focus away from Santiago. The elites established informal rule of law outside of Santiago and even when copper was finally discovered, resource rents never fundmanetally altered the economy,as they did in Peru.

Conversely, Peru has continued to struggle with the legacy of extractive economic policies. The post-independence period in Peru was extremely destabilizing and characterized by an inability to restructure government and society away from imperialistic methods of wealth and land distribution. The colonial elite resisted out of fear of losing its wealth, and the nation's first president, Bolívar (1824-26), did little to alter fundamental structures of inequality and underdevelopment. Elites managed to defeat liberal groups and maintain a regime characterized by protectionist policy for many years. This made it difficult to establish landownership and diversify the sources and recipients of wealth, crucial factors of development that Acemoglu et al. delineate.

Thus, countries whose urbanization and wealth stem from mineral resources have lagged behind those that started without endowments. Maddison also confirms that Mexico was richer than the U.S. in 1500 and 1700, and the most highly urbanized countries were Bolivia, Mexico and Peru in comparison to the low level of urbanization in Brazil, Canada, Chile and the U.S. Per capita industrial production started to increase in the U.S. and Canada relative to Brazil and Mexico only in the 1830s. In all of the countries where there was high urbanization, there was also high extraction of gold and silver. In countries that were initially considered resource-poor, even if resources were discovered later, government and institutions seem to have been able more effectively to promote investment and growth.

Following the idea of a reversal of fortune due to the extractive institutions in wealthy colonies, analysis of the data concludes that the reversal in relative incomes was prompted by the Industrial Revolution. Engerman (1981) provides evidence that much of Spanish America and the Caribbean were more prosperous than British North America until the eighteenth century. This brings me to the next hypothesis in this study, that type of mineral was another reason for variation among countries that developed with natural resources.

I distinguish between two categories of metals in this study: those that are considered precious and have intrinsic value like gold and silver, and those that acquired value only with the onset of the Industrial Revolution. I argue that as metals like iron, lead and copper became valuable as inputs of production, they contributed a larger value-add and encouraged policies that enabled expansion of other industries in order to increase demand. While the inherent value of gold or silver makes the process of generating value very short and does not necessarily require great skill or technology, industrial metals have a much longer value-added chain. With this in mind, the presence of non-precious metals actually encouraged technological innovation and industry-based learning. In terms of situations in which the initial discovery of metal in a country—oftentimes gold or silver—occured during colonial times, I am not suggesting that a later discovery of industrial metals would have necessarily reversed the effect of legacy poor economic policies. However, if resources were discovered later and consisted primarily of industrial minerals, I hypothesize that—coupled with the greater likelihood of private property institutions being in place—industrial minerals supported huge amounts of growth across a variety of sectors for which they were inputs.

Gold and silver in the colonial period had little other use except for coinage. As Garner explains in *Mining Trends in the New World, 1500-1810*, the New World contributed an astounding amount of currency to the world: "The addition of the 12,000-15,000 tons added to the volume of worldwide currency stock would have meant anywhere from 10-15% increase… New World mining would contribute about 100,000 tons to the worlds money stock, doubling or tripling the world's money stock" (Garner 2007).

Furthermore, the type of mineral may also have been a determinant in how long it took countries to be considered resource wealthy. Many of these industrial metals where not valuable until

much later than gold and silver, helping to explain why some countries were considered poor in resources for a long time after colonization. The reasons for the differences in time of discovery are varied. In some places, the ore grade was not high enough for older methods of refining and mining was not profitable until further technological developments had been made. In other situations, the type of mineral was not considered valuable until much later. For example, coal, iron ore, steel molybdenum, petroleum, and even copper were not valuable until the nineteenth century.

While there is always an intrinsic value associated with gold and silver, industrial metals required the demand of other industries in order to be profitable. This more intricate value-added chain stimulated not only mining but also other industries that used its products as inputs. Gavin and Wright (2002) argue that the U.S. was able to exploit and dominate resource production not because of inherent reserves but precisely because of technology and investments in extraction methods.

Contrary to the theory that resource industries lack labor-based learning or positive spillover effects, the realization of the U.S.'s potential in this regard came only after a large-scale mobilization of human resource and application of new technologies of extraction, refining and utilization, market development, and transportation.

