http://mapserver.lib.virginia.edu/.

Virginia Historical Society. 2001. “Lost Virginia. Vanished Architecture of the Old Dominion.” *Vahistorical.org*. http://www.vahistorical.org/lva/gallego.htm.

———. 2005. “Hunter Family Papers, 1766–1918.” *Vahistorical.org*. http://www.vahistorical.org/arvfind/hunter.htm.

Walton, Gary, and Hugh Rockoff. 2010. History of the American Economy. Mason: Cengage Learning. http://search.lib.virginia.edu/catalog/u4977535.

The Biological Standard of Living in Brazil, 1830-1960: Preliminary Evidence from Military and Passport Records

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ABSTRACT

I utilize anthropometric evidence to estimate secular and regional trends in the biological standard of living in Brazil from 1830 to 1960. I utilize two new sources of height data—military records (that capture typical Brazilian males) and passport records (that represent elite Brazilians). I find substantial improvements in the biological standard of living of the middle and lower classes during the period of rapid export-led industrial growth (1870-1913), yet no significant increase for the elite. Furthermore, soldiers from the North and Northeast were consistently shorter than those from the South and Southwest, irrespective of time period. I present preliminary evidence on the climatic variables that underpinned such persistent regional inequity. Rainfall intensity and the absolute temperature range are both economically and statistically significant. The final section concludes the paper and details plans for additional research.

I. Introduction

For most of the twentieth century, Brazil was one of the fastest growing economies in the Western world. However, we know little about the country's economic performance before 1900. Estimates run the gamut from strongly positive growth, to stagnation, to decline over the interval from 1850 to 1913. It is unlikely that the quality of these estimates will improve, absent the discovery of previously untapped data sources. Moreover, the record on living standards and human welfare is thin before the mid-twentieth century. Direct data on income per capita is scarce or focused on one locale for the nineteenth and early-twentieth centuries. Prior to 1940, other indirect indicators of wellbeing, such as infant mortality or life expectancy, are virtually inexistent. Despite improvements in overall economic development, identifying secular and regional trends in material wellbeing continues to challenge researchers. I turn to anthropometric evidence to chart changes in the biological standard of living from the 1830 through the 1960. My study exploits a relatively simple yet striking theorem: much more than genetic factors, the average height of a population depends on its nutritional and health status. I aim to answer two main questions: 1) Did export-led growth translate into substantial improvements in standards of living across regions and socioeconomic groups? 2) Did regional inequities in standards of living increase or decrease over time?

In addition to our skeletal knowledge of living standards, I study the time period ranging from 1830 to 1960 due to its unique place in Brazil's history. During that interim, the country underwent profound social, economic and political changes. In the final decades of the nineteenth century, decreased transport costs and increased urbanization stimulated demand for manufactured products. Though a limited number of textile and foodstuff plants emerged in the mid-1840s, industrial production in Brazil increased substantially in the 1870s. The abolition of slavery in Brazil came in 1888. Upon the formation of the Brazilian Republic in 1889, export taxation and government spending were vastly decentralized. Throughout this period, commodity booms and busts in coffee, rubber and sugar caused export earnings to fluctuate. While the economic impact of some of these instances has been singularly examined, no long-run systematic study has examined the evolution of living standards throughout the 1830-1960 era. Aside from the handful of shorter articles, a countrywide study of heights in Brazil has never been applied to this particular juncture in the historical timeline. Military records from the Historical Military Archive (AHEX, Arquivo Histórico do Exército), a previously untapped source of anthropometric data, shall form the crux of my body of evidence. Currently, the sample consists of 6,335 soldiers born in decades ranging from 1830 to 1960. I also use an ancillary sample of passports pertaining to individuals traveling from the port of Rio de Janeiro between 1917 and 1927.

Historical anthropometrics have often been applied to assess the welfare outcomes of industrialization. In the US and in Europe, various scholars have highlighted the adverse health consequences associated with rapid urbanization in the industrial era. I argue that the real income gains wrought from export-led industrialization outstripped any negative impact on stature associated with the disease environment. (The urban penalty may have only taken place in the largest Brazilian cities.) Increased government spending on infrastructure, health and sanitation likely amplified this income effect. Additionally, I indicate that climatological and agronomical factors (to be assessed in more detail future research) underpinned the persisting regional inequities in living standards.

II. Brazilian Economic Development, 1830-1960

Did export-led growth or import-substitution industrialization (ISI) strategies lead to sustained improvements in real income for the vast proportion of the Brazilian population? This study spans three crucial periods in Brazil's economic history: 1) a period of relative stagnation (pre-1870); 2) one of export-led growth (1890-1930); and one of import substitution industrialization (post-1930). Elaborating a long-run heights series during these critical periods yields insights into the development processes that have long eluded historians of Brazil. This section summarizes some scholarly assumptions regarding growth in Brazil during the period under study.

Economic stagnation in the nineteenth century resulted from low investment and low productivity, both of which were hemmed down by high transport costs. The rate of economic development began to increase in the mid-nineteenth century when coffee production began to dominate the commercial sector. According to Dean (1969), coffee production initially provided a stimulus for industrial development by creating a money economy, providing sufficient capital accumulation for rudimentary manufacturing to take flight. The dynamic coffee sector sparked increased demand for foodstuffs and raw materials and created industrial offshoots of coffee-related activities. Increased public spending and enhanced financial and hard infrastructure followed (Cano 1977). Railroad expansion between 1854 and 1930 made for continuous reductions in transportation and facilitated market integration (Summerhill 2003).

The onset of republicanism in Brazil enhanced financial regulations for private investment, and increased government spending on education, infrastructure, health and sanitation. According to Nathaniel Leff (1982) long-term growth did not commence until several bottlenecks were removed after the fall of the Empire (1889), when Brazilian states gained more fiscal power to invest in infrastructure. Decentralized government spending invigorated the initial phase of railroad development that had begun in the mid-nineteenth century.[1] In addition to hard infrastructure, states gained freedom to invest in public health, sanitation and education. A recent study on the political economy of elementary education in Brazil during the First Republic argues that increased profits from export taxation at the state level were positively correlated with increases in educational expenditures (Musacchio et al. 2010). Decline in coffee prices during the latter half of the 1890s prompted many planters to seek other productive capabilities, and many planters turned to industrial speculation. Analyzing the São Paulo Stock Exchange (est. 1890), Hanley (2005) sustained that formal and regulated financial institutions provided larger sums of capital for investment in a more diverse range of economic activities. Gail Triner (2000) argued that the expansion of the banking sector allowed for more efficient intersectoral economic activity and enhanced market building.

