Investor Sentiment and the Price of Slaves in the U.S. South

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Contents

Abstract

Economists have pointed to the evolution of observed slave prices as a proxy for the beliefs of slave owners in the U.S. South.[1] But this focus on observed prices does not account for changes in the fundamentals underlying these valuations, such as variations in the price of cotton or labor productivity. I construct a counterfactual price series based on asset pricing theory and observable demographic and economic factors. I compare observed and estimated prices to compute an annual investor sentiment index, which tracks important historical events of the period. It shows the low slave prices of the twenties and forties were higher than underlying cotton prices warranted, signalling upbeat investor sentiment. It indicates that the increase in slave prices in the run up to the Civil War was more moderate than previously thought once adjusted for changes in fundamental factors. It also points to the successive abolitions of slavery by Britain and France as important influences on investor sentiment.

The price of slaves in the American South has long been a subject of interest for economists and historians. For some, slaves were an investment in (human) capital, comparable to machines or stocks. U.B. Phillips used cotton-to-slave price ratios in the early twentieth century when "evaluating the wisdom of an investment in slaves."[2] For others, such as Eugene Genovese, "in the South specific forms of property carried the badges of honor, prestige and power."[3] In this sense, slaves were not wise investments but markers of class. Both Phillips and Genovese viewed slaves as under-performing or unprofitable investments. This traditional view, known as the *Phillips school*, was dominant until the 1950s.[4] It held that slavery would eventually succumb to its economic flaws.

In 1958, Conrad and Meyer[5] introduced a capital model of slave pricing, replacing the traditional accounting of revenues and expenses. Their approach, combined with new data sets, transformed the debate over the profitability of slavery, culminating in the work of Fogel and Engerman.[6] Despite its moral bankruptcy, it is now generally accepted that slavery in the American South was profitable. Moreover, Fogel and Engerman demonstrated that it was efficient, in that total factor productivity was consistently

[1] See for instance Phillips [38], Kotlikoff [26]
[2] Fogel and Engerman on Philipps [18], p. 60
[3] Genovese [23], p. 28
[4] Fogel and Engerman [17], p. 312
[5] Conrad and Meyer [10]
[6] Fogel and Engerman [18]

greater than in non-slave agriculture.[7]

Recent research has used reduced form models based on actual slaves prices in an attempt to distinguish the effect of observable characteristics (age, gender, skill set or skin colour) from that of unobservable characteristics, such as slave owner beliefs about the future.[8] This paper contributes to our understanding of beliefs about slave prices or "investor sentiment", by comparing the price of slaves arising from a model based on observed slave characteristics with observed slave prices. The differences allow me to make inferences about investor expectations regarding the future of slavery.[9]

Special attention will be paid to the gender price differential. Females typically traded at a 10% discount. Although male and female slaves were largely substitutable in the field, women were less productive and their productivity was further reduced during pregnancy but, on the other hand, they produced potentially valuable offspring, especially so after the *Act Prohibiting Importation of Slaves* of 1808. Male and female slaves therefore presented different investment opportunities, trading at different prices and yielding different payoffs over different time horizons. The differences in their valuations can reveal more about investor sentiment than a single type of human capital.

This paper is organized as follows: Section 1 introduces a theoretical model of slave prices. Section 2 deals with the estimation of the model parameters. Section 3 presents the model estimates of slave prices and compares them to observed prices. Section 4 outlines the investor sentiment index and its historical context.

1 A Model of Slave Pricing

In this section I describe a general pricing model, where an expectations component is added and returns on male and female slaves are distinguished. I heed Butlin's criticism of Conrad and Meyer: the demographic variables, mortality and fertility, are taken to be probabilistic.[10] I follow standard asset pricing theory, where, assuming risk-neutrality, "price equals expected discounted payoff".[11]

[7] Fogel and Engerman [19], p. 72-80

[8] See Calomiris and Pritchett [8] or Grynaviski and Munger [24] for example.

[9] Scholars of recent financial history have many tools at their disposal when it comes to evaluating investor sentiment: "closed-end fund discount, NYSE share turnover, the number and average first-day returns on IPOs, the equity share in new issues, and the dividend premium" (Baker and Wurgler [4], p. 1655). These measures are not available for the antebellum period.

[10] Butlin [6], p. x

[11] Cochrane [9], p. xiii. Later in this paper we will see how relaxing the risk-neutrality assumption, and assuming risk-aversion, can affect the results.

1.1 Prices with certainty

With certainty over revenues and costs (but not lifetime), the theoretical price of a slave is equal to the discounted sum of their marginal productivity net of costs. The following specification is used by Fogel and Engerman,[12] as inspired by Conrad and Meyer. It assumes perfect foresight of future revenues and costs. In order to keep the notation as simple as possible, I do not use time subscripts. It is therefore implied that all time-varying parameters (cotton prices, productivity, etc.) take current values.

$$P_a = \sum_{t=a}^{T} \pi_{t:a} \frac{MR_t - C_t}{(1+i)^{t-a}} \tag{1}$$

Prices are given in (1) where t is the age of the slave, $\pi_{t:a}$ is the probability of survival to age t, MR is marginal revenue, C is the cost of the slave (in terms of basic food, clothing, shelter and supervision, as well as cash and in-kind incentives), and i is the discount rate.