This is also calls in to question the inevitability of the Dutch disease, which states that the larger the natural resource sector, the higher the demand for non-tradable goods and therefore the smaller the allocation of labor and capital to manufacturing. The shrinking of the manufacturing sector and large dependence on revenue from a single, volatile sector is the visible result of the "disease," and once country is affected by it, it is unable to grow and develop at a normal rate. Yet during the period in which the United States ascended to leadership in mineral production, it also did so in education, mining, engineering, and metallurgy. The late nineteenth century also saw a growing interaction between mining schools and industry that culminated in various efforts to bring together engineering science and practical arts.

However, Gavin and Wright argue that the provision of geological information was perhaps the most important initial step in the collective enterprise of resource discovery and exploitation.

Recognition of the private economic value of such information drew geologists at an early stage directly into lucrative employment in the field of mineral wealth. The resulting body of information formed a critical part of the public knowledge infrastructure that supported the exploration and development activities of the U.S. minerals industry; state funded geological surveys from 1823 eventually became the foundation of the United States Geological Survey (USGS).[15] Many geologists were commissioned for other jobs worldwide, received tenure at universities, and assisted the development of railroads and other industrial projects. Gold and silver mining in these countries benefited from investments for education in the study of mineralogy, geology, and geophysics, exhibiting the positive learning spillover between mineral exploration, transportation, and industrial development.

Conversely, early-discovered endowments of gold and silver may have engendered a lasting tendency for low levels of resource-based knowledge and development.[16] In differentiating the responses of Scandinavia and Latin America to the Industrial Revolution, historian David Landes (1998) says that the former operated in an atmosphere of political stability where property rights were secure, whereas much of Latin America did not. Recent literature also suggests that in many countries, persistent wealth inequality may have played a role in slowing the regions ability to adopt foreign technologies (Engerman, Haber, Sokoloff 2000).

Chile's policies have not been without failure and the country's development is still not as sophisticated as that of the United States or Canada. Furthermore, in present times Peru produces copper, iron, and lead, while Mexico, Brazil, and Colombia produce copper and iron. These contemporary similarities underscore that the difference in timing that allowed for sound institutional development is important, and later production of industrial metals cannot necessarily reverse these problems. As many economists point out, there was a small window of opportunity to become competitive during the Industrial Revolution, and doing so required large investment in technology and education that these countries either could not or did not want to provide.[17]

IV. Model

First, I will delineate the type of measures for resource abundance used in this paper and discuss the inherent limitations in those used in other studies. Sachs and Warner measure resource abundance by primary export intensity, defined as the ratio of primary exports to national income. However, this ratio measures one factor in relation to another and therefore may fail to estimate absolute endowment or real output of resources. As Jean-Phillipe Stijns points out in Natural Resource Abundance and Economic Growth Revisited, "a resource-rich country may export few natural resources per se at the same time that its manufacturing sector exports embody intensively its natural resources" (2005). If another form of national income is failing while resource exportation remains static, the ratio will automatically increase even if no change has occurred in the resource industry. Therefore using a ratio of exports to national income may skew the outcome of data. For this reason, I define resource endowment as the current estimated total endowment of a country, comprising of both what has been extracted and the estimated potential to be extracted. Feasibility of extraction and production depend on mineral prices and available technology but these estimates assume an average level of price and technology that could be imported by foreign companies even if the country itself did not develop them. These absolute numbers eliminate the influence of exogenous factors such as changes in other industry output.

I also want to clarify what I define as natural resources and the cases I use. Some studies include agriculture as well as minerals and petroleum in their definition of natural resources (Sachs and Warner 1995); others look solely at minerals and oil (Auty 2003), though even Sachs and Warner (2001) contend that:

> "The variation in mineral exports across countries is responsible for a large fraction of the overall variation in the natural resource variable, so that the inclusion or exclusion of agriculture does not much alter the basic empirical results."

In an effort to eliminate these exogenous factors, I have chosen not to include agriculture in my definition of natural resources. I also do not include oil or coal because they are associated more with fuel than inputs of production. Consequently, I have chosen not to include Venezuela; although it does have some gold, its oil resources and current volatile political situation might skew the data. I also do not include Argentina because its resource industry has developed relatively recently.

Based on my observations and the research presented, I draw the following hypotheses:

> *Hypothesis I*: The greater the time between colonization of a territory and the first peak in its natural resource production, the higher its current GDP and level of development
> *Null Hypothesis I*: The difference in time between colonization of a territory and the first peak of its natural resource production has no effect on its subsequent growth rates and GDP.