[1] Railroad construction commenced in the 1850s. In 1854, Brazil's railroad lines extended to 14 kilometers. This figure climbed to 474 by 1864, and dramatically increased in the two subsequent decades, reaching 3,302 by 1884. In 1934, length of track totaled 33,106 kilometers (Baer 2008).

The 1930s altered the pattern of economic growth in Brazil. Coming to power in 1930, Vargas implemented populist policies that favored urban workers. Furthermore, ISI policies implemented after 1930 drastically increased protectionism and altered the rate of technological change. Some economic historians argue fervently that the high degree of protectionism encouraged economic growth. Abreu and Verner (1997) argued that real GDP grew at an annual average of 6.1 percent from 1930 to 1980, denoting a 28-fold increase. Labor and economic historians have focused on the pro-labor posture of Getúlio Vargas, yet none have quantified the populist president's presumed achievements in terms of human welfare.

III. Historical Anthropometrics: Theory and Applications

i.) Theoretical Overview

Anthropometric indicators are one of the most comprehensive and reliable markers of material wellbeing known to researchers. Since 1976, researchers concerned with living standards have used anthropometric measures as a heuristic proxy for material welfare. This burgeoning field of research has clarified a host of questions long of interest to researchers in many populations and epochs. The findings generated from anthropometric research have multifarious implications for researchers in economic history, health, demography and public policy. Successful studies melding economic theory with historical methods, drawing on auxology, physical anthropology and medicine, have contributed to four main research areas: demography (life expectancy, morbidity and mortality); welfare in slavery; health and living standards during industrialization; and inequality (Steckel 1998).

Height can best be conceptualized as one's cumulative nutritional intake, minus the claims to nutrients by physical exertion and disease. When available, a measure of body mass index (BMI) gives an additional glimpse into the individual's health and nutritional status at the time of measurement. The crucial periods influencing terminal adult height are the intrauterine, infant and adolescent stages of human growth. Undernutrition before age three largely stunts growth and causes individuals to reach full adult height later after a period of catch-up growth. Where traditional indicators of living standards—real income per capita, income distribution measures, infant mortality or life expectancy—are inexistent or unreliable, height research provides a strong foundation for clarifying secular trends and cross-sectional variation in material wellbeing amongst socioeconomic and racial subpopulations. In order to capture adult height, researchers often turn to military medical examinations and recruitment records. Minimum height requirements for military service and other selection issues presented a formidable obstacle for many of the path-breaking studies, but increasingly sophisticated statistical techniques to account for the shortfall in the distribution have yielded accurate population estimates.

The history of anthropometry itself saw significant developments in the 1960s, when James Tanner and Phyllis Eveleth commenced a massive longitudinal study of human growth in children and adolescents.[2] Their seminal study was a collaborative effort of researchers around the world that involved 340 projects in 42 countries. Eveleth and Tanner emphasize "environmental conditions" as the principal determinant of the growth profile.[3] The variables they use as growth correlates were derived mainly from country- or region-level statistics, although certain individual characteristics such as "urban" or "rural" and "rich" or "poor" were used. Their study found that children from rich families grew much faster than those from wealthy families. Africans from well-off regions (for example, the Yoruba of Nigeria) grew in patterns comparable to Europeans. Children of African ancestry in the United States were found to be taller and heavier than Europeans in Europe at any given age. Eveleth and Tanner discovered that Asians, even under the best conditions, were shorter than Europeans and Africans. Indo-Mediterranean children followed similar growth trajectories as Europeans and Africans. Eveleth and Tanner suggest that malnutrition was the root cause of lower-growth profiles (1976).

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[2] A note of clarification: for anthropometricians, a longitudinal study consists of measuring human height of an individual at different age intervals. A longitudinal study in historical anthropometrics is related to secular and temporal trends in stature.

[3] Because theirs was a longitudinal study on growth, they used many more descriptive measures in addition to height: skeletal and skull structure, body weigh, trunk-to-leg and shoulder-to-waist ratios.

ii.) Early Studies in Historical Anthropometrics

Several early historical height studies analyzed the height of slaves sold at auction for the interregional slave trade in the United States (see Engerman (1976), Trussell and Steckel (1978) Margo and Steckel (1982)). With these data, Trussell and Steckel relied heavily on Eveleth and Tanner's research to clarify the fecundability of slaves. Using the same data source, Steckel (1979) demonstrated that slaves born in the US were taller than those born in Africa. Additionally, American slaves were taller than European peasants, but approximately 1 inch shorter than northern whites. Also, the difference between slaves and masters was less than the difference between the gentry and lower classes of Western Europe. Eltis (1990) observed a precipitous decline in stature for Yoruba and non-Yoruba alike in Sierra Leone between 1780 and 1820. Average heights of slaves destined for the New World declined by 5 inches during that period. Comparison with slave manifests produced by Margo and Steckel shows that slaves in the US experienced a height advantage. Time trends reveal that the decline of the Oyo Empire (circa 1789) sparked a decline in nutritional status and increased disease.

Robert Fogel (1984) displayed the importance of historical anthropometrics to the study of demographic trends. Regressing mortality rates on stature, he revealed that improved diet accounted for over 40 percent of the decline in mortality in England from 1800 to 1980. The available data for the US has been extensively explored, and researchers have paved the way in terms of analyzing data sets collected from military regiments (Sokoloff and Villaflor (1979), Fogel (1984), Komlos (1987), Costa (1993), Steckel (1995)). Floud and Wachter (1982) found that the boys from the nineteenth-century Marine Society were shorter than the standards of 1980s England. Copious amounts of research on the "antebellum puzzle"—a term coined by Komlos (1987). In the decades preceding the US Civil War, researchers observed a precipitous decline in stature despite sustained economic growth over the interval. Researchers have attempted to surmise the root cause of such a widespread deterioration in standards of living. Some speculate that disease was to blame (Cuff 2005), while others point to a decline in nutritional intake (Komlos 1987).

