ON VALUING HUMAN CAPITAL
AND RELATING IT TO MACROECONOMIC CONDITIONS

Abstract

Human capital is the largest component of aggregate wealth, but its relation to other macroeconomic variables is murky due to the lack of market prices. Valuing human capital using historical costs or expected income is characterized by substantial measurement errors. We develop a human capital index using slave prices and relate its dynamics to that of other assets including equities and bonds. We present an extensive analysis of asset pricing, including portfolio optimization, SDF, and integration utilizing observed human capital returns. This analysis deepens our understanding of human capital dynamics, with applications to portfolio allocation, market integration, and diversification.

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Human capital, that colossal collection of assets, is also the most mysterious: illiquid, trading in no market, unverifiable in value, yet surely an immense influence on all investment decisions and the macro economy. For example, recent research considers the impact of human capital and its estimation on economic growth, as well as wealth differences across countries (cf., Lucas (2015), Jones (2014), and Manuellia and Seshradi (2014)). Existing research also considers the importance of human capital within an asset pricing context and the portfolio allocation decision (cf., Mayers (1972, 1973), Sharpe (1964), Linter (1965), Black (1972)). Roll (1977) claims that the true "market portfolio" cannot be measured without knowing human capital, and that ignoring it can lead to incorrect conclusions. The impact of human capital on portfolio allocation has further been studied with respect to the international diversification puzzle of French and Porterba (1991) (cf., Botazzi, Pesenti and Van Wincoop (1996), Baxter and Jermann (1997), Baxter, Jermann and King (1998)). Finally, further research has considered the impact of human capital in the context of the college premium (cf., Bowlus and Robinson (2012)), gender economics (cf., Pitt and Rosenzweig (2012)), immigration (cf., Friedberg (2000)), and many other areas. The breadth and depth of the literature relating to human capital highlight the importance of accurate estimation. In fact, many of the unresolved issues within the literature may relate to inaccurate estimates of human capital values.

Theoretically, the human capital calculation is straightforward: predict net lifetime labor income (gross revenue less sustenance and reinvestment) and discount to the present. However, contrasting virtually all other asset classes, from equities through real estate, the resulting human capital present value cannot be checked against a current market price. The existing literature has primarily relied on two approaches to measuring human capital, the historical cost, and the income-based, approaches to measuring human capital. However, each approach has substantial drawbacks. The historical cost approach is comparable to accounting book value, and 'book' valuation is well known to contain impressive errors. Similarly, the income-based approach is comparable to imputing equity values based on dividend streams, which again is well known to produce substantial errors.

The only feasible alternative to human capital measurement relies on observed market prices.

These markets are illegal and non-existent almost everywhere. From the past, however, there are some data. Prior to the enlightenment of the latter part of the 19^{th} Century, there were periods of history when human beings were traded in liquid markets. This inhuman practice, which we along with most everyone else condemn as a moral outrage, was associated with direct market valuations of human capital. The existence of these data is, of course, no excuse for the abominable traffic in human beings, but it is simply a fact. The empirical valuations exist, regardless of their disgraceful provenance. We contribute to the existing human capital literature by presenting and analyzing a novel measure that is derived from these observed market prices. Our work is similar to Calomiris and Pritchett (2016) who note that slave prices 'measure market perceptions of the discounted present value of future income and other benefits,' (p. 3) and they study slave prices to infer expectations regarding political events leading to the US Civil War.

We do not pretend that the market price of an enslaved human corresponds to that of an entirely free worker in terms of its absolute level. A number of wedges intervene. Incentives, shirking, and punishment are some of the obvious differences. But to the extent that such potential biases in the prices of human capital in slave markets are roughly constant over time, one can work with rates of change in hedonic slave price indexes and relate them to changes in macro variables. This is the strategy employed in our empirical work.

Utilizing hedonic regressions and data from the ante-bellum south of the United States, we construct a human capital index based on observed market prices from 1801-1860. We use our novel measure to build on the existing human capital literature and make several contributions. First, we provide a novel estimate of human capital that is based on observable market prices, and we document the dynamics of the estimate. For a period of approximately 60 years our analysis details the evolution in human capital returns through time. Although data are somewhat limited, we then relate human capital returns to wages, equity returns, bond returns, changes in interest rates, and other macroeconomic variables. Second, we examine the impact of human capital on portfolio allocation by creating optimal portfolios with human capital, equities, and government bonds, and then impose the restriction that human capital must make up a minimum total allocation. We find optimal portfolios are quite sensitive to the inclusion of human capital. In particular, including human capital tends to increase (decrease) the relative weight of government bonds (equities), suggesting that portfolios without considering human capital are sub-optimal. This analysis has clear implications for portfolio choice as well as asset-pricing research. Third, we contribute to the literature by presenting the SDF utilizing human capital returns by applying Pukthuanthong and Roll's (2020, henceforth PR) approach to estimate the SDF. Applying the PR estimator, we investigate how human capital integrates with each asset class over 1801-1860. We find the SDF of human capital is distinct from that of other assets. We also test the integration of human capital with each asset class and find human capital changes the SDF of other assets. This suggests that human capital was not integrated with the other asset markets during 1800s. We also examine whether the SDF of each asset combined with and without human capital is strictly positive, which implies the absence of arbitrage and find that human capital leaves arbitrage opportunities open. Fourth, our analysis in general contributes to a growing body of literature that utilizes historical episodes to facilitate understanding of modern phenomena. For example, Temin and Voth (2004) study the South Sea Bubble that occurred early in the 18th century to improve our understanding of speculative bubbles, and Goetzmann, Li and Rouwenhorst (2005) study global correlations over a period of 150 years to inform our understanding of diversification and periods of globalization. Further, Golez and Koudijs (2018) study dividend yields with data beginning in 1629. They find that 'dividend yields are stationary and consistently forecast returns' (p. 248).

In addition to our contributions with respect to measuring human capital during the sample with observable market prices, we further contribute to the literature by extrapolating human capital dynamics through present day. Specifically, within our sample we are able to observe the dynamics of the human capital output yield, the estimated value of production in the current year relative to the total human capital value. Utilizing the present value relation, the ratio of income less sustenance to present human capital value is strictly a function of the expected growth rate in income and the required return. Combining the dynamics of the output yield during the 1800s with current data on income and sustenance costs allows us to estimate current values of human capital. For example, projecting the observed output yield with current data for average income less sustenance from 2011 provides an estimate of average human capital value equal to $134,820. For the typical individual, this value would represent 66% of overall wealth, and 89% of wealth excluding real estate. Therefore, with our novel approach to human capital valuation, we contribute to the literature by providing current human capital valuation estimates that derive from previous market values. This approach also allows a cursory inspection of human capital during the recent financial crisis. The extrapolated measure indicates an increase in human capital value during the Internet Boom during 1999 to 2004, but then a precipitous drop of human capital value during the recent financial crisis. Roll (2011) suggests that dramatic decreases in human capital precipitated the financial crisis. We also find during our sample period of 2002 to 2013 human capital does not change the SDF of each asset class and the SDF of all asset classes is strictly positive, thereby suggesting the absence of arbitrage in these asset classes. The SDF of human capital seems to be unique during 1801-1860 but indistinguishable from that of other asset classes after 2000, supporting the evidence of an increasing trend in global market integration. This pattern cannot be proven absolutely true, of course, but it is not rejected by our tests after properly accounting for sampling variation. While speculative, the extrapolated analysis provides insights into present-day valuation of human capital.

I. HUMAN CAPITAL MEASUREMENT

The literature on human capital has a long and illustrious history that extends back to the earliest professional economists. For example, Adam Smith (1776) did not actually use the term "human capital," but he clearly was thinking about it when he discussed the "value" of acquired skills and abilities. Smith also noted that human capital was risky and provided returns that depend on job security and the probability of successful employment after investing in difficult and expensive education. Smith included the acquired and useful abilities of all the members of the society under the idea of capital. Further, David Ricardo's labor theory of value elevates human capital to the main determinant of the values of all goods.

It contends that the value of a good is proportional to how much labor was required to produce it, including the labor required to produce the raw materials and machinery used in the process.

Subsequent scholars devoted substantial attention to measuring human capital values indirectly, i.e., when there is no direct market price. There are essentially two methods. First, the cost-based method relies on historical information such as investment in education, as discussed by Adam Smith. It is backward-looking but has the virtue of simplicity and the data are usually available. Second, the income-based method utilizes future earnings. It is forward-looking and avoids the fallacy of sunk costs but, of course, it is plagued by forecast errors and data are not always available.

I. A. Historical Cost Valuation of Human Capital

Following the insights of Adam Smith, the creation of specialized labor is seen to require the use of scarce inputs. Education is frequently considered as a primary input, and this has led to a body of literature in which human capital is proxied by measures of school experience (cf, Barro and Lee [1993, 1996, and 2001a]). Recently, Barro and Lee (2012) provide a novel panel dataset that covers 60 years across 146 countries. In this literature, the human capital earnings function (cf., Mincer [1974] and Chiswick, [1998]) can provide a functional form for the relation between education, typically measured in years, and the stock of human capital, measured in monetary units. Years of schooling is only one of several education-related measures (cf., Temple [2001], Pritchett [2001], Krueger and Lindahl [2001], and Wolff [2000]).

The excellent critical survey by Wößmann (2003) provides a thorough discussion of total labor costs, adult literacy rates, school enrollment ratios, and levels of educational attainment as output per worker is related to these influences. Although schooling years is the most commonly employed determinant, the unweighted linear sum of schooling years lacks a sound theoretical foundation. Recently, some improvements have been made to this form of human capital measurement including Oxley, Greasley and Zhu (1999, 1999–2000), De la Fuente and Domenech (2006), Cohen and Soto (2007), Barro and Lee (2001b), and Wößmann (2003). However, even these new measures fail to capture the knowledge embedded in humans. One year of schooling does not provide an equal increase in human capital across each year of school, or across institutions.

Another determinant of human capital value under this general type of approach could be labeled as "husbandry" costs. The basic idea is from Engel's (1883) cost-of-production method of estimating human capital from child rearing costs borne by parents. Dagum and Slottje (2000) criticize this approach because it does not account for the time value of money nor the costs invested by society and not by parents. Machlup (1962) and Schultz (1961) address the omission of the time value of money by constructing the human capital stock as the depreciated value of the investment. Kendrick (1976) divides human capital investment into tangible and intangible portions. Tangible human capital investments include such items as the nourishment required to rear an adult physical human from a child, whereas intangible investments are related to increasing the productivity and quality of human capital.

Overall, the cost-based approach measures human capital as a function of the past flow of resources invested. Its main virtue is the ready availability of data on public and private spending. However, there are many drawbacks. First is the probable weak correlation between investments (of any type) and output quality (for many reasons). For example, Manuellia and Seshadri (2014) indicate that quality of human capital may vary substantially, even if years of education are comparable. Second, historical costs ignore non-pecuniary effects such as happiness from education, self-confidence, and self-fulfillment. Third, the depreciation rate of human capital is highly uncertain. The conceptual difficulties with the historical cost-based approach can be appreciated by considering the same method for valuing other kinds of capital. For instance, in some industries, accounting book value is calculated by adding up acquisition costs and subtracting depreciation. This provides a "book" valuation, which is well known to contain impressive errors. Indeed, the market/book ratio, which varies widely across companies and industries, is simply an indication of the imperfection in book value. One should expect an analogous imperfection in cost-based measures of human capital.

I. B. Using Prospective Labor Income to Value Human Capital

Numerous studies within the existing literature provide estimates of human capital in the context of prospective labor income. As an example, Weisbrod (1961) uses the income-based approach with cross-sectional data for earnings, employment rates and survival probabilities. Graham and Webb (1979) subsequently adjust this framework to incorporate economic growth. Mulligan and Sala-i-Martin (1997) develop a labor income-based measure of human capital to obtain an index value, rather than a monetary value, of human capital. In their approach, for a given state and a given year, they divide total labor income per capita by the wage of the uneducated, in order to control for physical capital available, and consequently isolate the value of human capital. Alternatively, Macklem (1997) estimates the value of human capital in Canada, where human wealth is computed as the expected present value of aggregate labor income net of government expenditures based on an estimated bivariate vector autoregressive model for the real interest rate and the growth rate of labor income net of government expenditures.

In likely the most comprehensive study involving the income-based approach to measuring human capital, Jorgenson and Fraumeni (1989, 1992) adopt the methods introduced by Farr (1852) and Dublin and Lotka (1930). Specifically, they use a new system of national accounts for the US economy that includes market and non-market economic activities and they attempt to assess the impact of human capital on economic growth. The model is applied to estimate the aggregate value of human capital for all individuals in the US population classified by sex, age, and education for a total of 2196 cohorts. Outside the United States, this method has been applied to estimate the human capital stock for Sweden (Ahlroth, Bjorklund and Forsulund [1997]), Australia (Wei [2001]), and New Zealand (Le, Gibson and Oxley, [2003]). In all cases, the estimated value of human capital greatly exceeds that of physical capital. For instance, using data from 1949 to 1984, Jorgensen and Fraumeni (1989) find the value of human capital is over eleven times the value of physical capital. Ahlroth, Bjorklund and Forsulund (1997) with Swedish data from 1967 to 1990, document that even the lowest estimates of the human capital stock (after tax, excluding leisure income) exceed the value of physical production capital by factors of 6 to 10. Le, Gibson and Oxley (2003) estimate that the mean per capita value of human capital embodied in the population 18 to 64 in New Zealand was about $372,000 in 2001 and that the stock of working human capital grew by 54 percent in the last two decades. Compared with the physical capital stock, human capital stock in New Zealand is well above double, and this ratio has increased over time reaching 2.7 to 1 in 2001. Liu (2011) provides a recent example of an implementation of the Jorgenson-Fraumeni approach, and reports results across 16 nations. However, according to Rothschild (1992), Jorgenson and Fraumeni's approach assumes that human capital has the same productivity for leisure and work. Rothschild shows that the choice of work hours is not independent of the level of human capital when individuals derive utility from non-labor income and that full income (or the value of human capital) is not a linear function of the wage rate. Therefore, full income is not a reasonable measure of welfare.

The work of Huggett and Kaplan (2011) within the income-based approach to measuring human capital is especially relevant to our current study, as they present a comparison of human capital and equity returns based on an individual's stochastic discount factor. Examining US data of male earnings and financial asset returns, they conclude (1) human capital value is far below the value derived by discounting earnings at the risk-free rate, (2) human capital and equity returns are marginally positively correlated over one's working life, (3) average human capital returns are greater than equity returns at young age and decline with age, and (4) the equity-related value of human capital is smaller than the bond-related value at all ages. This conclusion is based on projecting human capital values on both an equity index and a bond index and then considering their relative magnitudes.

