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A Substitution Effect as a Possible Cause for the Antebellum Heights Puzzle

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The first half of the nineteenth century was a time of significant economic growth in the United States. Economic growth generally coincides with increasing real wages and better health and nutrition. It is also common to see increasing stature of a nation over time as a result of economic development. Ironically, the antebellum period was a time of decreasing average stature. This contradiction is referred to as the antebellum puzzle. The literature regarding this puzzle offers some possible explanations. We focus on one possible hypothesis for the antebellum puzzle. Changes in Nutrition and Diet may have resulted from a transformation in the composition of US economic production leading to a temporary decrease in overall stature. This paper examines if there was a substitution effect between manufactured goods and agricultural output as the US developed during the antebellum period. Because of the lack of data about nutrition during the 1800s, stature is used as a proxy to reflect one's diet in the early stages of life. Our research finds that a substitution effect between manufactured goods and agriculture output may have contributed to the antebellum puzzle.

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Abstract

The first half of the nineteenth century was a time of significant economic growth in the United States. Economic growth generally coincides with increasing real wages and better health and nutrition. It is also common to see increasing stature of a nation over time as a result of economic development. Ironically, the antebellum period was a time of decreasing average stature. This contradiction is referred to as the antebellum puzzle. The literature regarding this puzzle offers some possible explanations. We focus on one possible hypothesis for the antebellum puzzle. Changes in Nutrition and Diet may have resulted from a transformation in the composition of US economic production leading to a temporary decrease in overall stature. This paper examines if there was a substitution effect between manufactured goods and agricultural output as the US developed during the antebellum period. Because of the lack of data about nutrition during the 1800s, stature is used as a proxy to reflect one's diet in the early stages of life. Our research finds that a substitution effect between manufactured goods and agriculture output may have contributed to the antebellum puzzle.

JEL: N31, N51, N61, O13, 014.

1 Introduction

Reliable statistics about consumption patterns, real wages, and household income are not readily available to study the standard of living in the United States during the nineteenth century. An alternative methodology is to use stature as a measure of welfare. This paper contributes to the relatively new approach of utilizing anthropometric data as a proxy for a population's standard of living.

The increasing height of a population is positively correlated with economic development. However between 1830 and 1860, the average height of the US population was declining despite rising incomes. This contradiction is known as the Antebellum Puzzle.

The Antebellum Puzzle has been analyzed by several economic historians. Forgel et al. (1979) were the first to recognize a declining mean stature during the Antebellum period. Forgel et al. (1982) examined factors that influence the average stature of a population. Margo and Villaflor (1987), Steckel (1995), and Craig (2016) show evidence that this trend took place during a time of economic growth and rising incomes.

Margo and Steckel (1983) compare height differentials of union army soldiers. Their regression models control for regions of birth, inter and intra migration status, birth year, and enlistment year. This paper found that farmers and wealthier union soldiers tended to be taller, while rural non-farmers and those with less prestigious occupations tended to be relatively shorter. In addition, the birth year categorical variables document the average heights among union soldiers during the Antebellum era.

Komlos (1987) utilizes height and weight records of cadets who attended the West Point Military Academy during the 1800s. He finds that the average height of the cadets declined throughout the early 1800s until the 1860s, and then increased thereafter.

Yoo (2011) applies a geographically weighted regression model in order to explore the Antebellum Puzzle. He finds that river transportation exporting routes for food tended to increase mortality rates and stunted stature. In contrast, those who lived in water transportation importing destinations for food products tended to be relatively taller and had lower mortality rates.

There certainly are deleterious consequences associated with economic development. For example, urbanization and an increase in immigration results in the spread of communicable diseases. Another ramification is environmental degradation. Such factors are impediments to ones physical

growth potential.

The following monograph focuses on another explanation for the antebellum puzzle. Changes in nutrition and diet may have resulted from a transformation in the composition of US economic production leading to a temporary decrease in overall stature. Komlos (1987) argues that the reason for the decrease of stature during the antebellum period was a result of a decrease in nutritional intake. This is because agricultural production was not able to keep up with the growing demand for food during economic expansion and urbanization. The labor supply and productivity in the agricultural sector did not increase nearly as fast as the demand for the production food.