These initial studies were met with considerable criticism from the academic community. Komlos recalls that academic journals rejected many articles in this initial phase of height research (1994). In an introductory essay, Tanner adequately sums up the response of these early detractors: "Frequently, when one confronts nonbiologist audiences with the proposition that height is a proxy for economic conditions, one gets the comment 'But surely height is inherited!'" (1994: 1). With Tanner's collaborative insights, trailblazing studies by Engerman, Fogel, Floud, Steckel, Wachter, Trussell, Sokoloff, and Villaflor paved the way for future research in historical anthropometrics.

iii.) Industrialization and Height

In quite a number of countries, the onset of industrial growth and urbanization did not provoke such a decline in stature. Martínez-Carrión and Moreno-Lázaro (2007) utilized military recruit data to analyze urban-rural differentials during the period of economic modernization in Spain. In contrast to the patterns observed in other European countries and North America, they find that urban heights were superior to rural for most of the period between 1870 and 1930. Sandberg and Steckel (1997) argued that industrialization in Sweden was not hazardous to public health as it was elsewhere. Real income levels rose with industrial expansion after 1870, coupled with improvements in hygiene and childcare, causing improvements in the biological standard of living. Average national income increased by 2.8 percent between 1870 and 1910. The authors observe that industrial development occurred in many nonurban locales in Sweden, perhaps limiting disease spread.

Several scholars have examined the agro-export phase in Latin America. López-Alonso (2007) used human stature data from passport applications and military recruitment records to survey changes in biological standards of living in Mexico from 1850 to 1950. López-Alonso's study benefited from differentiated anthropometric samples. While the military recruitment records sample the lower income groups, passport applications proxy the higher echelons of Mexican society. She concluded that income inequality worsened during the 1850-1950 period. An increase in height for the working classes did not accompany the improvements in overall economic performance during the period of industrialization emphasized by the Díaz regime (1876-1910).

However, López-Alonso argued that the welfare programs introduced by populist president Lázaro Cardenas in the 1930s did improve material welfare. Contrastingly, the living standards of the Mexican elite improved steadily throughout the hundred-year period. The case of Mexico serves as an important counterpoint for the Brazilian experience in which I find substantial improvements in the biological standard of living of military recruits during the phase of agro-export led growth.

Baten and Blum (2010) compared the average stature of several Latin American countries with income per capita, infant mortality, and cattle per capita between 1900 and 1950. The authors found a positive but not perfect correlation between stature and GDP. They observed a negative, albeit not as strong, relationship between infant mortality and height. For cattle per capita, a proxy for propinquity to protein nutrients, they found a correlation coefficient of 0.67 (p-value of 0.00). Argentina had the highest overall height and cattle per capita, while Guatemala had the lowest. Argentina's cattle stock per capita diminished from 1850-1950; however, there was an increase in average height during this period (of nearly 5 cm). Brazil's cattle stock per capita remained relatively unchanged, despite an improvement in stature from 1900 to 1950.

iv.) Heights in Brazil

Monasterio et al. (2010) studied the evolution of height and living conditions in Brazil from 1940-1980 with data collected in the Family Budget Survey (Pesquisa de Orçamentos Familiares, POF, 2002-3).[4] Monasterio and his colleagues concluded that there were modest improvements in material standards of living for the Brazilian population during that time period. Although the database lacks more longitudinal detail, the POF sample has the added benefit of documenting family income, allowing for a comparison of height and income inequality. The authors argued that income distribution worsened during the 1940-1980 period. The quintile average of heights increased as a

[4] The IBGE proclaims that the POF microdata are representative of the Brazilian population as a whole, and the authors randomly draw a sample of 40,000 men aged 21-65 at the time of interviewing. These researchers rely on The POF data, however, have the shortcoming of being strictly cross-sectional. Although height is corrected for diminutions in the aging process, Monasterio et al. can only make inferences regarding the secular trend in height based on the relative age of the individual at the time of the survey.

whole, but unevenly, favoring the wealthier income groups far more than the poor. Monasterio and his collegues found that six centimeters differentiated the richest from the poorest income quintiles. Despite regional convergence in economic indicators, heights from the North and Northeast tended to be 2 centimeters below the sample average throughout the birth cohorts.

Monasterio and Signorini (2008) conducted the only known anthropometric study on a period spaning the First Republic. Their paper analyzed the evolution in the biological standard of living in Rio Grande do Sul between the years of 1889 and 1920. Monasterio and Signorini drew a random sample of more than 11,000 *carteiras de trabalho* (work registration cards). The most extreme tails of the distribution were potentially underestimated due to selection bias in the sample—the richest likely did not use registration cards, and the poorest individuals probably worked informally. In the first birth cohorts, the authors noted relative stagnation in height, with annual averages vacillating between 168.9 and 170.2 centimeters from 1889-1914, and they noted a steady decline in height beginning in 1915. Cross-sectional regression analysis revealed that the illiterate were 1.3 centimeters shorter than literate workers at the 1 percent level of significance.

Nineteenth-century studies using prison records from the Rio de Janeiro city jail, the *Casa de Detenção* have produced unsavory findings regarding regional height trends. Frank (2006) collected a data sample of 1,142 observations and noted a negative trend in slave heights beginning in the 1830s and lasting until the 1860s. Frank also found evidence illustrating the "urban penalty" in the period. While this pioneering anthropometric study on nineteenth-century Brazil yielded some interesting conclusion, the relatively small size of the data set rendered many econometric techniques inconclusive. Baten et al. (2009) expanded upon the sample drawn from the *Casa de Detenção*. Their paper compared trends in overall welfare for Brazil, Argentina and Peru in the nineteenth century. In the Brazilian case, they used a sample of 6,771 height observations from the Rio de Janeiro city jail recorded between 1861 and 1901. They found a positive upward trend in stature for period ranging from 1860 to 1880. The authors also revealed a regional discrepancy by which heights from the North and

Northeast Brazilian provinces advanced at a quicker rate and reached a higher average height by 1880. Despite the intriguing upward trend, Baten et al. may have overstated the height of prisoners hailing from the North and Northeast. Economic historians generally agree that wage differentials between the regions began in the wake of late-nineteenth-century industrial expansion. Higher heights of Northern and Northeasterner recruits likely reflected their immigrant status: individuals born in the North and Northeast that were physically capable of making the arduous journey to the Southeast were likely more robust and taller than non-migrants.