Although many studies estimate human capital value in the context of the present value of future earnings, there are substantial conceptual and practical problems with this approach. First, it relies on an assumption that differences in current (and from that, projected) labor income reflect differences in productivity. Second, the data on earnings are not always available, especially for developing markets where the wage is not documented. Third, human maintenance costs are difficult to estimate and fraught with error. Fourth, since this method is based on the future, it is obviously subject to forecasting errors. Lastly, only the cash flow components of human wealth returns are ever observed; the discount rate is not (Lustig and Van Nieuwerburgh, 2008). In general, valuing human capital based on discounted earnings is comparable to imputing equity values based on dividend streams, which is well-known to produce imposing errors.

I. C. Market Based Measures of Human Capital

Because the cost- and income-based methods of estimating human capital have many drawbacks, it would be preferable to use observed prices. Although, existing literature documents the determinants of slave prices, we are aware of no study that has considered human capital value derived from slave prices in the context of the macro economy. We believe this is the first study to develop an extended time series of human capital values and relate it to other macroeconomic variables. Although far from conclusive, the evidence considering the market for slaves implies that slave auctions were relatively efficient. Consequently, we believe that slave prices were often rational and suitable for building a human capital index.

The existing research suggests slave prices relate strongly to economic conditions. For example, Mancall, Rosenbloom, and Weiss (2001) construct estimates of slave prices between 1722 and 1809 from probate inventories in South Carolina. They find that although the long-run supply of slaves was close to perfectly elastic, the short-run supply curve was inelastic. They also find the growth of world markets for rice contributed to rising output prices which helped push up slave prices after the middle of the eighteenth century. Galenson (1981) studies human capital values in the context of indentured servitude and finds that periods of high colonial demand for labor are related positively to human capital values. Following Galenson, the indentured servitude market received considerable attention. For example, Grubb (1985) studies the efficiency of the market in the context of forward pricing. Using the Hall (1999) dataset, one of two datasets employed in the current study, Coleman and Hutchison (2006) find that the Jefferson embargo (the prohibition of trade and commerce with France and Great Britain) in December 1807 and the prohibition of slave imports on January 1, 1808 differentially influenced the value of slaves in New Orleans and outside of New Orleans. After the embargo was lifted in 1814, differences in the valuation of slave characteristics between the two regions were considerably reduced. They conclude the Jeffersonian embargo and the War of 1812 were exogenous shocks to exports of cotton, tobacco, and rice, which were the primary crops produced with slave labor. Calomiris and Pritchett (2016) use slave prices effectively as a measure of human capital and analyze the impact of political events prior to the Civil War on slave prices.

Many existing studies in the literature consider the determinants of prices in slave markets, and document relations between characteristics of the individuals and observed prices. For example, Kotlikoff (1992) studies determinants of slave prices in the US using the Fogel and Engerman (1974) dataset.[1] This dataset is the second employed in the current study and consists of a sample of slave prices and characteristics drawn from auction records for New Orleans during the period 1804 to 1862. Kotlikoff's results suggest that the New Orleans market demonstrates economic sophistication and rationality on the part of slave buyers and sellers. That is, slave prices are observed to vary plausibly with personal slave characteristics, e.g., male slaves sold at a premium as did those with skills.

Galenson (1981), mentioned above, also provides evidence that prices reflect skills and individual characteristics. He studies the market for human capital created by the institution of indentured servitude in colonial America. The indenture system allowed English emigrants to obtain passage to the colonies by selling claims on their future labor. With the size of the debt approximately equal for all emigrants, the length of the term during which a servant was bound varied inversely with expected productivity. Galenson finds that age, skill, and literacy were negatively related to length of indenture, and women received shorter terms than men at young ages.

Pritchett and Hayes (2016) study newspaper advertisements during 1830 as a measure of occupational information and document a premium for a skilled slave. That is, newspaper advertisements were not simply "cheap talk." Finally, Chenny, St-Armour, and Vencatachellum (2003) examine the

[1] Coleman and Hutchison (2006) also study determinants of slave prices in the US.

determinants of slave prices from 910 slave sales recorded in bankruptcy and succession auctions in Mauritius from 1825 to 1827. They also find an impact of gender; male slaves had a value premium especially when they were sold during peak sugar cane season, and females with children also earned a value premium. Newland and Segundo (1996) examine the determinants of slave prices for 1791 slave sales in Peru and La Plata from 1767-1794 and also document that skilled slaves, as well as slaves of African descent were sold at a premium.

In addition to skills and characteristics of the individual, existing research shows that prices are influenced by additional factors. For example, Galenson (1981) finds that the destination of indentured servants influences value. Chenny, St-Armour, and Vencatachellum (2003) show that an individual's descent influences value. Newland and Segundo (1996) find a value premium for male slaves in La Plata, but not in Peru, implying that structural differences across markets may impact slave value. Similarly, Choo and Eid (2008) as well as Levendis (2009) study the structure of the market with respect to the number of bidders present.

I. D. Human Capital Related to Other Macro Variables

The relation between human capital and macro variables has been previously considered, at least to a limited extent. The World Bank (2011) measures human capital effectively as a residual. Total wealth is estimated based on future consumption, and human capital is estimated as the difference between total wealth less produced and natural capital. However, most of the literature in this area documents the relation between education, as a proxy for human capital, and macro variables. As examples, Barro (1991) uses the number of years in school to proxy for human capital and finds a positive relation with human capital and real investment, real GDP, and the total fertility rate. However, the findings on education and economic growth are mixed. Barro and Lee (1994) find that male schooling is positively related to economic growth while female schooling is not. Alternatively, Stokey (1994) argues that the previous result is influenced by Asian countries such as Hong Kong, Singapore, Taiwan, and South Korea, and that male schooling is not related to economic growth if female schooling is excluded from the sample. Lau, Jamison and Louat (1991) study the effect of education by level of primary and secondary schooling for different regions and find that primary education has a positive and significant impact only in East Asia, but a negative effect in Africa, and insignificant effects in South Asia and Latin America. Jovanovic, Lach, and Lavy (1992) investigate non-OECD countries and find a negative impact of education on a different set of capital stocks. Mankiw, Romer and Weil (1992) use average schooling duration to measure human capital and find a strong correlation with per-capita output. Overall, Mankiw, Romer and Weil's regression analysis shows that physical and human capital variations predict 80% of the income variation across countries.

However, given endogeneity concerns, the interpretation of the results concerning education as a proxy for human capital and growth is not obvious (Klenow and Rodriguez-Clare [1997]). Recent research has emphasized accounting approaches to avoid these concerns by decomposing output directly into its constituent inputs (see, e.g., the review by Caselli [2005]). A key innovation in measuring human capital stocks, where an economy's workers were translated into "un-skilled worker equivalents" is to sum up the country's labor supply with workers weighted by their wages relative to the unskilled (Klenow and Rodriguez-Clare [1997], Hall and Jones [1999]). This method captures the standard competitive market assumption where wages represent marginal products and takes wage returns to indicate the productivity gains from human capital investments. With this approach, the variation in human capital across countries appears modest, and physical and human capital predict only 30% of the income variation across countries (see, e.g., Caselli [2005]), which is a quite different conclusion than suggested by Mankiw, Romer and Weil's regressions. Recently Arrow et al (2012) implement the Klenow and Rogriguez-Clare (1997) approach to estimating human capital. Their focus is on measuring comprehensive wealth, of which human capital is a component.

Overall, a number of existing studies consider human capital value and macro-economic variables, using education as a proxy for human capital. To the best of our knowledge, there is no study examining human capital value using market prices and macroeconomic variables. Consequently, the shortcomings of the cost-based human capital measures previously discussed would apply to these existing studies. Further, the results are mixed in terms of the impact of human capital on growth within the existing studies.

II. DATA AND THE HUMAN CAPITAL INDEXES

Our approach utilizes market price observations to estimate human capital. The data come from two extensive data sets that contain price information along with the attributes of individual humans. This approach is similar in spirit to Calomiris and Pritchett (2016).

II. A. The Hall Dataset

Gwendolyn Midlo Hall of Rutgers University collected the background, characteristics and sales prices of 100,000 slaves who were brought to Louisiana, both in New Orleans and outside of New Orleans during the 18th and 19th centuries.[2] The data cover January 1719 through 1820 and include both slave and freed slave information. Within this dataset we restrict attention to a Hall-coded group variable "2," which denotes "sold or inventoried as an individual," thereby eliminating sales involving more than one person. We also require observations to have either a sales or inventory price. When available, the recorded sale value is our *Price* variable. If no sale value is available, we use the recorded inventory value instead.[3] Both sales and inventory values are expressed in a common currency when appropriate.[4] Given these screens, there are 25,803 useable observations from 1725 through 1820. Ten percent of the useable observations occur through 1778, with the remaining 90% between 1779 and 1820 inclusive.

Our purpose is to compare human capital value with macro-economic variables. Most of the macro-economic variables come from *Global Financial Data*, with the US data typically beginning in 1800.

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2 http://www.ibiblio.org/laslave/introduction.php

3 An inventory value is comparable to an assessed value, which was commonly used when selling an estate that included slaves as part of the property. The correlation is 0.95 between of our human capital index and a comparable index constructed from only sales prices (without inventory value).

4 Prior to the American revolution, the currency is typically, not always, the British pound. There are occasional periods when several other currencies are used.

Based on the nature of the useable observations from the Hall dataset as well as the availability and frequency of macro variables, we create the human capital index from the Hall dataset beginning in 1800. This final sample includes 14,490 useable observations, (56% of the total useable observations from the initial Hall dataset), and these observations match well with the availability of macro-variables. Of this final post-1800 Hall sample, 64% of observations correspond to sales price values, while the remaining 36% represent inventory values. The macro data are generally annual, so the primary HC index employs individual sales aggregated over each calendar year. We estimate levels of the human capital index beginning in 1800, to match with the first observation of the levels of the macro variables. Therefore, our analyses considering returns begin with the first annual return in 1801 for this dataset.

To derive the primary human capital index from the Hall dataset, we control for individual characteristics while including time fixed effects for each year, and consequently omitting the intercept. The time fixed effects capture time variation in a characteristics- and location- adjusted index of human capital value.[5] The fitted hedonic regression equation is,

$$Price = 110.5Male + 17.4Age - 0.3Age^2 + 137.5Expert + 51.6LS - 47.2 - 185.1Sick_1 - 197.2Sick_2 - 191.6Sick_3 - 345.9Sick_4 - 243.4Sick_5 + \sum\beta_k L_k + \sum\beta_t Time_t + e_{i,t},$$

where *t* denotes time in years and all variables occur within year t. *Male* is an indicator taking a value of 1 if gender is listed as 'male'; *Age* is the person's age (sample average = 22.8); *Expert* is an indicator taking the value of 1 if the person is described as 'very good at his or her primary skill'; *LS* is an indicator taking the value of 1 if person is described as 'having a little skill at his or her primary occupation'; *New* is an indicator taking the value of 1 if person is 'listed as newly arrived from Africa'; $Sick_i$ is an indicator variable

[5] This approach is similar to the approach employed by Calomiris and Pritchett (2016). They validate their hedonic regression using an alternative measure created from repeated sales and find that, although the repeated sales measure has greater volatility, the two indexes are 'broadly' similar.

taking the value of one if for five categories of illness or impairment provided within the dataset; L_k represents one of 27 indicator variables for 27 categories of standardized locations 'accounting for parish and post' that are included in the Hall dataset. Locations from the initial dataset with no useable observations are not included in the regression. An indicator variable is also omitted for one arbitrary location variable. $Time_t$ represents one of 21 indicator variables for each year from 1800 through 1820 included in our primary Hall sample. The R-square of the regression is 24.9%.

Given the pooled regression results above, the human capital index from the Hall sample for each year is calculated by taking the coefficient estimate of $Time_t$ and adding the following terms: the coefficient estimate for the male indicator variable (110.5) where this indicator is set to 1 for 59.9% of the sample, the product of the *Age* coefficient multiplied by its sample average ($17.4 * 22.8$), the product of the Age^2 coefficient multiplied by the square of the full-sample average of the *Age* variable ($-0.3 * 519.8$), the coefficient estimate for the third standardized location variable (353.6), corresponding to 'Orleans.' This indicator was chosen as this variable represents 47.8% of the sample, and the next most common location represented 8.4% of the sample. Therefore, the index level during year *t* is as follows:

$$IndexLevel_{Hall,t} = Time_t + 110.5 + 17.4 * 22.8 - 0.3 * 519.8 + 353.6 = Time_t + 684.77.$$

In this way, the index level represents the estimate for each point in time *t*, for a male of the average age in the most common location.[6] All additional indicator variables are set to zero. Finally, human capital price appreciation from the Hall sample may be calculated from the index levels above, with 20 annual return observations from 1801 through 1820.

II. B. The Fogel and Engerman Data

[6] The HC index represents a 'typical' individual so it includes age, gender, and location, as each individual should have values for these attributes. Age is set equal to the sample average, and location and gender to the most common value (male and 'Orleans'). For the remaining variables that were not included in the HC index, 0 would represent the typical or default condition. For example, the expert variable takes the value of 1 for approximately 2% of the sample (meaning these individuals were identified as experts in their particular craft) and takes the value of 0 for 98% of the sample (the other variables are comparable in terms of the percentages).

The Fogel and Engerman (1974) data (hereafter FE) contains 5,007 observations from 1804 through 1862. These data are more limited in terms of variables and observations. We eliminate all observations with missing price data. Further, we eliminate 1861 and 1862 due to limited observations (11 and 6, respectively). This leaves 2,704 useable observations from 1804 through 1860. Using a similar approach as above, we estimate the following model with this data set:

$$Price = 103.1Male + 2.7Age - 0.1Age^2 + 104.7Terms - 158.8Guarantee + \sum \beta_t Time_t + e_{i,t},$$

in which variables are as previously defined. *Terms* is an indicator taking the value of one if the sale involves credit terms, and *Guarantee* is an indicator taking the value of one if there was no 'guarantee' associated with the sale. The regression R-square is 43.6%. With the FE data, we use 'male' and an age of 23.7, which is equal to the sample average to define the human capital index. Therefore, the index level at time *t* is equal to:

$$IndexLevel_{FE,t} = Time_t + 103.1 + 2.7 * 23.7 - 0.1 * 561.7 = Time_t + 110.9.$$

Given the FE human capital index, we calculate the human capital price appreciation from year to year.