> *Hypothesis II:* If a country's resource endowment has intrinsic value, then it is more likely to be subject to the resource curse than a country whose metals were valuable only as inputs after the Industrial Revolution.
> *Null Hypothesis II*: The type of metal in a country endowed with resources has no effect on the probability of it being afflicted by said natural resource curse.

The null hypotheses suggest that the observed variations between the effects that resource output has on GDP cannot be explained by the reasons I hypothesize. It is equally as important to address these because, if proven correct, they eliminate two possibilities for the causes in variations. In this way, the outcome can better direct further studies on the subject in the future.

V. Data Description

Variables

I test two different independent variables in my regressions: Difference in time between colonization and discovery of natural resources and category of metal (precious or industrial). I test to see if these have a significant correlation with my dependent variable, GDP. In a cross-country regression I test 2006 level of GDP against the difference in time between colonization and discovery of natural resources. In a cross-country, time series regression I test yearly GDP against yearly resource production data.

Control Variables

The control variables for the cross-country regressions are different from the control variables I employ in my cross-country, time series regression. This is due partly to the fact that the cross-country analysis focuses on Hypothesis I (time difference), while the time series cross-country regression focuses on Hypothesis II (category of metal).

- *Lag GDP*: Controls for the effect that the previous year's GDP has on the following year in the time series analysis.
- *GINI Index*: Controls for inequality.
- *Settler Mortality*: Settler mortality rate has been examined in relation to colonial wealth and subsequent development. This variable controls for this factor.
- *Corruption*: This is an index of corruption for the country.
- *Total Endowment*: This controls for the total estimated size of a country's endowment and tests whether it is significant to GDP.
- *Precious Metal Endowment*: As well as testing category of metal as an independent variable, I control for type of metal in relation to my difference in time variable.
- *Industrial Metal Endowment*: Same as above.

I include nine countries in my study: Bolivia, Brazil, Canada, Chile, Colombia, Ecuador, Mexico, Peru and the United States. Countries of study that I have classified as having large endowments of natural resources will be based on current data. As previously mentioned, Sachs and Warner use a ratio of primary exports to national income for measuring resource abundance that I do not believe is an accurate historical measure of a countries endowment. A ratio can be affected by other factors, and I therefore will use estimated absolute endowment figures. What the perceived level of endowment was at time of colonization is unimportant. For this data I will use United States Geological Survey (USGS) endowment data compiled by Richard Leveille that classifies a country's endowment by mineral and tonnage.

I also use annual data in order to compare yearly production to yearly GDP. The time frame of my study extends from 1500 to 2006, but not all data is available for every year, nor is it available by any one source. Therefore I have compiled my own data from a variety of reliable sources and historical texts, and cross-verified these numbers wherever possible with other sources and qualitative data. All data has been converted to prices based on the value of the U.S. dollar in 1990. I have also supplemented my regressions with basic line graphs, seeking to roughly depict graphical trends over time for each country in relation to their GDP and resource production.

The original territories in the Americas were a diverse group, and some were controlled by more than one colonizing country. Argentina and Bolivia were both part of the Rio de la Plata Spanish colony; Colombia, Ecuador and Venezuela made up Nuevo Granada; Peru, Chile and the northern part of Argentina were part of the Viceroyalty of Peru. The United States was colonized by the British, French and Spanish, and Canada by the French, British and Dutch. Because there is enough data concerning the location of mines and their discovery times to locate them in their corresponding modern countries, I will use present-day borders to define my countries.

I will classify time of colonization as the year of the first settlement in a country and I will use the time of the first peak or "boom" in extraction as the time of discovery of natural resources. In many cases, for example in Chile, some copper was discovered in 1541 but used for artisanal purposes on a small scale until 1820. The aim of this study is to understand the effect of natural resources when they became a large portion of the economy, and the first peak generally "put them on the map" as a resource-rich country. I cross-checked as much of the production data as possible, but there is certainly possibility of error in the production figures, as I compiled them from different sources.