IV. Data and Methods

i.) Military Sample

Data collection for this project is still underway. The current sample consists of 6,335 soldiers in birth cohorts ranging from 1830-1960. Volumes of recruitment records (*assentamentos*) were summoned at random from the stacks at the AHEX. Records were generally assorted by first-name alphabetically. For the nineteenth century, all new entries from each volume were included in the sample. For the twentieth century, the volumes are much more concentrated with respect to region-of-origin. More specifically, there is an overabundance of recruits hailing from Rio de Janeiro state for soldiers incorporated after WWII. For such regionally-concentrated volumes, I implemented a screening strategy to suppress overly repetitive states-of-origin. Paging through the records, the first 20 soldiers were included in the sample. Thereafter, one soldier from the barracks' home location state was recorded; then, the next soldier from a non-domestic state was recorded. Sampling alternated by domestic and non-domestic state-of-origin in this manner.

Upon being inducted into the military, the identifying officer (*sargento identificador*) recorded pertinent personal information of the recruit. Though several inhomogeneities in record keeping existed between regiments and over time, the recruitment and transfer files generally include name, place- and date-of-birth, place-of-recruitment, parent names, skin color, height, occupation, literacy status, vaccination history, mode-of-entry, and marital status.[5] Independent variables analyzed in this study are occupation, region, skin color, marital status and age. I use recruit occupation as a socioeconomic indicator of skill acquisition. The basic premise is that parents that facilitated skill acquisition for their children likely invested more in their nutrition and healthcare. The region dummy variables isolate soldiers by the 5 main regions of Brazil: the North, Northeast, Center-west, Southeast and South. Skin color attempts to isolate racial subcategories. I have collapsed the racial categories into four to match census classifications: white (*brancos*), Amerindian (*caboclos*), mixed race (*pardos*) and black (*pretos*).[6] Marital status is a dichotomous dummy variable indicated as "1" if the soldier was married before entering the military. Generally, we might assume that taller individuals married at earlier ages. Age controls were added into the model to control for the lower overall height of soldiers recruited before age 21.

ii.) Considering Selection Biases

The historiography of the Brazilian military shows time-variant recruitment practices in nineteenth century could have created a potential (and ambiguous) selection bias with respect to height. Beattie (2001) discussed military recruitment and the role of the army in Brazil's social history between 1864 and 1945. Beattie labeled the nineteenth-century as "the era of impressment", when press gangs frequently ransacked the countryside for soldiers—a process oral historians have referred to as "nabbing time." Members of the middle classes and elite frequently became members of the National Guard to avoid direct service. Victims of dragooning were most frequently members of the "unprotected" poor, i.e., those unassociated with a regional *coronel*. After being pressed, the responsibility of proving immunity from service fell upon the recruit. Inductees were exempted from service if a patron or relative had the financial means to

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[5] Files from the twentieth century more commonly report the município, literacy status and vaccination history.
[6] Complexion was recorded by the scrivener upon induction into the military. I have logged over twenty categories for skin color, ranging from *trigueira*, to *cabocla*, to *preta* or *fula*, with a vast spectrum of mixed race gradations (*pardo claro*, *mulato*, *moreno escuro,* etc.). Though complexion was not self-reported, the multitude of recorded complexions calls into question the inter-rater reliability of racial classification in a population with a complex process of miscegenation.

submit a petition to the local *junta revisora de alistamento militar*. Until the Paraguayan War (1864-70), the military was generally used to quell regional revolts. Complications in mobilizing troops for the war effort highlighted the shortcomings of traditional recruitment practices. Although the military attempted to organize a draft in 1874, a full-scale draft lottery was not implemented until 1916. Though a minimum height requirement of 1.54 meters was put in place, most of the peacetime exemptions remained unchanged. Students of secondary or tertiary institutions were enrolled in reservist or shooting corps (tiros de guerra).

During the era of impressment, were the unprotected poor the least productive and hence shortest individuals of the adult male population? Or were those men outside the web of patron-client power relations the more robust men who sought to distance themselves from the clutches of regional strongmen? Close examination of the sample distributions of heights reveals that the bias may have been negligible.[7] To be sure, at least conceptually, the socioeconomic composition of the rank and file may have changed insignificantly, since the middle and upper classes consistently relied on legal safety nets to avoid the barracks. This shift in recruitment presents a formidable obstacle to assessing the secular trend in stature in Brazil. Future research will use more sophisticated statistical techniques to assess the magnitude of and control for this potential selection bias.

iii.) Covariates and Secular Trends

I report OLS regressions estimating the covariates of height in Table 1.[8] A model considering the effects of the independent variables jointly is presented in Column 1. Columns 2 through 4 report models in which occupation, region and skin color are the respective variables of interest. Unskilled soldiers are the reference group in Column 2. The dummy variable for agricultural workers is statistically significant and positive, suggesting agricultural workers had a greater nutritional status. Skilled manual workers were .67 centimeters taller than unskilled recruits, but somewhat shorter than agricultural workers. This perhaps reflects the larger propensity for skilled individuals to reside in

[7] Graphs available upon request. Will be included in oral presentation.
[8] OLS, complications with the TLS regression operations in Stata. Visual inspections of the sample distribution by cohort of birth.

urban areas in which they were more exposed to diseases. Semi-professionals had the greatest height advantage over unskilled workers, 1.65 centimeters, suggesting that recruits of higher human capital were also of greater nutritional status.

Column 3 examines regional dummy variables in more detail. Soldiers from the Center-west are the reference group. Northerners displayed a significant height penalty of 3.6 centimeters at the 99% level of confidence. Northeasterners were 2.0 cm shorter. Southeastern and Southern recruits display a height advantage of 1.5 and 1.3 respectively. Column 4 reports dummies for skin color as the variables of interest. All the skin color dummies are statistically significant at the 99% level. Compared to whites, those of mixed race were 1.9 cm shorter. Those reported as black were 1.3 centimeters shorter than whites. Those without a listed skin color were 5.7 cm shorter, while Amerindians were 5.2 cm shorter. These models display the overall discrepancies in height across occupational, regional and racial subgroupings respectively. Each specification controls for age, yet further research will incorporate time trends to examine whether such gaps remained relatively constant or converged over the period under study.