II. C. Measures of output value

The total return to human capital during any given year would include any price appreciation or depreciation, as well as a measure of the value of output from the individual (cf., Calomiris and Pritchett 2016). To estimate a time series of output value per individual, we utilize existing labor force and farm product data provided by the *Historical Statistics of the United States* (2006) as well as other sources. First, we use the Weiss data on the farm labor force by decade (Series Ba830). We assume a constant rate of growth within each decade and use these values as an estimate of the number of individuals involved within agriculture each year within our sample. Second, we use the sum of sales and consumption of farm products (Series Da 1278) as a measure of value created. This data is also available once per decade. Changes in the output value could be driven by both changes in productivity as well as changes in prices. To extrapolate the series to a yearly basis, we first deflate the output value that is available each decade by the USA Cole and Smith Agricultural Price index series available from GFD and calculate the annual growth rate across each decade.[7] We use a constant annual growth each decade to extrapolate the deflated values. Since the values are deflated by the agricultural price index, the calculated growth rates and resultant values are based only on changes in productivity and are independent from changing prices. We then multiply the annual values by the agricultural price index to obtain an estimate of the annual series of farm product output value within each year. These values are based on constant productivity growth within each decade, as well as annual price changes. Finally, for each year within the sample, we divide the estimate of output value by the number within the labor force to create an estimate of value produced per individual. Although the data is limited during this period, we are able to provide at least one comparable measure to validate our estimates. In particular, Mancall et al (2002) present an estimate of the value of agricultural production per worker in the lower south. They present estimates every decade from 1720 to 1800 expressed in 1840 dollars, with their estimate being equal to 125.83 in 1800. After adjusting to current dollars, their 1800 estimate becomes 182.68. This value is quite close to our estimate of 172.68 for the same year. As such, we consider the Mancall et al estimate to provide validation for our output measure, as these estimates were derived from different sources. To further validate our measure of output, we consider the output data in the context of available wage data. In particular, the *Historical Statistics of the United States* (2006) provides data on average monthly earnings with board for farm laborers beginning in 1818 (series D705). However, between 1818 and 1860, the data include only five observations. For each available labor rate observation, we calculate the percent change in the labor rate as well as the percent

[7] The agricultural price index is not available for the years 1821-1824. However, there is data for the USA producer's price index. We regress percent changes of the agricultural index on percent changes in the total price index for the years within our sample (R-square = 79.6%) and use the fitted values of the percent changes in the agricultural index for the four missing years.

change in our output measure. The correlation between these two rates of change is 0.96 (p-value < 0.05). This provides further validation of the output measure.

Relative to the value produced per individual, we deduct estimates of sustenance expenses. Conrad and Meyer (1958) provide an estimate of annual expenditures based on 1840-1860 data. Their estimates include a range of $25.00-$40.00, $1.50-$2.00, $0.39-$1.20 and $5.00-$15.00 for out-of-pocket food and clothing, medical care, taxes, and supervision, respectively. We take the middle value of each range and sum these estimates. We use this estimate for costs in 1850, and then adjust this throughout the sample based on the US rate of inflation. Our final measure of output is consequently the measure of value created described above, less this measure of sustenance expenses.

We initially present levels of the human capital indexes along with the estimated values of output in Figure 1. The figure details that, during the sample in which both Hall and FE data are available, these indexes appear very similar. For example, both indexes show sharp increases after 1815, followed by comparable decreases subsequently. Finally, estimates of output value seem to be reflected in human capital values. Periods of high human capital index levels frequently correspond to periods with high estimated values of output.

Insert Figure 1 about here

Table I presents summary statistics for human capital returns, using both the Hall and FE indexes. For both the Hall and FE indexes, the 'price' subscript denotes the return to the index level only, excluding output, and the 'output' subscript indicates the return includes both the index and the measure of output included in the human capital return. We retain both measures of human capital throughout. The 'price' series are based fully on observable market prices and not subject to our estimated output values. These series likely document the lower bound for human capital returns as well as the year-to-year volatility. The 'output' series include any change in human capital price as well as the estimated output value. These estimates are our fullest measure of human capital but are subject to the output specification and estimation. From the summary statistics, we note that human capital returns are quite volatile. Based on price appreciation alone, the mean returns are 1.507% and 1.348% for the Hall and FE indexes respectively, with standard deviations of 12.461% and 12.180%. Further, the output values have substantial impact on the annual return, with estimates of annual return equal to 15.981% and 17.913%, as well as comparable volatility, for the Hall and FE indexes.

Insert Table I about here

We next consider human capital and wages. Although wage data from this period is limited, we obtain daily common labor wage rates, *Wage Rate*, from the *Historical Statistics of the United States* (series Ba4253) which begins in 1825, as well as the index of money wages for unskilled labor, *Unskilled Rate*, (Series Ba4218). Within Table II we report summary statistics, correlations, and regression results for the percent annual change in this wage rates, as well as the Human Capital FE price index. We exclude the Hall index from this analysis as these data end in 1820.

***Insert Table II about here ***

Within Table II, Panel A presents the mean, median, and standard deviation of *Wage Rate* and *Unskilled Rate* as well as the correlations of the wage series with the human capital index. We note that the mean of the human capital return, 2.4% is comparable to the means of 1.3% and 1.7% for the wage rates. We also note that both series are positively and significantly correlated, with correlations of 0.39 and 0.46. Within Panel B, we note both regression coefficients are positive and significant. The R-squared values range from 0.154 to 0.216. For example, considering *Wage Rate*, a one standard deviation increase in the wage rate would be associated with a 490 basis point increase in human capital returns. The dynamics of wage rates with respect to human capital valuation has implications for the labor-based approach to human capital measurement.

Given the measures of human capital values and output, the analysis allows us to consider output yields in the context of human capital, and we present these results within Table III. This analysis is comparable to consideration of dividend yields in the context of dividend payout and equity prices. The estimated output yields are calculated by dividing our output value estimates described above by the level of each human capital index at each point in time. This analysis will detail the relation between human capital and output with observable human capital values. Further, assuming stability within the human capital output yield, the output yield values may be combined with current levels of income to estimate current values of human capital. In other words, this analysis details the percentage of total human capital value that is realized as income during the current year. First, Table III presents summary statistics for the human capital output yield. We note that estimates of output yield are comparable across the two human capital indexes. For example, the average and standard deviation of the output yield is 15.654% and 4.445% for the Hall index, respectively. These values compare to 18.097% and 4.436% for the FE index. The 25th and 75th percentiles are 13.455% and 17.488%, and 15.683% and 19.556%, for the Hall and FE indexes, respectively.

Insert Table III about here

Golez and Koudijs (2018) provide an extensive study of dividend yields from 1629 through 2015 based on data from the Netherlands, the UK, and the US. They find dividend yields are stationary and consider the predictive content with respect to future returns and to dividend growth. Within Table III, we consider within-sample dynamics of the human capital output yields in the context of the comparable dynamics of the dividend yield within this same period.[8] Specifically, for each variable (dividend yield or output yield for the Hall or FE sample periods), we regress the variable on a simple time trend and report the coefficient estimate (and associated p-value) as well as the R-square from the time trend regression. We subsequently report results from the Augmented Dickey-Fuller (ADF) test. Considering the Hall sample period, the time trend is negative and insignificant (significant) for the output yield (dividend yield), but the ADF fails to reject the null for both series. For the output and dividend yields measured during the FE sample, both time trends are insignificant, and we are able to reject the null with the ADF for both series. Taken in total, the results indicate that the inferences for our output yield

[8] We thank the authors for providing their dividend yield data.

variables are quite similar to the results based on the dividend yields during the same sample period. This provides important validation of our measure and indicates, at least with the lengthy FE sample period, we are able to demonstrate that the output yield is stationary.

Golez and Koudijs (2018) consider the predictive content of the dividend yield throughout their sample. We perform a comparable analysis within Panel C of Table III. In particular, we take lagged values of our output yield variables for the Hall and FE samples, OY_{Hall} and OY_{FE}, respectively, as well as lagged values of the Golez and Koudijs dividend yield, DY_{Hall} and DY_{FE}. The subscript on the dividend yield identifies the corresponding sample period, and all independent variables are standardized to mean zero and unit standard deviation to facilitate comparison within this analysis. We regress the GFD US total return equity index, *Equity*, as well as the human capital price return and total return indexes on the lagged independent variables. For each regression, the table reports the coefficient estimate, p-value based on Newey-West standard errors, and regression R-square. The results document that each asset ratio contains predictive information with respect to the asset's subsequent return. Within the first row of Panel C, we observe that the equity dividend yield positively relates to subsequent equity returns, with coefficients of 2.508 and 3.620 during the Hall and FE sample periods, respectively. The corresponding R-square values are 0.114 and 0.090. Interestingly, the Hall and FE output yields exhibit an insignificant and negative and significant relation, respectively, with respect to subsequent equity returns. However, the predictive regressions that relate the human capital yield to subsequent human capital returns document a positive relation. Considering the shorter Hall sample period (20 annual observations), the coefficient estimate with the human capital price index as the dependent variable is 4.445, but insignificant (p-value=0.155) and the coefficient estimate the total return Hall human capital index is 6.972 (p-value<0.05) and the R-square value is 29.5%. The comparable values for the FE index are 5.786 (p-value<0.01) and 7.849 (p-value<0.01) with R-square values of 22.6% and 37.5%. These results are the first to our knowledge to document a predictive component between human capital output yields and subsequent returns.

Within Section II, we develop two human capital series that include price changes in prices as well as estimated output. We validate the measure of output based on at least one comparable and available measure. We show that human capital correlates positively with available wage rate data and show that human capital output yields exhibit similar dynamics to available dividend yield data. Importantly, this section details the risk and return characteristics of human capital measured across a lengthy sample period and based on observable data. Further, this section documents a predictive component of human capital output yields relative to subsequent human capital returns.

III. HUMAN CAPITAL, MACRO VARIABLES, AND ASSET PRICING

Within this section we relate human capital returns to additional macro and financial variables during the observable human capital value period (1801-1860). Our emphasis is relating human capital to available financial return data to consider human capital within an asset pricing context.

III.A Additional variables

We initially consider human capital returns in the context of broadly defined available macro variables. We obtain our data for our sample period from *the Global Finance Data*. For financial assets, we include stocks and bonds where we collect data for the total return S&P 500 index, and the USA 10-year total return government bond index, denoted $Equity_t$ and $Bond_t$. We further use $Yield_t$ and Agr_t to represent percent changes in the CBOE 10-year government bond yield index, and the percent changes in the Cole-Smith agricultural price index. We include agricultural index because during the period the economy in the south was primarily agricultural based. The focus on the agricultural index would consider how human capital varied with the value of the output. $Price_{Prod,t}$ and $Price_{Cons,t}$ represent percent changes in the producer and consumer price indexes, respectively. Subscripts denote the time in terms of year *t* or *t*-1.[9,10] We also include the GFD UK equity index and the silver price index. We present summary statistics of these data, as well as correlations with the human capital indexes, within Table IV. For this

[9] We find a strong relation between the FE index and lagged variables. Therefore, we focus on these results generated from this index.

[10] Within the initial analysis, we are limited to the number of explanatory variables within the regression due to the number of annual observations. In subsequent analyses we extend the set of macro variables considered.

analysis, we match the additional macro variables to the sample for each human capital index, such that the summary statistics for these variables depend on the specific sample and human capital index in question.

Insert Table IV about here

Table IV details summary statistics for the variables. Human capital returns appear substantially more volatile, relative to the equity and bond market indexes. For example, the standard deviations of all possible human capital indexes exceed 12%. During the FE sample, the equity market standard deviation is comparable, with a value of 11.907%. However, during the Hall sample, the equity market volatility is 7.428%. For both samples, the volatility of the government bond total return index is approximately half the standard deviation of the human capital indexes. These results deepen our understanding of the dynamics of human capital returns relative to additional asset classes. Moreover, the autocorrelation of human capital returns estimated from both Hall and FE series is not significant; thus, the bias from high autocorrelation induced by infrequent trades and non-synchronous trading on variance and correlation is not a concern in our study (see Dimson, 1979; Dimson and Spaenjers, 2011).[11] Considering the correlations between our estimate of human capital and the additional macro variables, the Hall indexes (both price and output) are positively and significantly correlated with the stock and bond return indexes. Further, both Hall indexes are negatively correlated with the government bond yield index, as expected. The FE indexes detail a positive correlation with the US equity market index, the agricultural price index, and the producer price index.

To further analyze human capital returns in the context of macroeconomic variables, we present regressions with the measures of human capital within Table V. Within Table V, Panels A, B, C, and D present results in which the dependent variable is the Hall price, Hall output, FE price, and FE output human capital return. From Table V, we observe that the return to human capital is positively related to

[11] The autocorrelation of the returns from and is 0.093 and 0.15 and they are statistically insignificant.

the US stock market return. Considering the Hall price index presented within Panel A, the coefficient estimate on $Equity_t$ is positive and significant at the ten percent level or greater in seven of nine possible cases. The coefficient estimate on the market return is also positive and significant in multiple instances for the remaining human capital indexes as well. Further the regressions document that human capital is positively related to the bond return index in several cases, and as expected negatively related to the measure of bond yields. For the Hall index in particular, the R-square measure documents reasonable variation explained by the macro variables.

Insert Table V about here

III.B Human Capital and Optimal Allocation

The lack of market-based measure of human capital presents a significant impediment to asset pricing research. We now consider the market-derived measure of human capital and the subsequent inferences asset pricing analyses during 1801 -1860 when human capital price is observed. Within Table VI, we consider portfolio allocations and human capital. Later we consider human capital and the SDF as well as integration

We consider minimum variance portfolio and maximized Sharpe ratio allocations with and without human capital. For assets, we include the human capital indexes as well as the US equity return and the US treasury bond return in several analyses. We also expand to include the annual percent change in silver and the annual return to the UK equity index, with data from GFD.[12] We focus Table VI on the US variables for stocks and bonds that are available. We think it important since the US analysis only had three assets (stocks, bonds, and HC) to try to expand the opportunity set to include additional assets and it would be feasible to invest in the UK market as well as commodities. During the period, the US was on the gold standard such that the price of gold did not vary relative to the dollar; hence, we include silver as the next

[12] To conduct the optimization exercise we require a measure of the risk-free rate. GFD provides a central bank discount rate index measured in percent per year. We regress the central bank discount rate index on the Fama and French annual risk-free rate utilizing 84 annual observations from the 20th and 21st centuries in which both data are available. The model has an R-square of 90.63%. We utilize the predicted values of the risk-free rate based on the GFD data for our optimization exercise. All asset returns are measured net of this risk-free rate.

most prominent commodity (with a price that did vary). The purpose of including the additional assets (silver and UK equities) is to show that the impact of human capital on optimal weights is not just a diversification effect (adding one asset to an opportunity set of two others) but also the characteristics of human capital itself.

Within this exercise, we calculate the asset weights corresponding to the minimum variance portfolio across the different sets of assets in Panel A. The initial row presents results in which the weight on human capital is unconstrained. Within the remaining rows within each panel, we report results in which human capital is constrained to equal 0, 25%, 65%, or 88%. The case in which human capital is constrained to equal 0 will reveal the allocation results in the event the optimization exercise fails to include human capital..