In addition, food became less accessible as the result of industrialization. As urban areas developed, the distance from farms to city centers increased. As a result, the cost of transporting food increased. Consequently, the price of food was driven up and, thus, food consumption decreased. For example, grain prices increased 30 percent between the 1820s and 1850s and meat prices increased 22 percent compared to industrial goods. The increases in food prices prompted people to reduce their food consumption. Unfortunately, the harmful consequences were not known at that time.

Even people whose income increased along with food prices probably also decreased their food consumption. Because the price of food was increasing relative to industrial goods, even wealthy individuals substituted commodities in place of food (Komlos, 1987). As we will see in our regression models, even farmer's heights decreased during this time. This is contrary to what we would expect because of their easy access to food. One possible explanation may be that farmers sold more of their output at this time to take advantage of the rising prices. This paper examines if there was in fact a substitution effect between manufactured goods and agricultural output as the US developed during the antebellum period.

The contribution to the Antebellum Height literature that this paper makes is that it includes relative prices in an OLS regression model. Indexes of prices of manufactured goods and agriculture output are created for three cities that we have price information: Philadelphia, New York City, and Cincinnati. Then a variable is created where the index of the manufactured goods is divided by the index of agricultural goods in order to see the impact of relative prices on the Union Soldiers heights during their adolescence. Figure 1 shows the relative prices during the antebellum period for the three cities. We can see a downward trend in the relative price index (RPI). The purpose of this research is to examine if this trend contributed

to the Antebellum puzzle.

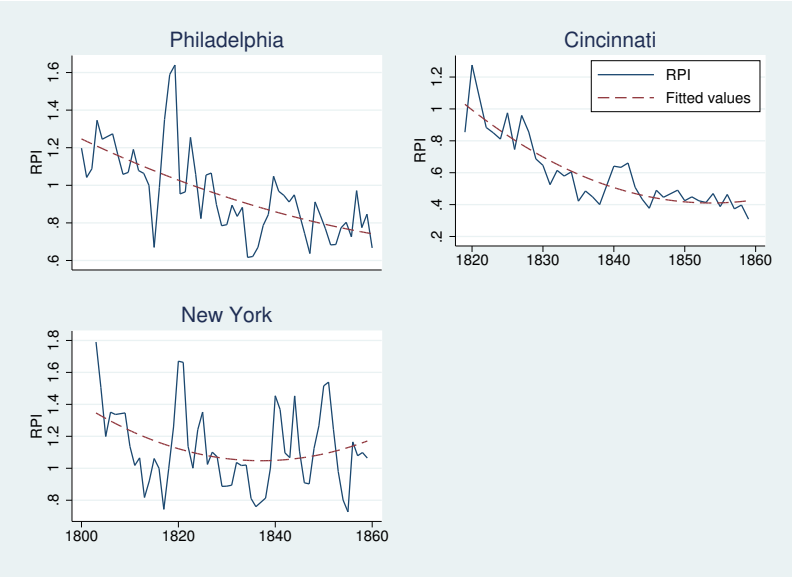

Figure 1: Relative price index by city

2 Theoretical Model

To motivate the behavior of households in this paper's model, this section reviews a simple health production function. A household maximizes utility by consuming non-food production, C, and by maintaining ones health via food consumption, H:

$$\max_{C,H} U = u(C, H) \tag{1}$$

subject to the a health constraint

$$H = h(Food, C; X) \tag{2}$$

and a budget constraint

$$E[expenditures] = P_c \cdot \ non\text{-}food\ consumption + P_F \cdot food\ consumption. \tag{3}$$

Exogenous factors such as household location, ethnicity, and gender are reflected in X.

The FOCs give us the optimal allocation of consumption of food and non-food consumption along with an expression that reflects an upper bound to food consumption:

$$\frac{MU_C}{P_c} = \frac{MU_F}{P_F} \tag{4}$$

$$Food = f(P_C, F_C, E, X). \tag{5}$$

The assumption of this paper is that food consumption goods and non-food consumption goods are substitutes, which implies

$$\frac{\partial Food}{\partial P_C} > 0 \tag{6}$$

$$\frac{\partial Food}{\partial P_F} < 0. \tag{7}$$

Thus, the hypothesis of this paper is that the substitution effect impacts the aggregate average height, H, of a population such that

$$\frac{\partial H}{\partial P_F} = \frac{\partial H}{\partial F} \cdot \frac{\partial F}{\partial P_F} < 0. \tag{8}$$

In the empirical model, the exogenous variable X is the union soldiers home state, occupation is a proxy for income, and birth cohort reflects relative prices over time.