Figure I. plots the raw cohort averages of my current data samples. Soldiers were inducted into the military between 1867 and 1979 (corresponding to decadal birth cohorts from 1830 to 1950).[9] The data demonstrate relative stagnation and some fluctuation in overall height in the first decades of the period, while time coefficients from roughly 1880 to 1910 display a significant improvement in stature of nearly 6 centimeters. It would appear that the Brazilian population was becoming increasingly insolated from commodity busts, since average stature increased greatly despite declining coffee terms of trade in the1890s. The real income benefits from industrial expansion were likely a driving force behind such astounding growth in material welfare. The expansion of bacteriology, medicine, and enhanced sanitation measures likely augmented this income effect. The dip in the 1920s and 30s may have been caused by smaller sample size in those cohorts. During the late-nineteenth century, the sample of passports shows no

[9] Soldiers measured in Portuguese inches were not included in the present study. The official conversion rate of 2.75 centimeters=1 Portuguese inch yielded uncharacteristic ranges of height values. Current data analysis is underway to establish a better conversion rate.

sustained upward trend. Interestingly, the 1930-1950 period examined in military recruitment records shows little upward trend in height, contrary to what one might expect given presumed achievements in human welfare during the Vargas era. The Brazilian economy may have grown substantially during the 1930-1960 interval, but the question remains whether added wealth was distributed to the vast cross-section of the population. The relative decline in growth of average height may reflect increased levels of union-induced unemployment frequently caused by populist economic policies.

iv.) Regional Trends in Height

Figure II. displays average height by macro-region from 1850 to 1950. The fluctuations in the Center-west were likely produced by smaller sample sizes for that region in nineteenth-century cohorts. As illustrated in the figure, the gap in height between the North and Northeast versus the South and Southeast remained relatively constant over the period, though the expansion of the coffee sector may have amplified the differential modestly. Previous historical heights studies on Brazil revealed relative equality between macro-regions before 1870 (see Baten 2009). Economic historians generally recognize the industrial expansion of the coffee sector as the cause of a gap in living standards between the North and South. It is fascinating to note that the gap in material welfare predated the industrial expansion of the late nineteenth century. A myriad of factors can explain such a persistent gap in height. Dietary patterns can give us a general idea of the quality and quantity of high-quality proteins and micro-nutrients typically consumed by region. Nineteenth-century records show that Northeasterners tended to consume higher amounts of dried beef (*carne seca* or *carne do sol*), whilst inhabitants of the South and Southeast consumed higher amounts of fresh vegetables and meats (see Baten 2009). Salting and solar radiation have been proven to drastically lower micronutrient content of beef (see Kipple 1989).

Climatic and agronomical factors also shared a role in explaining such a height gap. Recent research on Sub-Saharan Africa has illustrated the influence climatic factors had on overall height. Moradi (2012) found that the diurnal temperature range and relative humidity were statistically significant in explaining regional height variance. He speculated that smaller diurnal temperature ranges allowed for a more stable environment for bacteria to grow. My study uses historical data from the Annuário Estatístico do Brasil (1916) to display preliminary evidence on state-level climatic covariates of height. Table II shows cross sectional regressions of height on climatological variables. All standard errors are clustered at the state-level. In Column 1, both rainfall and rainfall/rainy days are statistically significant. Though statistically significant in the model, average rainfall was of little substantive importance. The rainfall/rainy days measure was constructed by dividing average annual rainfall by the average number of rainy days to obtain a crude measure of rainfall intensity. One standard deviation increase in rainfall intensity caused a decline in average height of 0.56 centimeters. The direction of the coefficient makes intuitive sense: soldiers hailing from regions in which torrential storms were more common were shorter than those from regions in which rainfall was spread out over a larger number of days. Long-soaking rains may provide agronomical advantages for increased aggregate production. Conversely, periods of dryness followed by heavy rains are horrible for crop yields, since topsoils become less compact. One possible channel by which climate affects height may be through its impact on soil erosion. Another possible explanation is related to the disease environment. Periods of heavy torrential rainfall can cause flooding, causing drinking water to become contaminated with sewage.

Colums 2 through 5 examine evaporation point, average temperature and average absolute temperature range as the variables of interest. One standard deviation increase in the evaporation point provoked a decrease in average height of 2.45 centimeters in Column 2. Closely related to humidity, higher evaporation points likely provided stable environments for bacteria to develop. Average overall temperature also decreased height as seen in Column 3 (one s.d. increase led to a decrease in height of 1.79 cm). Height was regressed on the absolute temperature range in Column 5. One standard deviation increase in the range caused an increase in height of 1.71 centimeters. As Moradi suggested for Sub-Saharan Africa, this study provides preliminary evidence that wider absolute temperature ranges conferred a height advantage in Brazil, perhaps because they provide a less stable environment for disease to proliferate.

v.) Passports Sample

The records from passports are held at the National Archive in Rio de Janeiro, and correspond to individuals travelling from the port of Rio de Janeiro from roughly 1917 until 1927. All individuals included in this sample were aged from 20 to 50 years, since terminal height may be reached by age 20 and individuals tend to shrink after age 50. Table II. presents preliminary regression results of height on occupational classifications and countries of origin. Those with skilled manufacturing positions consistently display a height disadvantage from 1.18 to 1.47 cm. Women employed in commerce had a significant and large height advantage, while those in manufacturing had a statistically significant and large negative height deficit.

Foreign-born individuals that became naturalized Brazilian citizens displayed a height advantage over those that did not naturalize. Immigrants that were able to integrate themselves in the Brazilian market had higher human capital acquisition, reflected in the higher overall stature. Those hailing from Portugal had a statistically significant and negative height coefficient. Speaking the same language and relying on a larger group of Portuguese friends and family already in Brazil likely decreased the cultural costs to migration for Portuguese immigrants. Ultimately, I plan to divide the passports sample and analyze Brazilian and foreign-born travelers separately.

V. Conclusion

In this paper, I present two main findings of research currently in progress: 1) The greatest enhancement in the biological standard of living in Brazil coincides with the initial phase of the period agro-export industrialization; and 2) Regional inequities between the Northern and Southern provinces predated the period of industrial expansion. I have additionally found that the height of passport bearers did not increase significantly during the same period. Data collection on passports commenced later and this section of my research is currently under construction. Future research will examine the regional and cohort effects of the passports sample. I also present preliminary evidence on the climatic covariates of stature in Brazil. OLS regressions with cluster-robust standard errors estimate influence rainfall intensity and temperature range may have had on aggregate production and disease proliferation.

In my sample, chronic under- and malnutrition, coupled with poor health and sanitation, were likely the main factors underpinning low and stagnated stature in the nineteenth century, prior to the modern and industrial era. The birth cohorts in which there were notable increases in stature were most likely the benefit of improved nutrition and health. Aggregated GDP per capita calculations reveal faster growth in the period post-1930, yet I observe little improvement in stature during that period. A number of aspects of my larger research project were beyond the scope of this paper. I plan to use state-levels data on exports in order to verify my first conclusion (that industrialization backed by agro-exports created conditions for enhancements in living standards). Additionally, cross-sectional analyses shall regress height by state on several climatological measures (average humidity, rainfall, and temperature) by year of birth in a panel data framework, as well as geographical factors (soil nutrient quality, average gradient, distance to coast).