Insert Table VI about here

The results within Table VI detail the importance of considering human capital and the impact on optimal allocations towards the remaining assets. For example, in Panel A for minimal variance portfolios, with short sales excluded and considering human capital, US stocks, and US Treasury bonds, the optimal allocation towards human capital would be 0 due to the high volatility. However, if human capital is constrained to equal 25% of total wealth, then the optimal allocation towards equities decreases from 26.3% to 13.4%. In Panel B, for maximized Sharpe ratio portfolios, with short sales excluded, the allocation to human capital is 100% for Hall human capital index and marginally below 100% for FE index. When short sales are allowed, human capital measured by Hall index contributes to 78.2% of the portfolios while stocks and bonds contribute to 14% and 68%, respectively. Silver and UK stocks are short sold with the proportion of -30% each. In contrast, for FE index, human capital contributes to 118% while silver and UK stocks are short sold at -30% each. Stocks are also short at -24% while bond is made of 66% of the portfolio. Taken together, human capital is associated with high risk and high returns. Including human capital in the optimization may have substantial impacts on the remaining allocations.

III.C Human Capital and the SDF

Modern finance theory stipulates that asset prices are determined by their covariances with the stochastic discount factor (SDF), which is usually linked to the marginal value of aggregate wealth. The SDF paradigm should apply to any partition of the available assets. Within this section, we initially discuss the SDF estimator employed within this study. We then apply the SDF estimator to an extrapolated measure of human capital, and finally present the SDF estimator during the human capital sample period. In total, we extrapolate human capital values to the present day, in order to present the SDF estimator, and then subsequently consider the SDF estimator within the period in which human capital was measured.

Let $p_{i,t}$ denote the cash value of asset i at time t. When markets are complete, the SDF paradigm implies the existence of a unique m_t, the SDF, such that

$$E_{t-1}(\tilde{m}_t \tilde{p}_{i,t}) = p_{i,t-1} \qquad \forall i, t.[13] \tag{1}$$

Denoting a gross return between t-1 and t by $R_{i,t} \equiv p_{i,t}/p_{i,t-1}$, equation (1) is the same as

$$E_{t-1}(\tilde{m}_t \tilde{R}_{i,t}) = 1 \qquad \forall i, t.[14] \tag{2}$$

In the financial economics SDF literature where (2) was originally derived, the SDF is invariably considered a function of preferences and consumption, often as held by a representative investor. In contrast Pukthuanthong and Roll (2020) (hereafter PR) propose an "agnostic" SDF estimator that depends only on observed returns.[15] We adopt their approach in the following.

$$\mathbf{m}/T \cong (\mathbf{RR'})^{-1}\mathbf{R1}. \tag{3}$$

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[13] For a representative agent, m is the discounted future marginal utility of consumption divided by the current marginal utility of consumption. The tilde denotes a random variable as of period t-1.

[14] Equation (2) is the only moment condition required by SDF theory. However, the basic SDF relation applies similarly to multiple periods; e.g., $E_t(\tilde{m}_{t+\tau} \tilde{R}_{i,t+\tau}) = 1$ for $\tau>1$ where the gross return and m span τ periods. This could provide some interesting features involving a term structure of SDFs but we do not explore that possibility in this paper.

[15] For reference, the working paper is available at the following:
https://www.dropbox.com/s/r4vvieuvracfpf1/agnostic%20estimator%20of%20the%20sdf_020221.pdf?dl=0

where a sample of N assets with simultaneous observations over T periods, with N > T. The ensemble of gross returns for the N assets can be expressed as a matrix **R** (hereafter boldface denotes a matrix or vector). There are N columns in **R** and the i^{th} column is $[R_{i,1}:\ldots:R_{i,T}]'$. We also need a column vector $\mathbf{m} \equiv [m_1:\ldots:m_T]'$ to hold T realized values of the SDF and a N-element column unit vector $\mathbf{1} \equiv [1:\ldots:1]'$.

Table VII reports results from the SDF analysis described above during the time period when human capital index is observed, which is from 1801 to 1860. We utilize the Hall and FE data to create an overall index for this period. We collect the price of all assets that were traded in the U.S. and that have the price index available during that time period from the *Global Financial Data*. The asset is listed in Panel A. There are 76 assets in total that have the data available and our sample period is 60 years. We realize these tests probably lack power because N-T, the degrees-of-freedom, is quite small. Nonetheless, we believe they are worth reporting while recognizing their likely limitations. It is impossible to perform our test within each asset class due to limited number of assets available during that time. In detail, there are 41 agricultural commodities including bacon, beef, cocoa, cotton, coffee, oat, sugar, tobacco, white oak, and etc, and 16 energy and material commodities including coal, copper, crude whale oil, iron bars, nails, silver, tin, etc. Bond series include municipal bond, T-bill, 10-year, 20-year government bond index, and etc while currencies include Canadian dollar, Hamburg Mark Banco, French Franc, Great British Pound, Jamaica dollar, Netherland Guilders, and Portugal Escudo per US dollar. There are three stock price series available. In aggregate, this meets the requirement of the agnostic SDF estimator of number of assets greater that the number of periods (N>T).

Insert Table VII about here

Panel A shows the slope from regressing the SDF constructed from all assets on that from all assets and human capital is about 6.05 and it is significantly different from zero, suggesting the SDFs generated with and without human capital are not disintegrated. If beta is close to one, the two SDFs are highly integrated. If beta is significantly apart from 1, the markets are disintegrated. We thus perform Wald test and find our slope is significantly different from one, which implies

Panel C presents the SDF derived from all assets is not significantly different from the SDF derived from all assets plus human capital in mean and median but it is different in its variance and composition. Thus, the evidence reveals human capital changes the combined (all-asset) SDF 1801-1860, but does not change it during 2002 to 2013. Panel D also shows SDFs from human capital plus other assets may not be significantly positive whereas that of other assets is weakly weakly positive, which implies human capital allows for the existence of arbitrage in 1800s. Thus, Panels B and C suggest that the SDF for human capital seems to be distinct from that of other assets.

The SDF of human capital seems to be unique during 1801-1860 but indistinguishable from that of other asset classes after 2000, supporting the evidence of an increasing trend in global market integration. This pattern cannot be proven absolutely true, of course, but it is not rejected by our tests after properly accounting for sampling variation. There are some caveats we should take into consideration. First, our human capital index is only a single index; thus, the test involved is unlikely to be very powerful. Second, our tests here are conducted with U.S. data spanning a single recent decade, and over 60 years from 1801 to 1860. More comprehensive tests with longer samples should be on the agenda for future research. Third, Pukthuanthong and Roll (2020) show the agnostic SDF estimator will be estimated more precisely if N is much greater than T, for instance N>2T. Future research can improve the analysis upon this direction.

III.D. Asset Integration

In the previous subsection, the agnostic PR SDF estimator requires the number of assets be greater than number of time periods. In addition, the number of available assets during the period when our human capital index is available is limited; thus, we cannot thoroughly examine the integration of human capital with individual asset classes. In this section, we follow Pukthuanthong and Roll (2009, henceforth PR09)'s approach and measure market integration from the R^2 of the regression of asset returns on global factors.

The assets that have a complete price index data during the time when human capital is available from 1801 to 1860 include 9 series of bonds, 3 equities, 7 pairs of currencies, 42 agricultural products, and 15 energy and materials. These 76 assets have the data from 1860 and every year thereafter, thus they present the largest assets that span the whole market when slave was traded. We use these 76 assets and only these 76 in estimating the global factors.

In principle, PR09's measure of market integration is based on the proportion of asset returns that can be explained by an identical set of global factors. The level of integration is indicated by the degree of R^2. The higher the R^2, the higher the integration. Two assets are viewed as perfectly integrated if the same global factors fully explain asset returns in both markets. In that case the R^2 would be 1.0, thereby suggesting no diversification benefit potential between two assets. Table VIII Panel A presents the market integration of each asset. We construct PCs from other assets besides the asset we want to measure integration and retain only the PCs that account for close to 90% of the cumulative eigenvalues (or, intuitively, 90% of the total volatility in the covariance matrix). For instance, to measure market integration of human capital, we construct PCs of other 75 assets besides human capital and retain only the PCs that explain 90% of total volatility. In all cases, there are 27 PCs retained out of 76 PCs. Interestingly, all assets have high market integration ranging from 28% to 80%. Figure 2 presents market integration of specific asset. Human capital is least integrated. Netherlands Guilder, long-term bond, sugar, cotton, silver and copper are highly interested with other assets. In groups, the most highly integrated asset is stocks, followed by bonds, energy and material commodities, currency, agricultural commodities, and human capital. Our result in this section supports the evidence shown in Table VIII human capital changes the variance and elements of other assets' SDF.

Insert Figure 2 about here

Insert Table VIII about here

The apparent lack of full integration of human capital implies that it offers substantial diversification benefits. Evidently, at least according to our findings, the same SDF satisfies the basic SDF equations, (1) or (2) above, for all of the assets we consider in 2001-2012 except for human capital during 1801-1860.

Panel B measures the market integration of human capital with each asset class. Human capital is the most integrated with agricultural commodities with R^2 of 19%. This might be because most of the assets traded at that time were agriculture products that required labor. Hence, diversification potential was lower when combining human capital and agricultural products as compared with either one combined with other assets such as equities and bonds. Human capital is integrated moderately with energy and material commodities (R^2 of 8.5%) followed by currencies (6.7%), stocks (2%), and bonds (1%).

IV. EXTRAPOLATED HUMAN CAPITAL

Based on the historical data, we extrapolate human capital values to the present day. We accomplish this utilizing the observed relation between human capital and output value. If the human capital discount rate and growth rate in income exhibits stability through time, the ratio of output value to human capital value may also exhibit stability. To explain this approach, the previous analysis contained within Table III details properties of the human capital output yield, defined as the estimated value of an individual's output from labor within a given year divided by the total value of the individual's human capital within the year. This output yield can be combined with current measures of income to estimate current human capital values. First, the measure of output should include disposable income less required sustenance expenditures. From the US Bureau of Labor Statistics (BLS) Consumer Expenditure Survey, we have income after taxes and net out food at home, housing, utilities, housekeeping supplies, apparel, transportation, and health care expenditures as the measure of output from 1984 through 2015. For example, considering 2011, we have income after taxes of $61,673. Subtracting the expenditures mentioned above leads to a value of $23,344 as our estimate of average output value during this year. From Table III, the mean output yield was 15.7% and 18.1% from the Hall and FE samples, respectively. Dividing the current levels of output value by the average output yield from the human capital sample allows us to extrapolate the relation between output and observed human capital values into the current period. For example, using the output value from 2011 leads to an estimate of average human capital value for 2011 equal to $148,688 and $128,972 based on the Hall and FE values, respectively. Alternatively, to consider a range of potential output yield values, based on the 25th and 75th percentiles from the Hall and FE samples output yield values leads to a range of estimates between $133,486 to $173,497 and $119,370 to $148,849, respectively. These values allow us to present a range of plausible human capital valuation during the current period based on current income and expenditures, and the relation between output value and human capital value during the period in which human capital was observable. These measures of human capital allow us to consider human capital in the context of an investor's portfolio. For example, from the 2011 US Census Bureau wealth tables, the median net worth, and median net worth excluding home equity values are $68,828 and $16,942, respectively. Based on these values and the extrapolated measures of human capital discussed above, human capital would constitute greater than 65% of all wealth, and greater than 88% of all wealth excluding home equity. These values further illustrate the importance of including human capital in the portfolio allocation problem, as well as deepen our understanding of the equity premium and investor behavior. To further detail the dynamics of human capital, we extrapolate and plot the estimated human capital value from 1984 through 2014 based on the available BLS data, and present these results within Figure 2.

Insert Figure 3 about here

In short, given the estimated relation between human capital values and annual output, we extrapolate this relation through the present day. We note substantial variation in extrapolated human capital values. In particular, the estimated human capital values decline sharply surrounding the global financial crisis. Using the average value of the output yield, the estimated average human capital valuation falls from a peak of approximately $140,000 to below $100,000, representing a decline of approximately 30%. Substantial literature discusses relative stability of earnings or dividend yields with respect to equities through time. Our measure, although speculative, relates to this literature. Under the assumption that the ratio of income less sustenance relative to total human capital value remains somewhat stable, our extrapolation exercise would detail the evolution of human capital during a lengthy recent sample period. All through speculative, we use the extrapolated measures of human capital returns to consider the SDF for human capital within the modern era.[16]

We estimate the PR SDF for each asset class with and without human capital and test whether human capital significantly changes the estimate. This analysis builds on the prior SDF analysis but utilizes the extrapolated human capital index. The PR SDF estimator requires more assets than time periods (N>T), so we start from 2002 because that is when we can get bond return data from TRACE and TRACE is the most common source researchers use for bond data. For a comparison, the data of other assets also start in 2002 and thus we end up with 225 bonds, 323 stocks, 47 commodities, 45 currencies, and 97 REITs representing real estate from 2002 to 2013; this sample satisfies the requirement that N exceeds T with a comfortable level of degrees of freedom.

For returns for corporate bonds, we use transaction records in the Trade Reporting and Compliance Engine (TRACE). TRACE provides high-quality corporate bond intraday information for trading price, trading volume, and sell and buy indicators etc. Our sample period is from August 2002 to June 2017. We follow Bai, Bali and Wen (2018)'s data screening procedure and return estimation approach. The monthly corporate bond returns are computed from the quoted price, accrued interest, and coupon payment for a month divided by the quoted price in the previous month. A bond's excess return is the difference its computed total return and the risk-free rate, where the latter is proxied by the one-month Treasury bill rate. Our final sample consists of 331,728 observations, and the cross-sectional mean monthly excess return is 0.389%, which is comparable to Bai, Bali and Wen (2018)'s sample. We include only bonds that have at least 30 continuous monthly returns;[17] 6421 bonds remain in our final sample.

[16] We focus this extrapolation exercise on the SDF and integration analysis within this section only. The extrapolation requires fitted values from the prior regressions. The benefit of the PR approach is the number of assets that can be considered, which allows us to include substantial variables that were not used in construction of the extrapolated series.

[17] The results are robust using different windows.

Our stock returns are from CRSP from 1962 to 2018. Similar to the standard procedure of screening stock returns in the existing literature, we collect monthly returns from the Center for Research in Security Prices (CRSP) and accounting information from the Compustat Annual and Quarterly Fundamental Files. We exclude financial firms and firms with negative book equity. We do not exclude stocks with prices per share lower than $1 or $5. That is, microcaps are included in our sample. Hou et al. (2019) do not exclude either, and they show most candidate factors are applied to microcaps. We apply the same screening criteria, and delisting returns similar to them, Commodities and currency index from Bloomberg and MSCI, and real estate price from REIT price index from Ziman REIT through CRSP database. We attempt to go back earlier during the time when slaves were traded; however, the data are so sparse especially for stocks and bonds that it is impossible for us to meet a requirement of N>T.[18] Our hypothesis is whether human capital is integrated with other asset classes. In other words, we test whether the SDF of each asset class is different from the SDF of each asset class combined with human capital. Table IX reports the results.