In summary, the variables in my model are as follows:

- *GDP*: 1820-2006
- *GDP Growth Rate*: 1820-2006 year on year GDP growth
- *Post Discovery*: Describes the time period after which the colony was settled
- *Post First Boom*: Describes the time period after the countries first major spike in production. I define this both qualitatively in historical texts and also as as ratio of volume over total estimated endowment
- *Precious Metal Boom*: Dummy variable for whether the main metal of production was a precious metal
- *Industrial Metal Boom*: Dummy variable for whether the main metal of production was an industrial metal
- *Any Industrial metal presence*: Dummy variable for whether there was ever presence of industrial metal production
- *Gold*: Tonnes of gold produced per year
- *Silver*, *Copper*, *Iron*, *Lead:* Same as above
- *Country Production* in USD
- *Aggregate IM USD*: Aggregate of Iron, Copper and Lead production converted to constant USD 2005
- *Aggregate PM USD*: Aggregate of Gold and Silver production converted to constant USD 2005
- *PM Production Rate*: Year on year growth rate
- *IM Production Rate*: Year on year growth rate
- *PM Total Endowment USD*: Aggregate endowment in USD 2005
- *IM Total Endowment USD*: Aggregate endowment in USD 2005
- *Total Endowment USD*: Aggregate endowment in USD 2005
- *Country Area*: In square kilometers
- *Settler Mortality Rates*: Settler mortality per 1000 people *Urbanization Rates*: Often used as a proxy for colony wealth in 1500
- *GINI Index*: Measures inequality

This can be shown through the following basic equations:

$$\text{Current GDP} = \alpha + \beta\,(\text{year of } 1^{st} \text{ peak-year after colonization})_x + \varepsilon$$

$$\text{GDP: } \alpha + \beta\,(\text{year of } 1^{st} \text{ peak-year after colonization})_x + \varepsilon$$

$$\text{Current GDP} = \alpha + \beta\,(\text{type of mineral})_x + \varepsilon$$

$$\text{GDP} = \alpha + \beta\,(\text{type of mineral})_x + \varepsilon$$

$$\text{GDP} = \beta_o + \beta_2\,(\text{Industrial Metal}) + \beta_3\,(\text{Precious metal}) + \beta_4\,(\text{lag GDP}) + \varepsilon$$

$$GDP = \beta_0 + \beta_2(2006\ GDP) + \beta_3(Difference\ in\ time) + \beta_4(settler\ mortality) + \beta_5(urbanization\ rate) + \beta_6(GINI\ Index) + \beta_7(total\ endowment) + \beta_8(Industrial\ Endowment) + \beta_9(Precious\ Endowment) + e$$

VI. Regression Analaysis

There are two different models for my regression analysis, a cross-country and a time series cross-country. The time series cross-country regressions measure yearly metal production by type, category, and as an aggregate against GDP. I use this data to study the significance of the relationship between GDP and the type of metal. I also use this to test the correlation between length between colonization and discovery by employing dummy variables for time before and after colonization and discovery of metals.

Cross-Country, Time-Series Analysis

Due to the length of time covered in this study, yearly data is not available for every year, country, and metal. There is certainly enough data from which trends can be discerned, but it is important to note that these gaps of data may affect results in my regressions. I use two dummy variables for type of metal. Industrial Metal=1 signifies a historically large amount of industrial metal production and =0 indicates nonexistent or insignificant historical amounts of industrial metal production. The Precious Metal dummy variable is measured in the same way. As I stated before, many studies, incldluing Sachs and Warner, use a ratio of resource production to other industries as a measure of endowment. I do not use this method because the ratio can be changed simply by lowering or increasing production of another industry. In this regression I also include a lag GDP variable control for the effect that the GDP of the previous year has on the next. Controlling for lag GDP will make it easier to observe the degree of significance concerning the correlation between production and GDP each year.

Table I tests data from Hypothesis II, which predicts that the category of mineral produced (industrial or precious) affects GDP and development. Table I shows the basic regression of GDP versus the dummy variables Industrial Metal and Precious Metal. Industrial Metal=1 when the main resource produced is historically industrial and Precious Metal=1 when the main resource produced is historically precious. Precious metals show a large, highly significant negative correlation with GDP. Industrial metals show a large, significant positive correlation between GDP. The size of the coefficient is due to the fact that the GDP figures are much larger than the Dummy Variable (1 or 0), and taking the log of the GDP would reduce the coefficient. When I control for lag GDP (Table II), results are no longer significant. This could indicate that the majority of the correlation is due to the last year's GDP and not the type of metal.

In order to see the different effect that category of metal has on each country, I regressed each one individually. This time I used the logGDP against yearly aggregate production of industrial or precious metals. Like the results in Table I, there is no discernable trend between the categories of metal production and GDP.

Mexico has a strong negative correlation between GDP and precious mineral production, but most other countries display a positive correlation bewteen GDP and precious minerals. Though most of the results are significant (aside from industrial and precious metals in Bolivia and industrial metals in Colombia, the cases for which I had the least amount of data), there does not seem to be a direct relationship between the two variables, using either the dummy variables or the yearly production data. These results lead me to believe that there are other factors that determine how the category of metal affects GDP.