3 Empirical Model

Using height statistics of white union army soldiers, we compare trends between the Northeast and Midwest during the antebellum period. Our regression model emulates that of Margo and Steckel (1983), Nicholas and Steckel (1990), and Steckel (1995). Data describing stature and other characteristics of white soldiers were available from the Civil War muster rolls. Regression analysis is used to compare stature differentials of army soldiers between regions. The proposed model correlates height with region of birth, year of birth, and civilian occupation.

In addition, we create a variable that tests whether a substitution effect could have caused the average height of US born army soldiers to decline during the antebellum period. The variable that reflects the agricultural-manufactured goods substitution effect is referred to as the Relative Price Index (RPI).

The empirical regression model thus formulated is given as follows:

$$\begin{aligned} stature = \beta_0 + \beta_1\ RPI + \beta_2\ farmer + \\ \beta_3\ professional\ 1 + \beta_4\ professional\ 2 \\ +\beta_5\ artisan + \beta_6\ service + \beta_7\ NY\ resident + \beta_8\ PA\ resident \\ +\beta_9\ born\ before\ 1825 + \beta_{10}\ born\ 1825 - 1829 + \beta_{11}\ born\ 1830 - 1834 \\ +\beta_{12}\ born\ 1835 - 1839 + \epsilon \end{aligned}$$

where β_0 through β_{12} are the parameters in the model to be estimated. The variables are explained in Table 1.

Table 1: Model Variables

Variable	Description
stature	Height of the union army recruit;
RPI	relative price index of the union soldiers home state;
farmer	farmers who were not hired agricultural workers;
professional 1	manufacturers, teachers, lawyers, and other professional workers;
professional 2	clerks, merchants and salesmen;
artisan	skilled labor including blacksmiths, carpenters, and masons;
service	service workers including assistants, spinners, and policemen;
NY resident	the army recruit was born and enlisted in New York;
PA resident	the army recruit was born and enlisted in Pennsylvania;
Born before 1825	the army recruit was born before 1826;
Born 1825-1829	the army recruit was born 1825-1829;
Born 1830-1834	the army recruit was born 1830-1834;
Born 1835-1839	the army recruit was born 1835-1839;
ϵ	disturbance term;

Only those who are born in the northern region or the Midwestern region of the US are included. Therefore there is not a variable that reflects migrants in this model. Those who are born after 1839 and are 18 years old or older are reflected in the intercept. Those born after 1845 are not included in the model.

The RPI is a price index of manufactured goods divided by a price index of agricultural goods:

$$RPI = \frac{P(manufactured\ goods)}{P(agricultural\ goods)}.$$

The assumption is that as the price of manufactured goods increases relative to the price of agricultural output, people will eat more food. In a developing country, more food consumption will contribute to the average height of the population over time. In contrast, if the price of food increases faster than the price of manufactured goods, then the population will begin to consume larger amounts of manufactured products relative to agricultural products. In this second scenario we posit that over time people will not grow as tall as in previous generations. Hence, we may have a possible explanation to the antebellum puzzle.

4 Data Collection

Information about army recruits were taken from the database "Aging of Veterans of the Union Army: Military, Pensions, and Medical Records, 1820-1940" (Fogel, 2000). Prices statistics were taken from Wholesale commodity prices in the United States, 1700-1861 (Cole, 1938). The index of this book includes monthly averages of several products for various US cities during the antebellum period. However, only three of the cities were applicable to this research: Cincinnati, New York City, and Pittsburgh. Prices of agricultural output and prices of manufactured goods were averaged in order to create a prices index for both types of products.