Insert Table IX about here

Panel A presents the sample descriptive statistics of the assets we use to construct SDFs. We have 323, 97, 225, 47 and 45 stocks, real estate, bonds, commodities and currencies. The number of these assets is much higher than T, which is 12 years. Clearly, during 2002 to 2013, stocks have highest returns of 12.8% followed by commodities, bonds, real estate and currency. The last has negative returns. Real estate has the highest standard deviation, followed by stocks, commodities, bonds and currency. To examine possible violations indications of market non-integration, we use two sets of tests. First, we regress the SDF constructed from asset returns on the SDF constructed from asset returns and human capital. Pukthuanthong, Roll and Wang (2020) suggest this is the appropriate way to test market integration as it can avoid bias associated with the mean and variance of the agnostic SDF estimator. If the slope is not

[18] We attempt to collect the stock and bond data from the International Center for Finance at Yale University, but the data is incomplete and does not meet a requirement of N>T.

significantly different from zero, it implies the SDFs of assets with and without human capital are disintegrated. If it is significantly different from zero, we cannot reject both SDFs constructed from both asset are not disintegrated. Interestingly, Table IX Panel B shows the slope of the regressions are very close to one across assets and extrapolation approaches. Except for the SDF of currencies and human capital estimated by the constant output yield approach, all of the adjust R^2 is 99% or more. We apply Wald test suggesting all estimated coefficients are most significantly different from one. Thus, across both extrapolating approaches, human capital does not make any difference in the SDF estimated from assets.

The next set of test is to examine the equality of the SDF distribution. The tests are the Kruskal/Wallis (1952) (KW) non-parametric one-way analysis of variance based on ranks, which rejects a false null hypothesis if one or more sample SDFs is stochastically dominant or has an abnormal median, the Welch (1951) (WE) test for equal means, which allows for unequal variances, the Brown/Forsythe (1974) (BF) test for unequal variances, and the Chi-Square tests that estimated SDF vectors are the same element by element. The relevant test depends on the nature of the difference among SDFs. For example, if the medians differ but the means and variances are about the same, the KW test should reject the null but the WE and BF test might not. Similarly, if the SDF distributions have similar location on the real line but have disparate volatilities, the BF test should reject but the other tests would not. If the SDF estimates have the same location and volatility but different time patterns, the Chi-Square test should work well. If one or more asset groups is characterized by departure of the basic SDF expectation (1) from unity, all four tests could conceivably detect it.

The Kruskal/Wallis (1952) (hereafter KW) test indicates whether one set of SDF estimates stochastically dominates any other and it also provides a test of the difference in medians. There are ten series of SDFs, five of which are for each asset class with human capital (there are five asset classes), and the other five, one of which for each asset class without human capital. Each pair of SDFs (one asset class with and without human capital) implies that the KW Chi-Square variate under the null hypothesis (H_0: no SDF dominates another) has one degrees-of-freedom. According to the KW test results reported in

Table VII Panel C, there is no stochastic dominance between human capital and other asset classes. The sample medians are not significantly different from one another. Hence, this test rejects the SDF uniqueness of human capital. Table VII also reports tests for the equality of means and variances across each pair of SDF estimates for five pairs, the Welch (1951) (WE) test for means and the Brown/Forsythe (1974) (BF) test for variances. In agreement with the non-parametric KW test, the WE test finds no evidence of a difference in means for the SDFs estimated independently from the five asset classes with and without human capital. None of the p-values indicates significance. The WE test allows for unequal volatilities across asset classes, thus we implement the BF test for differences in variances. The BF test suggest we cannot reject the null of equal variance. The Chi-Square test no longer detects significant differences in the SDF vector elements and thus essentially agrees with the BF test in that its p-value is insignificant among testing asset pairs. Evidently, the sample SDF of each asset with and without human capital appears to be located with their means, medians, and variance close to one another.[19] This is apparently supported by insignificant differences in the elements of some estimated SDF vectors.

Similarly, the SDF is indifferent in mean, median and variance when human capital is constructed by constant output yield approach. However, similar to the SDF from regression approach, the Chi-Square test no longer detects significant differences in the SDF vector elements and is consistent with other approaches in that its p-value is insignificant among testing asset pairs. From the regression and constant output yield approaches, the SDFs with and without human capital are not disintegrated.

In the last three rows of Panel C, we test whether all asset classes with human capital are unique. The results reveal there is strong evidence against the difference in the mean and median of the SDFs except for their variance. Evidently, although the sample SDFs appear to be located with their means and medians close to one another, at least one asset class has sample SDFs with significantly larger or smaller variance than the others. This is apparently sufficient to induce significant differences in the elements of some estimated SDF vectors. In order to ascertain which asset class (or classes) is responsible, Panel D

[19] The Welch test for equal means is valid even when variances are unequal.

reports the time series standard deviations of the sample SDFs for each asset. The standard deviation of commodities SDF is about two times as large as that of bond, and real estate, and almost three times as large as that of stocks. In aggregate, human capital does not change the results that all asset classes share the same SDF. The same panel also tests whether SDF of each asset class with and without human capital is significantly positive. If it is positive, it implies law of one price holds and thus there is no arbitrage opportunity. The results supports those in Panel A in that human capital does not change the SDF of each asset class. It also shows the SDF of all asset classes is strictly positive during our sample period of 2002 to 2013, thereby suggesting the absence of arbitrage in these asset classes.

VI. CONCLUSIONS

The empirical study of human capital is hampered by the lack of direct market-based valuations. Economists have resorted to two knowingly imperfect proxies, measuring human capital either by historical costs or by discounted expected labor income. We present another alternative: direct measurement of human capital values using slave auction prices from the ante-bellum South.

We develop a human capital index and relate its dynamics to that of other financial assets. We find that human capital returns are indeed strongly related to the returns on broad economic indicators. We present extensive results considering human capital and asset pricing. Human capital alters the optimal allocation to equities and bonds. Human capital seems not to be integrated with other markets during the time when human capital was traded in 1801-1860 as we find human capital changes the variance and elements the SDF derived from other assets. Human capital, on the other hand, seems to be integrated with other markets in the modern era .

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Table I. Human Capital Returns

The table reports summary statistics for human capital returns. For a given human capital index, $HC_{i,j}$, subscript i denotes the index formed from either the Hall or FE datasets, and the subscript j denotes the specific series. The subscript '*Price*' denotes the return is calculated based on capital appreciation only, and no additional measure of output is included. The '*Output*' subscript indicates the output measure is included in the return, and this measure is descripted in the text. The Hall sample contains returns for the years 1801 through 1820, while the FE sample contains returns for the years 1805 through 1860. Returns are reported in percent form.

	Mean	*Median*	*St Dev*	*Skew*
$HC_{Hall,Price}$	1.507	-1.826	12.461	1.676
$HC_{Hall,Output}$	15.981	12.952	12.532	1.074
$HC_{FE,Price}$	1.348	1.557	12.180	-0.530
$HC_{FE,Output}$	17.913	20.104	12.817	-0.468

Table II. Human Capital and Wage rates

The table reports summary statistics and regression results the FE human capital price index on *Wage Rate* and *Unskilled Rate*. *Wage Rate* is the daily common labor wage rate (series Ba4253) and *Unskilled Rate* is the index of money wages for unskilled labor (series Ba4218), both from the *Historical Statistics of the United States*. ϱ is a correlation between $HC_{FE,Price}$ and interested variable. $HC_{FE,Price}$ contains returns computed from the FE human capital index for the years 1805 through 1860. ***, **, and * present 1%, 5% and 10%, significance levels respectively.

	Mean(%)	*Median(%)*	*St Dev(%)*	ρ with $HC_{FE,Price}$
$HC_{FE,Price}$	2.367	2.212	12.572	-
Wage Rate	1.293	1.042	6.834	0.392**
				(0.020)
Unskilled Rate	1.664	1.235	11.268	0.464***
				(0.005)
		α	β	R^2
Wage Rate		1.435	0.721**	0.154
		(0.483)	(0.020)	
Unskilled Rate		1.505	0.518***	0.216
		(0.442)	(0.005)	

Table III. Human Capital Output Yield

The table reports summary statistics and regression results for human capital output yields and dividend yields. The output yield, OY_i is calculated as the measure of output divided by the level of the given human capital index, *i*. DY_i represents the dividend yield from Golez and Koudijs (2017) corresponding to either the Hall or FE sample periods. The sample period for $OY_{Hall,Output}$ and $OY_{FE,Output}$ is from 1801 to 1820 and 1805 to 1860, respectively. Panel A presents the summary statistics. Panel B presents the coefficient estimate (associated p-value) and R-square from a regression of the given variable on a linear time trend. The final row in Panel B presents results from the Augmented Dickey Fuller test under the specification of single mean or time trend depending on the results from the time trend regression and the results based on an AR(2) specification. Panel C presents coefficient estimates, associated p-values based on Newey-West standard errors, and R-square values of a predictive regression. The dependent variable is identified in the initial column and the independent value is the lagged value of the variable identified with the column heading.

	OY_{Hall}	DY_{Hall}	OY_{FE}	DY_{FE}
	Panel A: Summary Statistics			
Mean	15.654	4.365	18.097	4.247
StDev	4.445	0.759	4.436	0.771
P25	13.455	3.878	15.683	3.639
P75	17.488	4.757	19.556	4.648
N	21	21	57	57
	Panel B: Trend regression and ADF			
Trend	-0.036	-0.069	0.024	0.003
	(0.827)	(0.008)	(0.514)	(0.639)
	0.003	0.318	0.008	0.004
ADF	-2.23	-2.59	-3.19	-4.38
	(0.202)	(0.289)	(0.026)	(0.001)
	Panel C: Predictive Regressions			
Equity	-1.524	2.508	-4.315	3.620
	(0.334)	(0.009)	(0.003)	(0.001)
	0.042	0.114	0.128	0.090
$HC_{i,Price}$	4.445	2.175	5.786	-1.011
	(0.155)	(0.291)	(0.002)	(0.478)
	0.122	0.029	0.226	0.007
$HC_{i,Output}$	6.972	2.614	7.849	-0.668
	(0.026)	(0.304)	(0.000)	(0.664)
	0.295	0.042	0.375	0.003

Table IV. Macro Variable Summary Statistics

The Hall and FE human capital returns are calculated using the primary measure of output value described in the text. $HC_{i,j}$, subscript *i* denotes the index formed from either the Hall or FE datasets, and the subscript *j* denotes the specific series. The subscript '*Price*' denotes the return is calculated based on capital appreciation only, and no additional measure of output is included. The '*Output*' subscript indicates the output measure is included in the return, and this measure is described in the text. Variables $Equity$ and $Bond$ represent returns to the GFD US total stock return and US 10-year government bond total return indexes, respectively, and *UK Equity* represents the return to the GFD UK equity index. $Yield$ and Agr represent percent changes in the CBOE 10-year government bond yield index, and the percent changes in the CS agricultural price index. *Silver* represent ths GFD index. Finally, $Price_{Prod,t}$ and $Price_{Cons,t}$ represent percent changes in the producer and consumer price indexes, respectively. The sample period is from 1801 to 1860. Subscripts denote the time in terms of year *t* or *t*-1. Entries under the $\rho_{HC,Price}$ and $\rho_{HC,Output}$ headings present the correlation (and associated p-value) between the given macro variable and the price or output human capital index, respectively. Panels A and B present the results for the Hall index, and the FE index, respectively. ***, **, and * present 1%, 5%, and 10% significance level.

	Mean(%)	*St Dev(%)*	$\rho_{HC,Price}$	$\rho_{HC,Output}$
$HC_{Hall,Price}$	1.700	12.753	-	-
$HC_{Hall,Output}$	16.151	12.833	-	-
$Equity_t$	6.853	7.428	0.623***	0.502**
			(0.003)	(0.024)
$UK\ Equity_t$	0.057	11.573	0.413	0.383
			(0.070)	(0.096)
$Bond_t$	7.111	5.890	0.606***	0.489**
			(0.005)	(0.029)
$Yield_t$	-0.975	7.913	-0.550**	-0.421*
			(0.012)	(0.065)
Agr_t	-1.633	12.8101	-0.079	0.117
			(0.742)	(0.623)
$Price_{Prod,t}$	-1.463	11.877	-0.098	0.089
			(0.683)	(0.709)
$Price_{Cons,t}$	-0.344	8.268	-0.135	0.008
			(0.570)	(0.973)
$Silver$	-0.278	6.191	0.251	0.243
			(0.286)	(0.303)

$HC_{FE,Price}$	1.348	12.180	-	-
$HC_{FE,Output}$	17.913	12.817	-	-
$Equity_{t-1}$	5.396	11.907	0.317**	0.257*
			(0.018)	(0.056)
$UK\ Equity_t$	0.017	13.679	0.064	0.026
			(0.642)	(0.849)
$Bond_{t-1}$	5.328	6.131	0.140	0.120
			(0.303)	(0.378)
$Yield_{t-1}$	-0.206	6.174	-0.249*	-0.178
			(0.064)	(0.190)
Agr_{t-1}	-0.234	13.105	0.361***	0.436***
			(0.006)	(0.001)
$Price_{Prod,t-1}$	-0.485	9.350	0.247*	0.361***
			(0.066)	(0.006)

$Price_{Cons,t-1}$	0.008	7.331	0.009 (0.949)	0.134 (0.325)
$Silver$	-0.026	3.707	-0.152 (0.265)	-0.073 (0.592)

Table V. Macroeconomic Regressions

The Table presents regression results from the human capital measures regressed on macroeconomic variables. The macroeconomic variables are as described in Table IV. The sample period is from 1801 to 1860. Panels A, B, C, and D present results with the human capital Hall price index, Hall output index, FE price index, and FE output index, respectively. Entries within the table represent coefficient estimates, and associated p-values. All variables are standardized. ***, **, and * are significance at 1%, 5% and 10% level, respectively.