Table IV displays the results from the cross-country regression testing my first hypothesis which states that the longer the time between colonization and discovery of natural resources, the higher the country's GDP. It is purely a cross-country analysis of the time difference factor. The simple regression shows a strong significant correlation between the length of time between discovery of minerals and GDP. Controlling for inequality using the GINI index, initial settler mortality rates and corruption, the correlation remains significant and positive. Total endowment, precious endowment and industrial metal endowment remain positive though small and this is largely because the data is not logged in this case. For the corruption variable, which is an index based on a

Tables I-II

Type of Metal	Dependent Variable #1: GDP	
	Coefficient	Std. Error
Precious Metal Boom	-1258.829	246.5358*
Industrial Metal Boom	1730.606	167.3701*
Any Industrial Metal	3718.456	210.8251*
	Dependent Variable #2: LogGDP	
	Coefficient	Std. Error
Total Production	.1205388	.0085016*
Industrial Metal Production	.0703537	.0028022*
Precious Metal Production	.1003451	.005663*

** Significant at 99%, ** Significant at 95%, *** Significant at 90%*

Table III

	Dependent Variable #4: LogIm		Dependent Variable #4 logPm	
log GDP by Country	Coefficient	Std. Error	Coefficient	Std. Error
Bolivia	.0106213	.0265536	-.008403	.0146056
Brazil	.1116791	.0058541*	.1434082	.0139538*
Canada	.1895711	.0097811*	.4321472	.0240029*
Chile	.3520719	.0083227*	.5264543	.0386595*
Colombia	.0487509	.1225303	.1906839	.0390009*
Ecuador				
Mexico	.1366055	.0082745*	-.8974686	.0911643*
Peru	.3532223	.0111998*	.4771658	.0278973*
United States	.9847163	.1300329*	.2515338	.0229576*

** Significant at 99%, ** Significant at 95%, *** Significant at 90%*

variety of factors, including other variables such as risk of expropriation or the level of property rights might yield a higher significance, though it is still statistically significant in this case.

VII. **Conclusion**

Results for Hypothesis I seem to indicate that the difference in time between time of colonization and time of the first boom of natural resources does explain some of the variation of GDP within resource wealthy countries in North and South America. Time is certainly not the only factor that has determined the policies and institutions that have developed within resource rich countries. There are many other factors that affect the institutions formed in all nations, including unique and isolated events that cannot necessarily be compared to those in other countries. Still, I think these findings give further direction to future studies on the inevitability of the resource curse.

My second hypothesis was much less conclusive than the first. Although I cannot prove through this study that type of metal is a factor that determines how country is afflicted by the resource curse, I still do

Table IV

	Dependent Variable #3: GDP	
	Coefficient	Std. Error
Simple Regression	56.47411	12.77759*
GINI Index	36.6606	14.06971**
Settler Mortality	16.36778	10.72848
Corruption	47.53385	22.99602***
Total Endowment	4.21 e^{-9}	8.88 e^{-10}*
Precious Metal Endowment	4.2 e^{-08}	6.32 e^{-9}*
Industrial Metal Endowment	4.35 e^{-09}	1.08 e^{-09}*
Dependent Variable GDP Growth Rate		
Total Endowment	7.15 e^{-16}	9.59 e^{-16}

** Significant at 99%, ** Significant at 95%, *** Significant at 90%*

not think it can be assumed that it has no effect. The level of significance of the results suggests that there is some relationship between GDP and type of metal, but that it is not a direct causal mechanism of variations in GDP. It is possible instead that perhaps the effect of industrial or precious metals is also determined by the type of institutions and the timing of discovery. This also may support the theory that after the small window of opportunity to industrialize and produce resources competitively during the Industrial Revolution, those that did not become competitive in the production of precious or industrial metals lagged significantly behind.

Nonetheless, neither hypothesis is fully proven by this study and there are a variety of other aspects that I believe would be valuable to study further. Because the measurement of variables is so important to outcome, I think it is necessary to test different definitions and metrics in order to ensure that results are not specific to only one definition. For example, testing GDP growth rate instead of GDP might yield different results. Additionally, the importance of volume of production could be further studied as well. Other things I'd like to explore are the effect that the ratio of first boom to later production has on subsequent GDP, as well as the relationship bewteen Mexican and Brazilian GDP. I would also like to add more control variables to my time series cross-country data and attempt to test Hypothesis I using that data. It is also extremely useful for further studies to continue to verify and fill the missing production and GDP data as much as possible in order to ensure accurate results.