Marginal revenue is based on farm output and prices, so that this analysis is best suited for unskilled farm workers or "field hands".[13] Indeed, field hand was the main occupation of slaves in the Antebellum South. In 1850, 73% of slaves were agricultural labourers, and 73% of these labourers worked cotton farms.[14]

1.2 Prices with uncertainty

Here the perfect foresight assumption is relaxed and replaced with a model that includes buyer expectations. Research by McDevitt and Irwin, based on slave prices in Richmond, VA, supports a weak-form of the Efficient Market Hypothesis, the efficient use of publicly available past data.[15] Accordingly, I assume expectations of future net earnings are a function of past productivity and costs, and a parameter ρ, that captures factors *other* than productivity, cotton prices or costs, such as possible legal and political developments. Therefore, ρ is the variable of particular interest in this paper, in that it captures investor sentiment.

$$E\big(\textit{future net earnings at age } a\big) = (1+\rho)^{t-a} E(MR_t - C_t)$$

[12] Fogel and Engerman [20], 2:592

[13] Skilled slaves, such as blacksmiths, carpenters, coopers, or shoemakers, did not work in the field, generated higher marginal revenues and commanded higher prices (Kotlikoff [26]).

[14] Fogel and Engerman [18], p. 40-41

[15] McDevitt and Irwin [33]

The expectations regarding future output and costs per slave, $E(MR_t - C_t)$, are treated as formed at age a and are constant for the entire remaining life of the slave. They can be based, for example, on the average observed net earnings over N previous periods, or on the trend value based on the past T years. Therefore, assuming risk-neutrality, we have:

$$P_a = \sum_{t=a}^{T} \pi_{t:a} \frac{(1+\rho)^{t-a} E(MR_t - C_t)}{(1+i)^{t-a}}$$

$$= \sum_{t=a}^{T} \pi_{t:a} \frac{E(MR_t - C_t)}{(1+i')^{t-a}} \qquad \textit{with} \;\; i' = \frac{i-\rho}{1+\rho} \approx i - \rho \tag{2}$$

By estimating the relevant parameters and comparing estimated and observed slave prices, I will be able to estimate the evolution of ρ, my proxy for investor sentiment, over the period. Since observed slave prices are gender specific, I present two versions of (2).

Male

In the case of male slaves, I simply add the superscript m.

$$P_a^m = \sum_{t=a}^{T} \pi_{t:a} \frac{E(MR_t^m - C_t^m)}{(1+i')^{t-a}} \tag{3}$$

Female

Adapting the model to female slaves requires the modeling of child-bearing. Letting ϕ_t be the probability of giving birth at age t and O_t be the value of new-born offspring in that year, we have:

$$P_a^f = \sum_{t=a}^{T} \pi_{t:a} \left\{ (1-\phi_t) \frac{E(MR_t^f - C_t^f)}{(1+i')^{t-a}} + \phi_t \frac{E(MR_t^o + O_t - C_t^o)}{(1+i')^{t-a}} \right\} \tag{4}$$

The first term represents the return from a female slave in years when she does not give birth.[16] The second term captures the return during pregnancy years,[17] denoted

[16]Hence should a female be known to be infertile ($\phi_{t:a} = 0, \forall t$), her price would be: $P_a^f = \sum_{t=a}^{T} \pi_{t:a} \frac{E(MR_t^f - C_t^f)}{(1+i')^{t-a}}$

[17]it is assumed productivity disruptions related to pregnancy only last a year. While this may seem short, it is, in fact, a conservative assumption. Pregnant women would often be forced to work in the field "down to the week of delivery" ([21], p. 321). After the birth, Metzer finds a statistically significant drag on productivity for 11 weeks. "The decline in productivity due to pregnancy and nursing lasted about four months" ([20], 1:202). This will be reflected in the parameter estimates.

by the superscript o.

Comparing (3) and (4), we note the three components of the gender premium:

(a) gender-specific differences in net productivity: $(MR^m - C^m) - (MR^f - C^f)$

(b) the opportunity cost of giving birth: $(MR^f - C^f) - (MR^o - C^o) \equiv X$

(c) the net value of offspring: $O - X$

In the next section, I provide estimates of the parameters in (3) and (4) necessary for derivating price estimates. These are then compared to observed prices.

2 Parameter Estimates

The following parameters are estimated: π, ϕ, MR, C, O, and i. A large number of data sets are available for the antebellum era: some were produced by the U.S. Government through the Census or the Department of Agriculture, others were put together by academics from historical documents, such as plantations records, slave diaries and probate records, among other sources. When specific data is not available, I use the assumptions previously made in the literature as a reference point and make adjustments as deemed appropriate.