VI. Figures and Tables

Figure I.

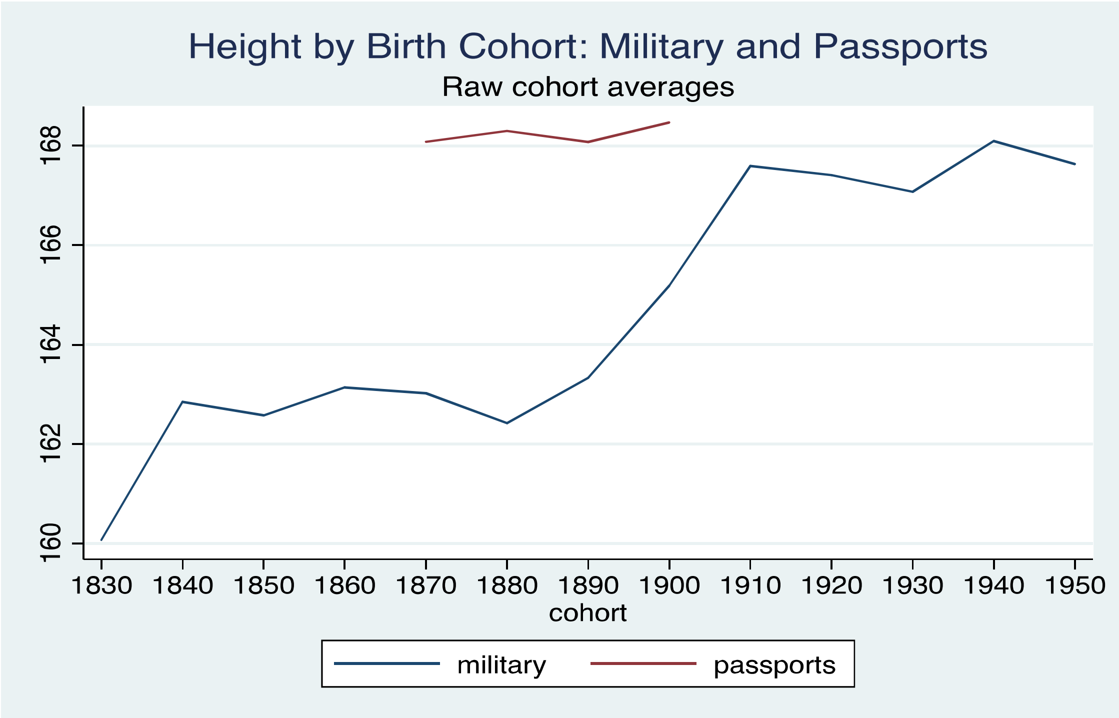

Figure II.