					Dependent variable: $HC_{Hall,Price}$					
mkt_t	0.420*	0.480		0.622***	0.621***	0.693***	0.265	0.379*	0.409*	0.494**
	(0.056)	(0.106)		(0.004)	(0.005)	(0.004)	(0.369)	(0.099)	(0.068)	(0.036)
$Bond_t$	0.382*		0.463**				0.386*	0.463*	0.432*	0.404*
	(0.078)		(0.025)				(0.080)	(0.073)	(0.071)	(0.066)
$Yield_t$		-0.191	-0.372*				-0.204			
		(0.506)	(0.065)				(0.449)			
Agr_t				-0.066				0.134		
				(0.732)				(0.522)		
$Price_{Prod,t}$					-0.015				0.117	
					(0.938)				(0.546)	
$Price_{Cons,t}$						0.163				0.201
						(0.441)				(0.311)
F-stat	8.27***	5.78**	8.01***	5.50**	5.40**	5.91**	5.58***	5.47***	5.44***	5.91***
	(0.003)	(0.012)	(0.004)	(0.014)	(0.015)	(0.011)	(0.008)	(0.009)	(0.009)	(0.007)
R^2	0.493	0.405	0.485	0.393	0.389	0.410	0.511	0.506	0.505	0.526
	Dependent variable: $HC_{Hall,Output}$									
mkt_t	0.337	0.424		0.504**	0.523**	0.620**	0.251	0.231	0.311	0.451*
	(0.172)	(0.195)		(0.026)	(0.022)	(0.013)	(0.467)	(0.342)	(0.198)	(0.082)
$Bond_t$	0.309		0.384*				0.312	0.521*	0.432*	0.342
	(0.208)		(0.098)				(0.217)	(0.065)	(0.099)	(0.158)
$Yield_t$		-0.104	-0.273				-0.114			
		(0.745)	(0.229)				(0.717)			
Agr_t				0.127				0.352		
				(0.547)				(0.134)		
$Price_{Prod,t}$					0.158				0.291	
					(0.457)				(0.187)	
$Price_{Cons,t}$						0.275				0.307

						(0.234)				(0.175)
F-stat	4.01**	2.93*	3.69**	3.11*	3.25*	3.88**	2.58*	3.74**	3.45**	3.50**
	(0.038)	(0.080)	(0.047)	(0.070)	(0.064)	(0.041)	(0.090)	(0.033)	(0.042)	(0.040)
R^2	0.320	0.257	0.303	0.268	0.277	0.313	0.326	0.412	0.393	0.396
	Dependent variable: $HC_{FE,Price}$									
mkt_{t-1}	0.315**	0.260*		0.240*	0.277**	0.341**	0.266*	0.206	0.248	0.332**
	(0.034)	(0.066)		(0.067)	(0.039)	(0.014)	(0.084)	(0.163)	(0.104)	(0.028)
$Bond_{t-1}$	0.004		0.082				-0.014	0.071	0.061	0.024
	(0.979)		(0.552)				(0.921)	(0.620)	(0.683)	(0.871)
$Yield_{t-1}$		-0.154	-0.228				-0.156			
		(0.272)	(0.102)				(0.274)			
Agr_{t-1}				0.300**				0.314**		
				(0.023)				(0.021)		
$Price_{Prod,t-1}$					0.190				0.204	
					(0.152)				(0.140)	
$Price_{Cons,t-1}$						0.096				0.100
						(0.477)				(0.470)
F-stat	2.95*	3.64**	1.94	6.00***	4.12**	3.24**	2.38*	4.03**	2.76*	2.13
	(0.061)	(0.033)	(0.153)	(0.005)	(0.022)	(0.047)	(0.080)	(0.012)	(0.051)	(0.108)
R^2	0.100	0.121	0.068	0.185	0.135	0.109	0.121	0.189	0.138	0.109
	Dependent variable: $HC_{FE,Output}$									
mkt_{t-1}	0.252*	0.222		0.157	0.190	0.312**	0.222	0.109	0.138	0.290*
	(0.092)	(0.124)		(0.219)	(0.145)	(0.024)	(0.158)	(0.449)	(0.350)	(0.053)
$Bond_{t-1}$	0.011		0.080				-0.000	0.099	0.108	0.056
	(0.941)		(0.568)				(0.998)	(0.477)	(0.460)	(0.705)
$Yield_{t-1}$		-0.097	-0.158				-0.097			
		(0.500)	(0.263)				(0.506)			
Agr_{t-1}				0.396***				0.415***		
				(0.003)				(0.002)		
$Price_{Prod,t-1}$					0.321**				0.347**	
					(0.015)				(0.012)	
$Price_{Cons,t-1}$						0.214				0.224
						(0.117)				(0.110)
F-stat	1.88	2.12	1.04	7.17***	5.23***	3.24**	1.39	4.91***	3.64**	2.17
	(0.163)	(0.130)	(0.362)	(0.002)	(0.008)	(0.047)	(0.256)	(0.005)	(0.019)	(0.102)

R^2	0.066	0.074	0.038	0.213	0.165	0.109	0.074	0.221	0.174	0.111

Table VI. Asset Allocations

The table presents optimal portfolio allocations that minimize portfolio variance in Panel A and maximize Sharpe ratio in Panel B. The human capital index, Hall or FE, and the allowance of short sales is indicated within each panel head. The sample period is from 1801-1860. If short sales are allowed, the constraint is included that no individual short position may exceed 30% of portfolio value. In addition to the human capital return, *Stock* represents the U.S. total return S&P 500 index, *Bond* represents the total return U.S. treasury bond index, *Silver* represents the percent return to the GDP silver price, and *UK Stock* represents the return to the UK FTSE all share index with GFD extension. For the FE human capital index, all series are lagged.

Panel A: Minimized variance portfolio

Hall Human capital index and short sales excluded					
Human Capital	Stock	Bond	Silver	UK Stock	Variance
0.019	0.037	0.609	0.335	0.000	17.387
0.000	0.061	0.628	0.311	0.000	17.476
0.250	0.000	0.339	0.411	0.000	29.359
0.650	0.000	0.047	0.303	0.000	82.862
0.880	0.000	0.000	0.120	0.000	132.160
0.000	0.263	0.737	-	-	31.700
0.000	0.263	0.737	-	-	31.700
0.250	0.134	0.616	-	-	42.885
0.650	0.000	0.350	-	-	90.645
0.880	0.000	0.120	-	-	135.840
Hall Human capital index and short sales allowed					
Human Capital	Stock	Bond	Silver	UK Stock	Variance
-0.013	0.076	0.648	0.381	-0.091	16.272
0.000	0.060	0.633	0.391	-0.084	16.308
0.250	-0.125	0.463	0.455	-0.043	28.415
0.650	-0.270	0.314	0.398	-0.922	78.471
0.880	-0.300	0.201	0.349	-0.131	123.490
-0.071	0.300	0.771	-	-	31.122
0.000	0.263	0.737	-	-	31.700
0.250	0.134	0.616	-	-	42.885
0.650	-0.072	0.422	-	-	90.424
0.880	-0.190	0.310	-	-	134.280
FE Human capital index and short sales excluded					
Human Capital	Stock	Bond	Silver	UK Stock	Variance
0.137	0.000	0.343	0.521	0.000	11.973
0.000	0.016	0.786	0.199	0.000	23.474
0.250	0.000	0.175	0.575	0.000	17.309
0.650	0.000	0.000	0.350	0.000	73.156
0.880	0.000	0.000	0.120	0.000	131.28
0.132	0.000	0.868	-	-	33.625

0.000	0.033	0.967	-	-	36.655
0.250	0.000	0.750	-	-	36.125
0.650	0.000	0.350	-	-	81.974
0.880	0.000	0.120	-	-	134.47

FE Human capital index and short sales allowed					
Human Capital	Stock	Bond	Silver	UK Stock	Variance
0.141	-0.064	0.392	0.547	-0.017	11.418
0.000	0.030	0.772	0.292	-0.094	21.815
0.250	-0.111	0.259	0.594	0.007	15.936
0.650	-0.230	0.124	0.435	0.021	67.183
0.880	-0.298	0.047	0.343	0.282	119.730
0.135	-0.012	0.877	-	-	33.610
0.000	0.033	0.967	-	-	36.655
0.250	-0.049	0.799	-	-	35.841
0.650	-0.181	0.531	-	-	78.170
0.880	-0.257	0.377	-	-	126.30

Panel B: Maximized Sharpe Ratio portfolio

Hall Human capital index and short sales excluded					
Human Capital	Stock	Bond	Silver	UK Stock	Sharpe
1.000	0.000	0.000	0.000	0.000	0.885
0.000	0.179	0.821	0.000	0.000	0.401
0.250	0.078	0.672	0.000	0.000	0.694
0.650	0.000	0.350	0.000	0.000	0.860
0.880	0.000	0.120	0.000	0.000	0.881
1.000	0.000	0.000	-	-	0.885
0.000	0.179	0.821	-	-	0.401
0.250	0.078	0.672	-	-	0.694
0.650	0.000	0.350	-	-	0.860
0.880	0.000	0.120	-	-	0.881

Hall Human capital index and short sales allowed					
Human Capital	Stock	Bond	Silver	UK Stock	Sharpe
0.782	0.143	0.675	-0.300	-0.300	1.171
0.000	0.547	1.053	-0.300	-0.300	0.819
0.250	0.428	0.922	-0.300	-0.300	1.041
0.650	0.215	0.735	-0.300	-0.300	1.167
0.880	0.088	0.632	-0.300	-0.300	1.170
1.239	-0.300	0.061	-	-	0.902
0.000	0.179	0.821	-	-	0.401
0.250	0.078	0.672	-	-	0.694
0.650	-0.137	0.487	-	-	0.864
0.880	-0.268	0.388	-	-	0.891

FE Human capital index and short sales excluded					
Human Capital	Stock	Bond	Silver	UK Stock	Sharpe
0.991	0.000	0.009	0.000	0.000	1.052
0.000	0.053	0.947	0.000	0.000	0.176
0.250	0.000	0.750	0.000	0.000	0.702
0.650	0.000	0.350	0.000	0.000	1.024
0.880	0.000	0.120	0.000	0.000	1.050
0.993	0.000	0.007	-	-	1.052
0.000	0.053	0.947	-	-	0.176
0.250	0.000	0.750	-	-	0.702
0.650	0.000	0.350	-	-	1.024
0.880	0.000	0.120	-	-	1.050
FE Human capital index and short sales allowed					
Human Capital	Stock	Bond	Silver	UK Stock	Sharpe
1.181	-0.242	0.661	-0.300	-0.300	1.198
0.000	0.151	1.449	-0.300	-0.300	0.445
0.250	0.046	1.238	-0.300	-0.235	0.794
0.650	-0.100	0.931	-0.300	-0.181	1.127
0.880	-0.163	0.811	-0.300	-0.228	1.182
1.036	-0.294	0.258	-	-	1.084
0.000	0.053	0.947	-	-	0.176
0.250	-0.044	0.794	-	-	0.705
0.650	-0.176	0.526	-	-	1.048
0.880	-0.250	0.370	-	-	1.080

Table VII. SDF Tests With Assets and Human Capital during 1801 to 1860

Stochastic discount factors (**m**) are estimated for the U.S. assets that have the annual price available during 1801-1860 in the Global Financial Data. The requirement of the agnostic SDF estimation is the number of assets be greater the number of periods. Panel A tests the differences between those assets and human capital index in the estimated SDFs for stochastic dominance with the non-parametric Kruskal/Wallis (1952) statistic. Means and variances are compared with, respectively, the Welch (1951) and Brown/Forsythe (1974) tests. A Hausman (1978) type Chi-Square tests whether estimated SDF vectors are equal element by element. This Chi-Square test compares each asset pair and is considered significant if the minimum p-value is below the type I error divided by a Bonferroni correction, i.e., p-value less than .05/10 = .005 (with ten pairs being compared.) The minimum across ten pairs is reported. P-values are for the null hypothesis that the asset classes are all priced with the same SDFs. A low p-value rejects the null. Panel B presents the asset that we use to test. ***,**, and * present significance level at 1%, 5%, and 10%, respectively. Panel A presents the test of the difference in the distribution among the SDFs, Panel B presents the mean, standard deviation and the test whether the mean of M is significantly different from zero, Panel C presents regression analysis of $\mathbf{m}_{\text{Assets plus human capital}}$ on $\mathbf{m}_{\text{assets}}$.. Panel D presents mean, median, standard deviation, min and max of the returns of assets that have the data from 1801 to 1860.

Panel A: Asset statistics from Global Financial Data

Asset symbol	Asset description	Mean	Median	Stdev	Min	Max
	Agricultural Commodities					
_CO1599D_7	Cocoa Spot Price (USD/Metric Ton)	-0.019	0.000	0.191	-0.729	0.693
_SU1599D_7	Sugar #11 Spot Price (US Cents/Pound)	-0.012	-0.023	0.148	-0.288	0.630
CMCBJCOFIM_7	Boston Jamaica Cod Fish ($/cwt) (Cole)	-0.014	-0.042	0.238	-0.482	0.488
CMCBOSCCANDM_9	Boston Sperm Candles ($/lb) (Cole)	-0.022	0.000	0.325	-0.701	0.916
CMCCCCUCOFM_8	Charleston Choice green Cuba Coffee (Â¢/lb) (Cole)	-0.008	0.000	0.144	-0.425	0.435
CMCCHGSTURPM_8	Charleston George soft Turpentine ($/bbl) (Cole)	-0.006	0.000	0.084	-0.357	0.251
CMCCHLBOARDSM_7	Charleston Lumber-boards ($/M. Ft.) (Cole)	-0.012	0.000	0.234	-0.740	1.030
CMCCHLEATHM_9	Charleston Leather ($/lb.) (Cole)	-0.015	-0.011	0.279	-0.868	0.734
CMCCHMCOTM_7	Charleston Middling Cotton ($/lb) (Cole)	0.006	0.000	0.111	-0.318	0.251
CMCCHMSBFM_7	Charleston Boston mess Beef ($/bbl) (Cole)	-0.011	-0.016	0.183	-0.685	0.545
CMCCHPRMGCM_9	Charleston Prime green Coffee (Â¢/lb) (Cole)	-0.003	0.000	0.185	-0.642	0.405
CMCCHTOBXM_8	Charleston Tobacco inspected for Export ($/cwt) (Cole)	0.005	0.000	0.162	-0.765	0.366
CMCCHWOHHSVM_17	Charleston White Oak Hogshead-Hdng Staves (Â£/M) (Cole)	0.001	0.000	0.136	-0.322	0.403
CMCCINWWHISM_21	Cincinnati New Whisky ($/gal) (Cole)	-0.008	0.000	0.171	-0.408	0.435
CMCCIPRBFBM_21	Cincinnati Bacon-Flitch Bacon (Â¢/lb) (Cole)	-0.015	-0.021	0.209	-0.604	0.635
CMCCIPRIOCOM_20	Cincinnati Rio prime Coffee (Â¢/lb) (Cole)	-0.007	0.000	0.165	-0.693	0.238
CMCCIWRNHM_21	Cincinnati Western Hops ($/lb) (Cole)	-0.001	-0.027	0.229	-0.582	0.738