In order to create a price index that reflected price sensitivity to stature determination, two separate annual indexes were created. These price indexes are the average prices of manufactured and agricultural goods for the time periods t = -1, 1, 2, 12, 13, and 14; where t = 0 is the army soldiers birth year. These years represent when an individual's stature is most sensitive to food consumption. These are also the ages in which adolescent growth rates are the highest. The index also includes the year before birth when the nutrition of pregnant women is also a factor in determining ones stature during adulthood. Discussions regarding the ages of stature growth of adolescence can be found in Evelenth and Tanner (1976), Fogel et al. (1982), and Steckel (1995).

The variable RPI is a ratio of the two price indexes. Our hypothesis is that as the relative price of one composite good increases, we expect the quantity demand of the other composite good to increase. Hence, we expect the following relationship to hold:

$$\sum_{i-1}^{n} \sum_{t-1}^{T} stature_{it} = f\Big(\frac{Price\ Index\ of\ Manufactured\ Goods}{Price\ Index\ of\ Agricultural\ Goods}\Big)$$

where i is the i^{th} soldier born at time t.

5 Evidence and Implications of the Model

In this section, we analyze our model without the variable RPI and compare it to a model with this variable. The soldiers included in both sample were born and enlisted in the same state. The sample includes soldiers only in the states that we had price statistics for: Pennsylvania, Ohio, and, New York. As a result, the sample size is 1,751. The relative price index has a coefficient of 1.25 and is statistically significant. Model (1) does not include the RPI variable and is included in table 2 for comparison purposes. We also ran a t-test and an F-test in order to verify that our RPI variable significantly contributed to the model. The adjusted-R increased from 0.088 to 0.097.

The Relative Price Index seems to suggest that there was in fact a substitution effect between food and manufactured goods that contributed to changes in consumption patterns.

The occupation variables corroborate what the papers cited above observe. Farmers and professionals were relatively taller compared to those in lower paying occupations. The missing occupation variable are referred to as "unproductive." This cohort consisted primarily of students. During the Antebellum period, students were from wealthy families. Not surprisingly, the artisan and service workers were shorter than the Professional workers and farmers.

The NY resident and PA resident variables are both negative. These coefficients are comparing union soldiers that were born and also enlisted in Ohio. Therefore, we can see that there is an advantage to being born and raised in the Midwest. However, we have additional insight that there was an advantage to being born in New York over Philadelphia. Both of these variables are statistically significant.

The birth year cohort variables show the declining average stature of the union soldiers over time. Those born after 1839 but were over the age of 18 are reflected in the equation's constant. Comparing the birth year categorical variables to those born after 1839, those born before 1825 were on average 1.9 inches taller. Those in the remaining birth year cohorts are shorter than those born before 1825, but taller than those born after 1839. The birth year cohort variables are all statistically significant. A sensitivity analysis is described in the appendix.

6 Conclusion

The Antebellum Puzzle refers to the empirical evidence that the average height of the American population was declining during a time of significant economic growth. Research regarding the antebellum puzzle has given various explanations for declining heights and increasing mortality rates during the first half of the nineteenth century. We analyze an additional explanation. The purpose of this paper is to determine if there was a substitution effect between food and manufactured goods that may have had a deleterious effect on ones height during the antebellum period. This paper's model includes a variable that reflects the relative prices of food and manufactured goods. The model regression seems to verify that there was in fact a substitution away from food and towards manufactured goods that impeded American's heights during the antebellum period.

Table 2: Regression of Union Soldier's Heights on Relative Price Index, Occupation Variables, State the Recruit was Born and Enlisted, and Year of Birth Categories.

	(1)	(2)
RPI		1.25
		(0.537)
Farmer	0.267	0.265
	(0.213)	(0.213)
Professional 1	-0.27	-0.336
	(0.497)	(0.497)
Professional 2	-0.450	-0.464
	(0.352)	(0.352)
Artisan	-0.581	-0.591
	(0.252)	(0.252)
Service Worker	-0.467	-0.459
	(0.351)	(0.350)
NY resident	-1.13	-1.59
	(0.163)	(0.258)
PA Resident	-0.686	-0.842
	(0.674)	(0.376)
Born before 1825	1.90	1.9
	(0.343)	(0.342)
Born 1825-1829	1.266	1.22
	(0.303)	(0.303)
Born 1830-1834	1.18	1.22
	(0.236)	(0.214)
Born 1835-1839	1.26	1.27
	(0.145)	(0.144)
Constant	67.34	66.38
	(0.246)	(0.504)
Observations	1,751	1,751
Adjusted R^2	0.088	0.097