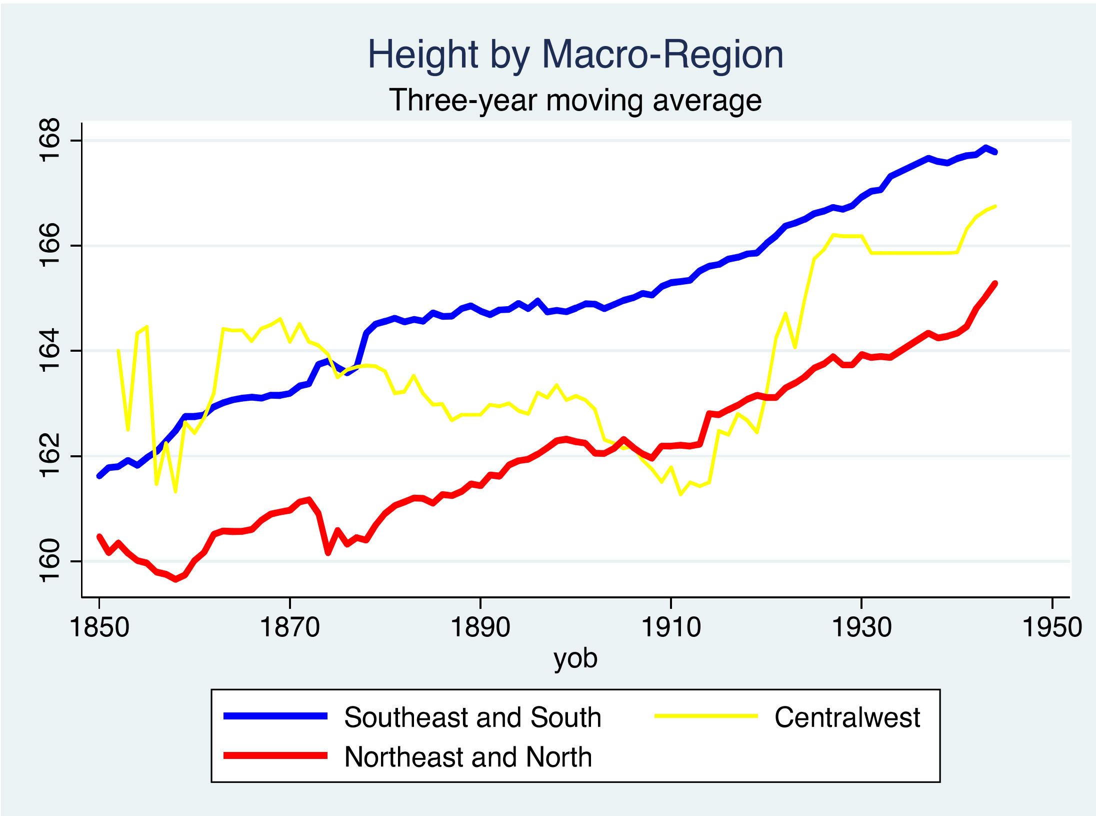

Table I. Correlates of Height: Military Sample

VARIABLES	(1) Height (cm)	(2) Height (cm)	(3) Height (cm)	(4) Height (cm)
unskilled	(0.555)	Ref.		
	(0.387)			
agriculture	-0.894*	0.958**		
	(0.513)	(0.429)		
skilled_manual	(0.474)	0.678***		
	(0.373)	(0.230)		
semi-professional	(0.073)	1.658**		
	(0.729)	(0.688)		
north	(6.979)	(7.756)	-3.614***	
	(7.184)	(7.286)	(0.751)	
northeast	(4.860)	(6.138)	-2.090***	
	(7.158)	(7.260)	(0.448)	
centralwest	(3.824)	(4.108)	Ref.	
	(7.173)	(7.273)		
southeast	(2.396)	(2.706)	1.563***	
	(7.160)	(7.263)	(0.450)	
south	(1.791)	(2.850)	1.359***	
	(7.160)	(7.262)	(0.471)	
white	2.480***	3.021***	3.182***	Ref.
	(0.914)	(0.923)	(0.923)	
mixed	2.092**	2.002**	2.154**	-1.974***
	(0.911)	(0.923)	(0.922)	(0.209)
amerindian	(0.580)	(1.240)	(1.240)	-5.274***
	(0.989)	(1.002)	(1.003)	(0.575)
black	2.643***	2.160**	2.260**	-1.356***
	(0.929)	(0.940)	(0.941)	(0.328)
nocolor	-1.804*	-2.208**	-2.186**	-5.762***
	(1.012)	(0.997)	(0.998)	(0.571)
single	(0.320)	(0.017)	(0.028)	0.328
	(0.369)	(0.366)	(0.366)	(0.376)
age17	-3.594***	-3.547***	-3.699***	-3.071***
	(0.468)	(0.468)	(0.466)	(0.477)
age18	-2.884***	-2.788***	-2.889***	-2.413***
	(0.341)	(0.342)	(0.340)	(0.347)
age19	-1.163***	(0.047)	(0.151)	0.537*
	(0.324)	(0.283)	(0.281)	(0.281)
age20	(0.455)	0.007	(0.037)	0.024

	(0.319)	(0.318)	(0.318)	(0.326)
cohort1830	1.049			
	(5.129)			
cohort1840	3.375			
	(5.084)			
cohort1850	2.775			
	(5.081)			
cohort1860	2.176			
	(5.087)			
cohort1870	2.222			
	(5.085)			
cohort1880	1.810			
	(5.082)			
cohort1890	2.619			
	(5.091)			
cohort1900	3.133			
	(5.106)			
cohort1910	4.831			
	(5.092)			
cohort1920	5.221			
	(5.087)			
cohort1930	5.263			
	(5.117)			
cohort1940	6.738			
	(5.105)			
Constant	164.1***	167.0***	163.0***	166.0***
	(8.853)	(7.316)	(1.059)	(0.376)
Observations	6064	6064	6064	6064
R-squared	0.135	0.106	0.104	0.052

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table II. Effects of Climatic Variables on Height

VARIABLES	(1) height	(2) height	(3) height	(4) height	(5) height	(6) height
rainfall	0.00186***					
	(0.000623)					
rainfall/rainydays	-0.153**					-0.123
	(0.0541)					(0.0774)
baromet_pressure	-0.00873**					
	(0.00402)					
avghumid	0.247					
	(0.267)					
avgtemp	0.631	-0.0679	-0.560***			
	(1.194)	(0.289)	(0.0639)			
evaporation point	-1.400	-0.727***		-0.561***		
	(1.340)	(0.224)		(0.0633)		
absolute temp range	-0.0114	-0.0808			0.181***	0.193***
	(0.0800)	(0.0875)			(0.0322)	(0.0255)
popdens	2.09e-06		1.90e-06***		1.56e-06**	
	(1.79e-06)		(5.21e-07)		(6.73e-07)	
Constant	159.7***	180.3***	177.5***	173.9***	159.8***	161.0***
	(26.82)	(7.839)	(1.508)	(1.042)	(0.797)	(1.278)
Observations	4,946	4,946	6,064	4,946	5,750	5,750
r2	0.0711	0.0636	0.0560	0.0625	0.0526	0.0544

Robust standard errors in
arentheses
*** p<0.01, ** p<0.05, *
<0.1

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
height	6064	164.7592	7.643647	120	195.64
rainfall	6064	1622.416	455.0726	825.9	3096.35
rainfall/rainydays	6064	12.35569	3.752945	5.8574	27.05682
baromet	5877	757.5794	50.95325	691	1011.2
avghumid	5729	77.84962	4.096713	69.2	84
avgtemp	6064	22.87878	3.199581	16.2	27.2
evp	4946	16.28035	3.369735	11.4	21.1
range	5750	27.43849	9.615236	12.9	41.1
popdens	6064	34389.96	118182.8	83	528317.8

Table III. Occupational Effects of Height: Passport Sample

VARIABLES	height Total	height Men only	height Women only	height Total	height Men only	height Men only	height Men only	height Men only
single						-0.00344	-0.00389*	-0.00392*
						-0.00213	-0.00214	-0.00214
professional	0.00950***	0.00357	-0.00573	0.00584*	0.00277	0.00266	0.00228	0.00225
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
skilled_manu	-0.0128***	-0.0147***	-0.0321**	-0.0118***	-0.0145***	-0.0144***	-0.0130***	-0.0129***
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
commerce	0.00127	-0.0117***	0.0476**	0.00202	-0.0115***	-0.0114***	-0.0114***	-0.0114***
	(0.00)	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
noeduc				0.0188**	0.0122	0.0121	0.0121	0.0123
				(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
superior				0.0194***	0.00438	0.00416	0.00367	0.00375
				(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
russian							0.000212	-9.73E-05
							(0.01)	(0.01)
turkish							-0.0125	-0.0125
							(0.01)	(0.01)
romanian							-0.0306***	-0.0314***
							(0.01)	(0.01)
natural_brazo							0.0133*	0.0144*
							(0.01)	(0.01)
adopted_brazo							0.022	0.0223
							(0.03)	(0.03)
german							0.0475	0.0475
							(0.04)	(0.04)
portuguese							-0.0187***	-0.0196***
							(0.01)	(0.01)
italian								-0.0166
								(0.02)
spanish								0.0412
								(0.03)
Constant	1.682***	1.699***	1.604***	1.663***	1.687***	1.689***	1.690***	1.690***
	-0.00168	-0.0019	-0.00327	-0.00881	-0.00817	-0.00826	-0.00825	-0.00826
Observations	4,082	3,574	508	4,082	3,574	3,574	3,574	3,574
R-squared	0.007	0.012	0.016	0.01	0.013	0.014	0.02	0.021

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

VII. Bibliography

Abreu, M. P. 1990. *A ordem do progresso: Cem anos de política economica republicana, 1889-1989*. Rio de Janeiro, Brasil: Editora Campus.