Asset symbol	Asset description	Avg	Median	Stdev	Min	Max
CMCCLMICOTM_21	Cincinnati Louisiana Middling Cotton ($/lb) (Cole)	0.005	0.000	0.326	-1.591	1.504
CMCCMJASUGM_22	Charleston Muscovado Ja. Sugar ($/cwt) (Cole)	-0.025	0.000	0.254	-0.521	0.833
CMCCWPCLLURDM_7	Charleston White pine clear Lumber-boards ($/M ft) (Cole)	-0.012	0.000	0.105	-0.473	0.190
CMCNOGUINDM_17	New Orleans Guatemala Indigo ($/lb) (Cole)	-0.005	0.010	0.227	-0.544	0.482
CMCNOWOPSM_22	New Orleans White Oak pipe Staves ($/M) (Cole)	-0.006	0.000	0.153	-0.560	0.405
CMCNYGEWHM_21	New York Genesee Wheat ($/bu) (Cole)	-0.006	0.027	0.343	-1.185	0.803
CMCNYNOCM_13	New York Northern Corn (Â¢/bu) (Cole)	-0.005	-0.019	0.144	-0.448	0.361
CMCNYPHBAM_22	New York Pickled hams Bacon (Â¢/lb) (Cole)	-0.010	0.000	0.152	-0.707	0.423
CMCNYPWWHM_20	New York Prime white Wheat ($/bu) (Cole)	-0.003	0.000	0.196	-0.606	0.386
CMCNYRQDUCM_1	New York Russian 1st qual. Duck ($/bolt) (Cole)	-0.005	0.000	0.272	-0.618	0.542
CMCNYWHCM_21	New York White Corn (Â¢/bu) (Cole)	-0.008	0.000	0.124	-0.276	0.347
CMCNYYECM_21	New York Yellow Corn (Â¢/bu) (Cole)	-0.012	0.000	0.163	-0.511	0.405
CMCPARETALM_20	Philadelphia American Refined Tallow ($/lb) (Cole)	-0.007	0.000	0.153	-0.384	0.351
CMCPHBIXM_21	Philadelphia Butter Inspected for Export (Â¢/lb) (Cole)	-0.012	0.000	0.299	-0.629	0.788
CMCPHLCCM_22	Philadelphia Lower county Corn (Â¢/bu) (Cole)	0.000	-0.029	0.231	-0.552	0.483
CMCPHLVPRSM_22	Philadelphia Liverpool ground Salt (Â¢/bu) (Cole)	-0.001	0.000	0.152	-0.567	0.651
CMCPHUFLOM_20	Philadelphia Flour ($/cwt) (Cole)	-0.001	0.000	0.155	-0.330	0.309
CMCPSFIGM_20	Philadelphia Simpson-Fish Gin ($/gal) (Cole)	-0.003	0.000	0.180	-0.613	0.532
CMCPTGUCOTM_20	Philadelphia Tennessee-Georgia Upland Cotton ($/lb) (Cole)	-0.012	-0.039	0.198	-0.518	0.357
CMCSAGRM_22	USA Cole and Smith Agricultural Price Index B	-0.005	0.000	0.128	-0.303	0.345
CMCSPM_20	Pennsylvania Corn Prices (US$/bushel)	-0.002	-0.014	0.264	-0.601	0.558
CMRICEM_14	Rice Spot Price, Bangkok (US $/Metric Ton)	0.005	0.019	0.149	-0.502	0.586
CMWSPM_20	Pennsylvania Wheat Prices (US$/bushel)	-0.007	-0.040	0.260	-0.529	0.542
COT_AFRD_20	Cotton Spot Price (Cents/Pound)	-0.025	0.007	0.236	-0.562	0.691
OATS_RAD_20	Oat Spot Price (US$/Bushel)	-0.012	-0.017	0.277	-0.679	0.470
	Energy & Material Commodities					
__CU_NYD_9	High Grade Copper (US Cents/Pound)	-0.014	0.000	0.130	-0.418	0.314
__SN_NYD_9	Tin (Straits, Pigs) Prices (US Cents/Pound)	0.001	0.000	0.202	-1.099	0.478
__XAG_HD_16	Silver Cash Price (US$/Ounce)	0.000	0.000	0.037	-0.133	0.114
__XAU_D_1	Gold Bullion Price-New York (US$/Ounce)	0.001	0.000	0.024	-0.111	0.116
CMCCIPRIRONM_22	Cincinnati Puddled Iron, bar (Â¢/lb) (Cole)	-0.008	0.000	0.165	-0.460	0.405
CMCCIPRSTM_21	Cincinnati American blistered Steel ($/lb) (Cole)	-0.013	-0.031	0.171	-0.318	0.531
CMCCWRICM_20	Cincinnati Wheeling River Coal (Â¢/bu) (Cole)	0.002	-0.025	0.216	-0.756	0.453

Asset symbol	Asset description	Avg	Median	Stdev	Min	Max
CMCNONAILM_17	New Orleans 4d-20d Nails (Â¢/lb) (Cole)	0.009	0.000	0.137	-0.419	0.374
CMCNYANCOM_20	New York Anthracite Coal ($/ton) (Cole)	-0.001	0.000	0.254	-0.560	0.636
CMCNYCORIRONM_13	New York Country refined Iron, bar (Â£/ton) (Cole)	-0.077	0.000	0.558	-3.912	0.990
CMCNYSCCOM_22	New York Schuylkill Coal ($/ton) (Cole)	-0.009	0.000	0.235	-0.693	0.575
CMCPCRWHOM_21	Philadelphia Crude Whale Oil ($/barrel) (Cole)	-0.018	-0.007	0.326	-1.139	0.978
CMCPHAHAIRONM_1	Philadelphia American hammered Assorted. Iron, bar ($/ton) (Cole)	-0.015	-0.036	0.164	-0.336	0.603
XRUSAMADAG_1	Massachusetts Dollar in Grams of Silver	0.000	0.000	0.016	-0.078	0.041
XRUSDAG_22	United States Dollar in Grams of Silver	0.000	0.000	0.016	-0.041	0.078
	Bond					
_TNXD_9	CBOE 10-year US Government Bond Yield Index	-0.003	0.001	0.062	-0.215	0.193
IGUSA10D_21	USA 10-year Bond Constant Maturity Yield	0.002	0.000	0.088	-0.151	0.332
IGUSALTD_22	United States Long-Term Bond Yield	-0.003	0.001	0.062	-0.215	0.193
IGWLDA_1	GFD Indices Long-Term Government Bond Yield Index	-0.006	-0.018	0.078	-0.279	0.269
MOMUNIW_21	Moody's Municipal Bond 20-year Composite Yield	-0.006	-0.007	0.056	-0.197	0.178
TRUSABID_21	GFD Indices USA Total Return Daily T-Bill Index	0.045	0.045	0.006	0.030	0.058
TRUSABIM_21	GFD Indices USA Total Return T-Bill Index	0.046	0.048	0.006	0.030	0.057
TRUSAMUM_21	USA Municipal AAA Bonds Total Return Index	0.056	0.055	0.024	-0.024	0.137
TRUSG10M_21	GFD Indices USA 10-year Government Bond Total Return Index	0.053	0.049	0.069	-0.128	0.208
	Currency					
USDCAD_13	Canada Dollar per US Dollar	0.023	-0.003	0.183	-0.136	1.374
USDDEH_21	Hamburg Mark Banco per US Dollar	0.001	0.000	0.061	-0.361	0.135
USDFRF_22	France Franc per US Dollar	0.001	0.000	0.060	-0.230	0.183
USDGBP_1	GBP per US Dollar	-0.001	0.001	0.039	-0.141	0.096
USDJMD	Jamaica Dollar per US Dollar	0.002	0.000	0.051	-0.148	0.135
USDNLG_21	Netherlands Guilder per US Dollar	0.000	0.000	0.038	-0.151	0.143
USDPTE_21	Portugal Escudo per US Dollar	0.002	0.008	0.060	-0.223	0.148
	Stocks					
_SPXD_8	S&P 500/Cowles Composite Price Index (w/GFD extension)	0.000	-0.001	0.095	-0.279	0.191
USCFALLM_22	USA Cole and Smith All Stock Index	-0.010	0.000	0.117	-0.371	0.372
_SPXTRD_9	S&P 500 Total Return Index (w/GFD extension)	0.057	0.062	0.099	-0.208	0.320

Panel B: Regression analysis

	Independent variable: $\mathbf{m}_{Assets}$	Adj R2	N
Dependent variable: $\mathbf{m}_{Assets\ plus\ human\_capital}$	6.05*** (9.14)	58.23%	60

Panel C: Test the difference in the distribution among SDFs

Asset classes	# of assets within each asset class	Stochastic Dominance (Kruskal/Wallis)	Equal Means (Welch)	Equal Variances (Brown/Forsythe)	Equal Elements (Chi-Square)
		P-value for identical SDFs ($\mathbf{m}_s$)			
$\mathbf{m}_{Assets} = \mathbf{m}_{Assets\ plus\ human\_capital}$	76	0.637	0.983	<0.001***	<0.001***

Panel D: Test whether SDF is significantly different from zero

SDF	Mean	Std. Dev.	P-value
$\mathbf{m}_{Assets\_and\_human\ capital}$	0.895	33.763	0.839
$\mathbf{m}_{Assets}$	0.982	4.291	0.081*

Table VIII. Market integration based on R^2 from 1801 to 1860

This table presents the measure of market integration, R^2, from a regression of each asset index returns on global factors. See Table VIII Panel C for the descriptive statistics of each asset return. Panel A presents R^2 from the regression of the asset return on the 26 global factors, which are estimated by the principal components computed with the returns from other assets. All 76 assets have annual returns data from *Global Financial Data* from 1801 to 1860. Panel B presents R^2 from the regression of the human capital return on the 26 global factors based on all assets except human capital, and the factors constructed from each asset.

Panel A: Adj. R^2 based on global factors

Assets	R^2 (%)	Assets	R^2 (%)
Cocoa	62.95	HC	28.29
Sugar	71.01	S&P 500/Cowles Composite Price Index	84.68
Boston Jamaica Cod Fish	95.23	USA Cole and Smith All Stock Index	73.19
Boston Sperm Candles	66.74	S&P 500 Total Return Index	82.93
Charleston Choice green Cuba Coffee	74.75	Average Stocks	80.27
Charleston George soft Turpentine	62.46	High Grade Copper	85.63
Charleston Lumber-boards	51.87	Tin	77.04
Charleston Leather	75.31	Silver	71.41
Charleston Middling Cotton	52.02	Gold Bullion	67.53
Charleston Boston mess Beef	65.03	Cincinnati Puddled Iron, bar	72.30
Charleston Prime green Coffee	74.74	Cincinnati American blistered Steel	72.34
Charleston Tobacco inspected for Export	72.22	Cincinnati Wheeling River Coal	67.42
Charleston White Oak Hogshead-Hdng Staves	57.96	New Orleans 4d-20d Nails	54.60
Cincinnati New Whisky	61.16	New York Anthracite Coal	83.29
Cincinnati Bacon-Flitch Bacon	79.51	New York Country refined Iron, bar	70.27
Cincinnati Rio prime Coffee	73.94	New York Schuylkill Coal	36.47
Cincinnati Western Hops	61.58	Philadelphia Crude Whale Oil	74.18
Cincinnati Louisiana Middling Cotton	58.22	Philadelphia American hammered Assorted. Iron, bar	82.17
Charleston Muscovado Ja. Sugar	91.74	Massachusetts Dollar in Grams of Silver	87.19
Charleston White pine clear Lumber-boards	53.94	US$ in Grams of Silver	87.19
New Orleans Guatemala Indigo	62.42	Energy & Material Commodities	72.60
New Orleans White Oak pipe Staves	72.28	10-year Bond	52.38
New York Genesee Wheat	43.95	Long-Term Bond	93.02
New York Northern Corn	78.91	Long-Term Government Bond	69.25

New York Pickled hams Bacon	71.30	Moody's Municipal Bond 20-year	76.08
New York Prime white Wheat	75.28	Daily T-Bill	79.47
New York Russian 1st qual. Duck	77.02	Monthly T-Bill Index	81.23
New York White Corn	66.38	Municipal AAA Bonds	72.97
New York Yellow Corn	72.56	10-year Government Bond	80.12
Philadelphia American Refined Tallow	50.70	CBOE 10-year US Government Bond	93.02
Philadelphia Butter Inspected for Export	79.75	Bonds	75.57
Philadelphia Lower county Corn	56.36	Canada Dollar per US$	37.30
Philadelphia Liverpool ground Salt	72.72	Hamburg Mark Banco per US$	77.39
Philadelphia Flour	66.48	France Franc per US$	83.69
Philadelphia Simpson-Fish Gin	43.69	GBP per US$	78.19
Philadelphia Tennessee-Georgia Upland Cotton	57.63	Jamaica Dollar per US$	61.45
USA Cole and Smith Agricultural Price Index	90.64	Netherlands Guilder per US$	98.93
Pennsylvania Corn Prices	69.36	Portugal Escudo per US$	70.63
Rice Spot Price, Bangkok	54.59	Currency	72.51
Pennsylvania Wheat Prices	91.41		
Cotton Spot Price	91.22		
Oat Spot Price	67.81		
Agriculture commodities	68.45		

Panel B: Regression of human capital returns on global factors excluding human capital

Assets used to construct global factors	Number of assets used to construct the global factors	R^2(%)
All	76	28.29
Bonds	9	1.36
stocks	3	2.24
Agricultural commodities	42	18.77
Energy	15	8.49
Currencies	7	6.73

Table IX. SDF Tests With Five Asset Classes and Extrapolated Human Capital from 2002 to 2013

Stochastic discount factors (SDFs_henceforth, **m**) are estimated for five different asset classes in the U.S., equities, bonds, currencies, commodities, and real estate (REITs), using annual observations for individual assets from 2002 through 2013, (12 years.) Panel A shows the regression results of the SDF constructed from assets without human capital on the SDF constructed from assets and human capital. The extrapolated human capital index is constructed from constant output yields approach (human capital_constant output yield). See Section IV for the description. Panel B tests the differences between each asset class and human capital index in the estimated SDFs for stochastic dominance with the non-parametric Kruskal/Wallis (1952) statistic. Means and variances are compared with, respectively, the Welch (1951) and Brown/Forsythe (1974) tests. A Hausman (1978) type Chi-Square tests whether estimated SDF vectors are equal element by element. This Chi-Square test compares each asset pair and is considered significant if the minimum p-value is below the type I error divided by a Bonferroni correction; i.e., p-value less than .05/10 = .005 (with ten pairs being compared.) The minimum across ten pairs is reported. P-values are for the null hypothesis that the asset classes are all priced with the same SDFs. A low p-value rejects the null. Panel C presents t-stats testing whether SDF of each asset class is significantly different from zero and associated P-value. Panel D describes statistics of assets used to construct SDFs. ***,**, and * present significance level at 1%, 5%, and 10%, respectively.