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Endnotes

1 "extractive institutions concentrate power in the hands of a small elite and create a high risk of expropriation for the majority of the population" (Acemoglu, Robinson, Johnson)

2 "Precious metals like gold and silver had little value in the commercial sense. Except for some artistic endeavors they were not fabricated into other products. Today of course (especially silver) do have a wider applicability within the industrial sector. The history of gold and silver mining is generally associated with coins and currencies." Garner 2007

3 "Although some large mines and perhaps more daring entrepreneurs concocted elaborate hoist and pulley systems with buckets to remove the water, mechanization was barely evident inside the mines even at the end of the colonial period" (Garner 2007)

4 Chile and Peru are a good example, both countries have had various periods of closed trade policies yet Chile still has a much higher GDP than Peru now and historically. I discuss this comparison in more detail later.

5 As I mention in the introduction there is increasing evidence that bad economic policies are linked to a variety of the theories that explain the resource curse. Robinson et al argue that resource dependent economies often lead to inefficient and ineffective government policies (Robinson et al 2006) and "entrenched inequality" (Isham et al). Auty's (2001)). Auty's (2001) concurs that the "chronic tendency for the state to become over expanded" (pg.123) and "the staple trap is a less deterministic outcome than Sachs assumes and owes more to policy choice" (Auty 1998 p. 40) and Engerman and Sokoloff (2000) claim that the divergence in North and South American growth is attributable at least in part to weak property right institutions.

6 The reversal and income to which they refer involves changes in income across areas and does not imply that a specific population, such as Native Americans in North America, became wealthier over time.

7 In their paper "The Reversal of Fortune", Acemoglu, Johnson and Robinson use urbanization measures from Bairoch (1988) as a proxy for economic prosperity. This is a widely accepted correlation, they site Kuznets 1968 on economic growth "we identify the economic growth of nations as a sustained increase in per capita or per worker product, most often accompanied by an increase in population and usually by sweeping cultural changes in distribution of population between the country side and cities".

8 Gavin and Wright describe the mining legal structure as such: "The government claimed no ultimate legal title to the nations minerals, miners could obtain exclusive permits to work a given area, required only to bring ore to a smelter where the government collected 10% of findings…Free prospecting privileges, coupled with the simple and inexpensive rules for initiation of titles was particularly important in encouraging those forms of mining that required heavy fixed capital investment, by allowing the investor to capture the full value of a vein of ore, wherever it might lead.

9 "Though mining was a private endeavor in South and Latin America as well, it was subject to numerous regulations and dependent upon royal monopolies in the conduct of it's affairs" (Garner,2007)

10 I do not claim that property rights were necessarily always secure. A lack of proper litigation caused some property rights to come in to question. The point of this example is to show how without a centralized power in control of mineral production, citizens were forced to delineate some of their own rules in order afford the risks of their investments.

11 As Garner points out "because the mining industry emerged late in Brazilian colonial history, it proved difficult for the royal government, which was far less developed than its Spanish counterpart, to exercise control over the Brazilian gold fields." (Garner, 2007).

12 With the discovery of the Potosi silver mine (modern day Bolivia in Upper Peru) in 1545 and the Huancavelica mercury mine in 1563, the territory became known as "Spain's great treasure house" (Frederick B Pike in Peru Country Study).

13 The encomienda system was designed to attract settlers to the colonies and was practiced all over Spanish America. Officials doled out land and natives to settlers in exchange for their work to Christianize the natives on their land. Essentially they became like large slave estates and settlers gained a large amount of power as landowners.

14 Later tax and revenue courts were established as well in Mexico City, Lima and Bogota (also in countries who were soon discovered to be extremely rich in gold and silver).

15 George P Merrils massive study " the first one hundred years of American Geology" dedicated more than half the study to the Era of State Surveys from 1830-1880

16 Richard Garner notes that Mexico did have a colonial mining college and important geologists and scientists visited the camps but still, neither mining nor refining changed very much over the 300 yrs.

17 Us had patent system which was probably the most favorable in the world to common people, whereas brazil and Mexico, patents restricted by costs and procedures to the wealthy or influential, where the rights to organize corporation and financial institutions were granted sparingly, largely to protect the value of rights already held by powerful interest. (Maloney, 2002)