Baer, W. 2008. *The Brazilian Economy: Growth and Development*. 6th Ed. Boulder, CO: Lynne Rienner Publishers

Baten, J., Pelger, I., Twrdek, L. 2009. "The Anthropometric History of Argentina, Brazil and Peru during the 19th and Early 20th Century." Economics and Human Biology 7, 319-333.

Bourne, Richard. 1974. *Getulio Vargas of Brazil, 1883–1954 Sphinx of the Pampas*. C. Knight: London.

Brasil, Diretoria Geral de Estatística. 1916. *Annuario Estatistico do Brasil, 1908-1912*. Typographia de Estatística: Rio de Janeiro.

Cano, Wilson. 1997. *Raízes da concentração industrial em São Paulo*. São Paulo, Brasil: Difel.

Chiswick, Barry R. 2000. "Are Immigrants Favorably Self-Selected? An Economic Analysis." in Caroline D. Brettell and James F. Hollifield, eds. *Migration Theory: Talking Across the Disciplines*. New York: Routledge.

Coatsworth, J. H., 1996. "Welfare." American Historical Review 101, 1-12.

--------., Taylor, A., 1998. *Latin America and the World Economy Since 1800*. Cambridge, MA: Harvard University Press.

Costa, Dora L. 1993. "Height, Wealth, and Disease among the Native-born in the Rural, Antebellum North. Social Science History 17(3): 355-83.

Cuff, Timothy. 2005. *The Hidden Cost of Economic Development: The Biological Standard of Living in Antebellum Pennsylvania*. Farnham: Ashgate Publishing

Frank, Zephyr. 2006. "Stature in Nineteenth-century Rio d Janeiro: Preliminary Evidence from Prison Records." Revista de Historia Económica (Second Series), 24 : pp 465-489.

Fogel, R. W., "Nutrition and the Decline in Mortality Since 1700: Some Preliminary Findings." NBER Working Paper No 1402

--------2004. *The Escape from Hunger and Premature Death, 1700-2100. Europe, America, and the Third World.* Cambridge: Cambridge University Press.

Kipple, Kenneth F. 1989. "The Nutritional Link with Slave Infant and Child Mortality in Brazil." The Hispanic American Historical Review, Vol. 69, No. 4 (Nov., 1989), pp. 677-690.

Komlos, J., 1989. *Nutrition and Economic Development in the Eighteenth-Century Habsburg Monarchy: An Anthropometric History*. Princeton, New Jersey: Princeton University Press

---------. 1985. "Stature and Nutrition in the Habsburg Monarchy: The Standard of Living and Economic Development." Am. Historical Review. 90, 1149-1161.

---------.1987. "The Height and Weight of West Point Cadets: Dietary Change in Antebellum America." The Journal of Economic History, Vol. 47, No. 4 (Dec., 1987), pp. 897-927

Leff, N. H 1982. *Unerdevelopment and Development in Brazil: Vol. I Economic Structure and Change, 1822-1947.* Allen & Unwin: Winchester, Mass.

Lobo, E. M. L., 1978. *História do Rio de Janeiro (do capital comercial ao capital industrial e financeiro)* V.2. IBMEC, Rio de Janeiro, Brasil
López-Alonso, M. 2007. "Growth with Inequality: Living Standards in Mexico, 1850-1950." UK: Cambridge University Press.
---------., Grajales-Porras, A., 2011 "Physical Stature of Men in Eighteenth-Century Mexico: Evidence from Puebla." Economics and Human Biology 9 (2011), 265-271.
---------., Condey, R. P., 2003. "The Ups and Downs of Mexican Economic Growth: The Biological Standard of Living and inequality, 1870-1950." Economics and Human Biology 1 (2003) 169-186.
Margo, R. 1982 "The Heights of American Slaves." Social Science History, Vol. 6. 516-538
------------., Steckel, R. H., 1983. "Heights of Native Born Whites during the Antebellum Period." Journal of Economic History 43, 167-174.
Mokyr, J., Kelly, M., Gráda, C., 2011. "Precocious Abolition: Factor Prices, Technological Change and the British Industrial Revolution." Conference Paper, UCLA Von Gremp Workshop in Economic History, 05/2011
Moradi, Alexander. 2012. "Climate, Height and Economic Development in Sub-Saharan Africa." Journal of Anthropological Sciences Vol. 90 (2012), pp. 1-4.
Monasterio, L. and Signorini, M. J. S. 2008. "As Condições de Vida dos Gaúchos entre 1889-1920, Uma Análise Antropométrica." EconomiA, Selecta: Brasília (DF), v.9, n.4, p.111–126, Dezembro 2008.
Musacchio, A., Martínez-Fritscher, A., Viarengo, M. 2010. "The Great Leap Forward: The Political Economy of Education in Brazil, 1889-1930." Working Paper
Salvatore, R. 1998. "Heights and Welfare in Late-Colonial and Post-Independence Argentina." In: Komlos, J. Baten, J. (Eds.), *The Biological Standard of Living in Comparative Perspective*. Franz Steiner Verlag, Stuttgart, pp. 97-121.
Salvatore, R., Coatsworth, J., Challú, A., 2010. *Living Standards in Latin American History: Height, Welfare, and Development, 1750-2000*. Cambridge, MA: Harvard University Press.
Steckel, R. 1995. "Stature and the Standard of Living." Journal of Economic Literature 33 (4), 1903-1940.
------------. 1998. "Strategic Ideas in the Rise of the New Anthropometric History and Their Implications for Interdisciplinary Research." The Journal of Economic History, Vol. 58, No. 3 (Sep., 1998), 803-821.
------------., and Floud, Roderick. 1997. *Health and Welfare during Industrialization*. Chicago: The University of Chicago Press.
Stein, Stanley J. 1957. *The Brazilian Cotton Textile Manufacture: Textile Enterprise in an Underdeveloped Area, 1850-1950.* Cambridge, MA: Harvard University Press.
Tanner, James. 1981. *A History of the Study of Human Growth.* Cambridge, UK: Cambridge University Press
Triner, Gail D. 2000. *Banking and Economic Development: Brazil, 1889-1930*. New York: Palgrave.
Verner, D., Abreu, M. 1997. *Long-Term Brazilian Economic Growth, 1930-94*. OECD