Panel A: Sample descriptive statistics of assets constructed SDF

	# assets	Mean	Median	Stdev	Min	Max	Data source
Stocks	323	0.128	0.148	0.326	-0.498	0.658	CRSP
Real estate	97	0.010	0.062	0.338	-0.713	0.489	Ziman REIT
Bonds	225	0.050	0.022	0.207	-0.260	0.554	TRACE
Commodities	47	0.061	0.069	0.301	-0.519	0.520	Bloomberg
Currency	45	-0.009	-0.018	0.087	-0.137	0.165	MSCI

Panel B: Regression analysis

Dependent variable	Independent variable (N=12) m_{Bond}	$m_{Commodities}$	$m_{Currencies}$	$m_{Real\ Estate}$	m_{Stocks}	Adj R2
					(305.52)	
	Extrapolated human capital index from constant output yield approach					
$m_{Bond\ and\ human\ capital}$	0.96^{***} (44.17)					99.89%
$m_{Commodities\ and\ human\ capital}$		1.03^{***} (45.86)				99.48%
$m_{Currencies\ and\ human\ capital}$			1.18^{***} (4.75)			66.20%
$m_{Real\ Estate\ and\ human\ capital}$				0.99^{***} (91.55)		99.87%
$m_{Stocks\ and\ human\ capital}$					1.01^{***} (4,614.18)	100.00%

Panel C: Test the difference in the distribution among SDF

Asset classes	Stochastic Dominance (Kruskal/ Wallis)	Equal Means (Welch)	Equal Variances (Brown/Forsythe)	Equal Elements (Chi-Square)
	P-value for identical SDFs ($\mathbf{m}$)			
	Extrapolated human capital returns from constant output yield			
$m_{Bonds\ and\ human\ capital} = m_{Bonds}$	0.885	0.993	0.899	0.216
$m_{Commodities\ and\ human\ capital} = m_{Commodities}$	0.977	0.983	0.923	0.276
$m_{Currencies\ and\ human\ capital} = m_{Currencies}$	0.840	0.983	0.262	0.202
$m_{Real\ Estate\ and\ human\ capital} = m_{Real\ Estate}$	0.885	0.992	0.973	0.352
$m_{Stocks\ and\ human\ capital} = m_{Stocks}$	1.000	0.998	1.000	0.378

	With human capital from constant output yields		
$m_{Bonds} = m_{Stocks} = m_{Commodities} = m_{Currencies} = m_{Real\ Estate}$	0.955	0.991	0.001***
	Without human capital		
$m_{Bonds} = m_{Stocks} = m_{Commodities} = m_{Currencies} = m_{Real\ Estate}$	0.856	0.998	0.013**

Panel D: Test whether SDF is significantly different from zero

SDF	Mean	Std. Dev.	t-stat	P-value
$m_{Bond\ and\ human\ capital\_constant\ output\ yield}$	0.989	0.774	4.607***	0.001
m_{Bond}	0.989	0.771	4.443***	0.001
$m_{Commodities\ and\ human\ capital\_constant\ output\ yield}$	0.939	1.455	2.006**	0.070
$m_{Commodities}$	0.928	1.532	2.098**	0.060
$m_{Currencies\ and\ human\ capital\_constant\ output\ yield}$	0.998	1.06	2.086***	0.061
$m_{Currencies}$	1.002	1.169	2.996***	0.012
$m_{Real\ Estate\ and\ human\ capital\_constant\ output\ yield}$	0.94	0.76	4.218***	0.001
$m_{Real\ Estate}$	0.936	0.78	4.161***	0.002
$m_{Stocks\ and\ human\ capital\_constant\ output\ yield}$	0.877	0.569	5.271***	<0.001
m_{Stocks}	0.875	0.575	5.272***	<0.001

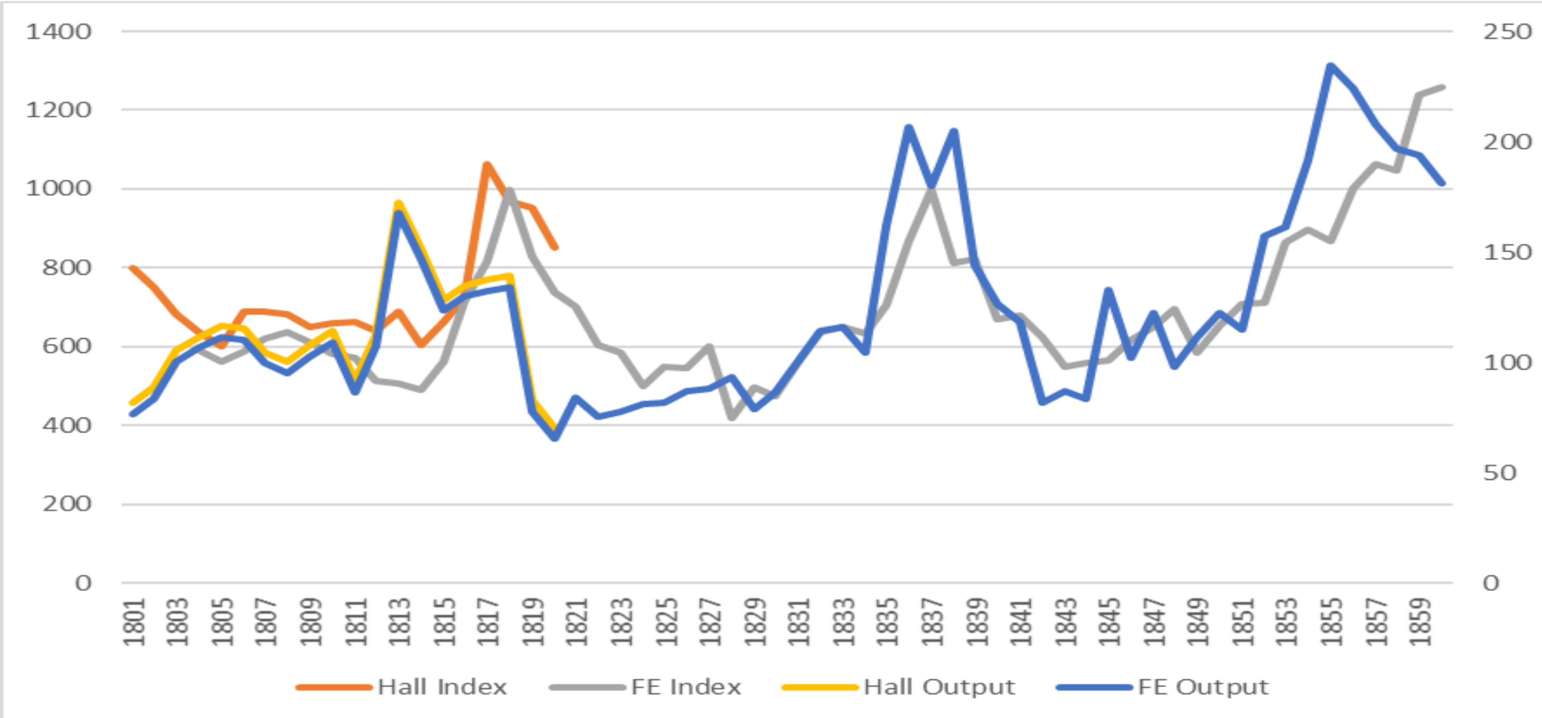

Figure 1. Human capital index levels and output values
The figure presents levels of the Hall Human Capital Index and the Fogel and Engermann (FE) Human Capital Index, as well as the estimated output values by year.

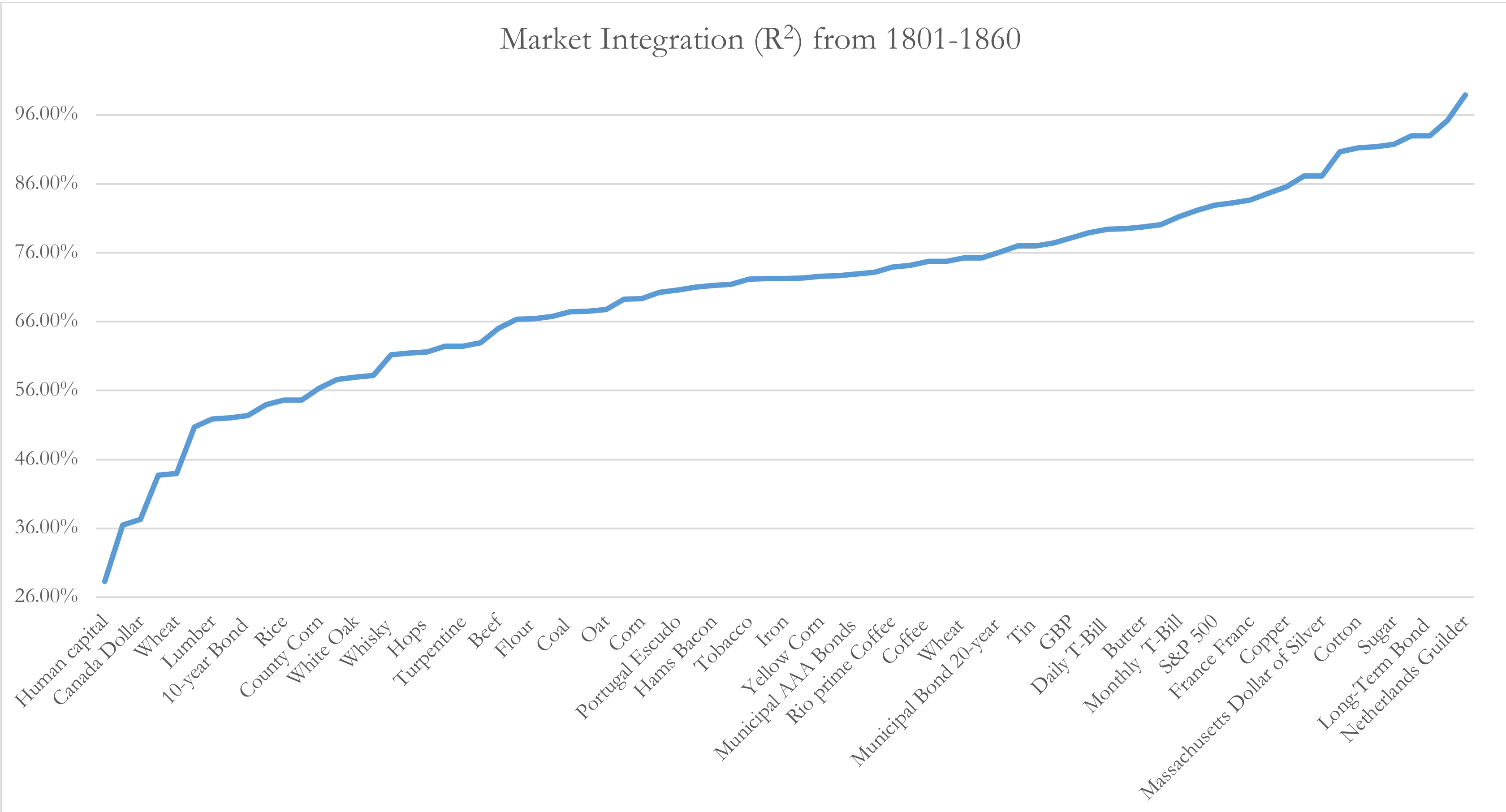

Figure 2: Market Integration from 1801-1860. This figure presents the measure of market integration, adjusted R^2, from a regression of each asset index returns on global factors. See Table VIII Panel C for the descriptive statistics of each asset return. R^2 is from the regression of the asset return on the 26 global factors, which are estimated by the principal components computed with the returns from other assets without its own. All 76 assets have annual returns data from *Global Financial Data* from 1801 to 1860.

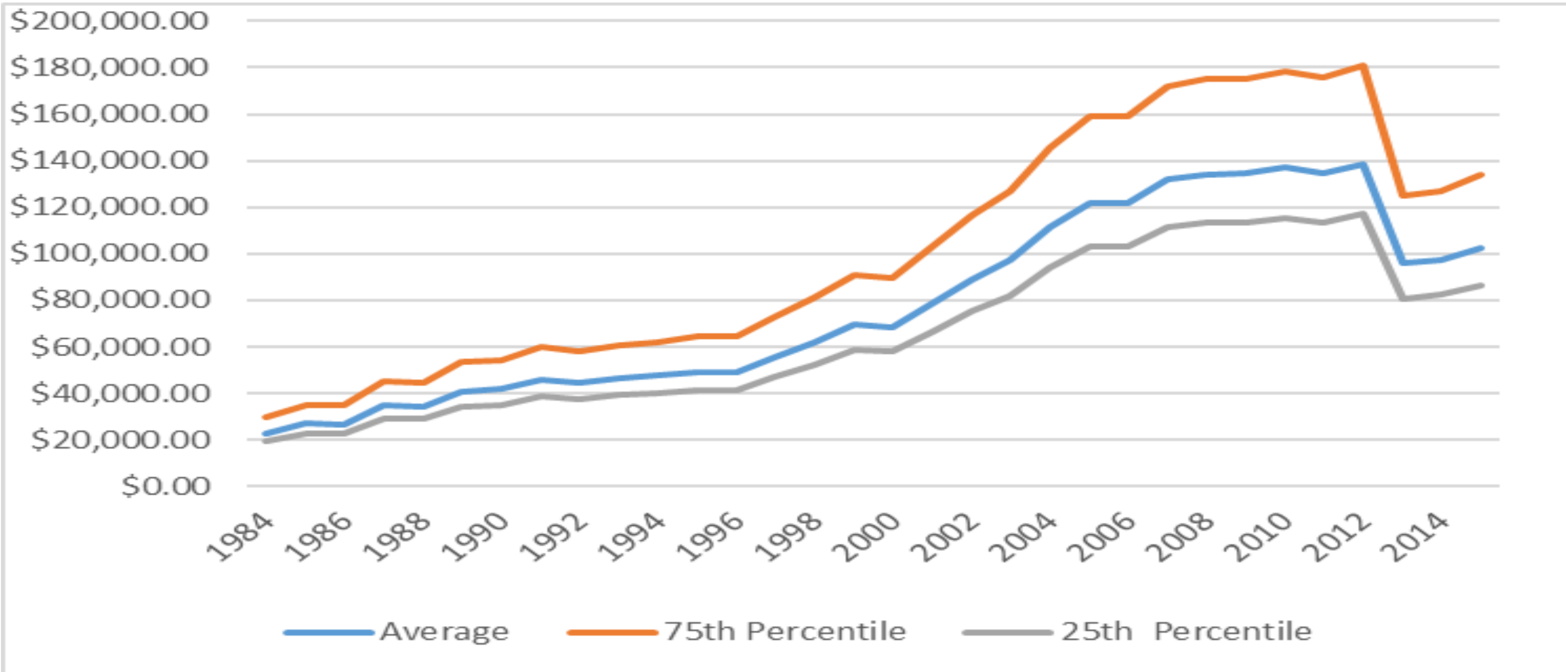

Figure 3. Extrapolated human capital from the observed output yield

The figure plots the estimated value of human capital from 1984 through 2015 based on the observed output yield during the human capital sample. Disposable income less sustenance expenditures is calculated based on the US Bureau of Labor Statistics, with food at home, housing, utilities, housekeeping supplies, apparel, transportation and health care expenditures subtracted from income after taxes. Disposable income less sustenance is then divided by the average output yield from the Hall and FE human capital samples to provide an estimate of the value of human capital for the average individual during the 1984-2015 sample. Estimated human capital values are also provided based on the 25th and 75th percentiles of the output yield from the Hall and FE samples.