Standard errors in parentheses

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7 Appendix: Regression Model Sensitivity Analysis

In this section, we run additional regression models in order to conduct robustness checks. Various specification are compared to see how sensitive farmers are to same relative price indexes as the other occupations. The assumption is that the majority of the non-farming occupations are urban job. The prices used in this study are for the cities of New York City, Philadelphia, and Cincinnati. The union soldiers were from both rural and urban areas. Below we run and compare regressions to see if are there significant changes in the coefficients. Farmers clearly lived in rural areas so it is difficult to assess the relation between urban are rural prices of the same goods.

Table 3 presents five specifications of the model including the two regression models from Table 2. All five specifications include the state of birth-enlistment variables and the birth year category variables. Since the coefficients are all statistically significant, there is strong evidence to support that these variables impacted ones nutrition during adolescence and eventually stature during adulthood.

Since the impact of relative prices on adulthood stature is the primary topic of this paper, it is included with the variables described above in equation (1), where it is statistically significant. Next, equation (2) then adds the occupation variables, which is the regression model (1) in Table 2. Including farmers in the sample is questionable since prices in the price indexes are from the cities. Urban prices may or may not be highly correlated with the prices of the same commodities in the rural areas. As we saw above, farmers were the tallest occupational cohort. Thus, it is easy to assume that farmers were immune from the deleterious affects of rising food prices in urban areas as children. For the purpose of comparison, equation (3) excludes the farmer occupation variable and equation (4) includes this variable. Regression equation (4) is the same as regression equation (2) from Table 2.

Equation (5) also includes an interaction term between the RPI variable and the farmer occupation variable, which is statistically significant. This implies that the relative urban prices during adolescence could have affected a farmer's stature during adulthood. From this sen-

sitivity analysis, we can see that the estimated coefficients are robust.

Table 3: Regression of Union Soldier's Heights on Relative Price Index, Occupation Variables, State the Recruit was Born and Enlisted, and Year of Birth Categories.

	(1)	(2)	(3)	(4)	(5)
RPI	1.09		1.107	1.25	0.99
	(0.54)		(0.54)	(0.537)	(0.6611)
RPI×Farmer					0.188
					(0.69)
Farmer		0.267		0.265	0.06
		(0.213)		(0.213)	(0.78)
Professional 1		-0.27	-0.58	-0.336	-0.35
		(0.497)	(0.46)	(0.497)	(0.49)
Professional 2		-0.450	-0.64	-0.464	-0.42
		(0.352)	(0.30)	(0.352)	(0.35)
Artisan		-0.581	-0.78	-0.591	-.57
		(0.252)	(0.177)	(0.252)	(0.25)
Service Worker		-0.467	-0.65	-0.459	-0.42
		(0.351)	(0.30)	(0.350)	(0.35)
NY resident	-1.59	-1.13	-1.53	-1.59	-1.53
	(0.26)	(0.163)	(0.257)	(0.258)	(0.26)
PA Resident	-1.00	-0.686	-0.86	-0.842	-0.815
	(0.373)	(0.674)	(0.37)	(0.376)	(0.38)
Born before 1825	1.82	1.90	1.98	1.9	1.965
	(0.34)	(0.343)	(0.34)	(0.342)	(0.34)
Born 1825-1829	1.48	1.266	1.61	1.22	1.59
	(1.48)	(0.303)	(0.306)	(0.303)	(0.31)
Born 1830-1834	1.72	1.18	1.803	1.22	1.77
	(0.24)	(0.236)	(0.237)	(0.214)	(0.23)
Born 1835-1839	1.43	1.26	1.47	1.27	1.45
	(0.15)	(0.145)	(0.15)	(0.144)	(0.15)
Constant	66.45	67.34	66.55	66.38	66.46
	(0.47)	(0.246)	(0.47)	(0.504)	(0.1531)
Observations	1,751	1,751	1,751	1,751	1,751
Adjusted R^2	0.085	0.088	0.097	0.097	0.097

Standard errors are in parentheses