2.1 $\pi_{t:a}$ | Survival rate

The life expectancy of slaves was important to southern planters in that it affected the value of their investments, but also to abolitionists who saw it as reflecting the harshness of the institution.[18] Various combinations of Census data, plantation records and demographic adjustments have been used over the years, yielding estimates of life expectancy at birth ranging from 28 to 38 years. Most recent analyses have relied on plantation records. While these have proved a useful addition to census data, they regrettably do not contain enough information regarding the sex of slaves to build gender-specific life tables.[19]

Table 1 presents survival rates at birth and at age 20 of U.S. slaves circa 1830. Their life expectancy was 29.8 years at birth and 39.0 years at age 20. Nearly 1 in 3 children did not survive past their first year and only 1 in 2 reached age 20. However, the mortality of blacks (slave or free) aged 10 and over was not statistically different from whites. I

[18] Steckel [20], 2:393

[19] Steckel [20], 2:395. Gender-specific census data is not available for the antebellum period. Such data for subsequent years for non-slave populations, shows females with slightly greater life expectancy than males, Carter et al. [7], Table Ab952-987 – Death rate, by sex and race: 1900-1998.

follow Fogel and Engerman in assuming that the survival rates are constant over the period, and that slave owners had knowledge of these rates.

Table 1: Survival rates at birth ($\pi_{t:0}$) and at age 20 ($\pi_{t:20}$), U.S. slaves circa 1830

age	at birth	at age 20
0	1.000	
1	0.686	
5	0.548	
10	0.518	
15	0.504	
20	0.486	1.000
30	0.442	0.909
40	0.391	0.805
50	0.338	0.695
60	0.267	0.549
70	0.165	0.340

Source: Fogel and Engerman [21] Table 41.1, p. 285

The addition of mortality rates to the model addresses Butlin's criticism of Conrad and Meyer. The latter lack a probabilistic approach to mortality, assuming that all slaves survived to a specific age, T. This simplification does not take into account the costs incurred early in the lifecycle (and hence more influential in a discounted sum). Taking infant and child mortality into account, Butlin calculates that it took 1.67 births to see one child reach age 20. His calculations are based on mortality tables of the Jamaican population of the late nineteenth century, taken as a proxy for the American slave population.[20] A similar calculation, based on Fogel and Engerman's mortality data (Table 1), which I will continue to use in this paper, shows the number of live births needed to see one child reach age 20 was 2.06.[21]

2.2 ϕ_t | Fertility rate

Given the value of slave children, it has long been debated whether slaveowners engaged in slave breeding, the manipulation of fertility rates. Lowe and Campbell give

[20] Butlin [6], Table 9, p. 55

[21] The survival rates used by Butlin are higher, which is surprising given that Jamaica and the United States had very different slave demographic dynamics. In the United States, the prevalence of cotton (rather than sugar), the large share of the free population in each state and *relatively* better treatment of slaves created the conditions for population growth. In Jamaica, the basis of Butlin's estimates, natural population growth was negative, that is, "the death rate was so high and the birth rate so low that these territories could not sustain their population levels without large and continuous importations of Africans" (Fogel [19], p. 32-33). These facts can be reconciled, I believe, because Butlin's Jamaican data is estimated from 1879-1882 observations, well after the year (1838) when slavery was abolished (Bultin [6], p. 27).

Table 2: Fertility rates (ϕ) observed in comparable non-contraceptive societies

age	**rate**
< 20	0.000
20	0.500
25	0.385
30	0.296
35	0.228
40	0.176
42	0.158
> 42	0.000

Source: Fogel and Engerman [20], Table 21.7, 2:468

an overview of the issue and come to the conclusion that there is no evidence of distorted age or sex ratios that a model of "buying" and "selling" states would imply.[22] The ratio of the number of children in their first year to the number of females of child-bearing age is not significantly different across states. In the end, there seems to be no empirical support for the slave breeding thesis beyond the anecdotal. Consequently, Fogel and Engerman use a fertility rate of $\phi_{20} = 0.5$, as observed in non-contraceptive societies. Fertility decays at the rate of 5.1% per year ($\frac{d\phi}{dt} = -0.051$). Over a lifetime, this translates to a total of 6.86 live births over the ages of 20 to 42 (see Table 2).

Their modeling of fertility is consistent with the average age of first birth, which is estimated to be between 19.8 and 21.6 years.[23] This places peak fertility at the beginning of the child-bearing period, set at age 20, which then decreases at a constant rate until the end of the period, set at age 42. Although I retain this approach, I note that other fertility rate patterns have been put forward, such as the bell-shape used by Lewis in his analysis of nineteenth century fertility rates and savings in the United States.[24]

2.3 MR | Marginal revenue

Marginal revenue brought in by field hands can be broken down into two parts: field productivity (in absolute terms, for example in pounds of output per year, or in relative terms, that is, in terms of a productivity benchmark) and the price of output. I first describe absolute and relative productivity of cotton production before accounting for the fact that slaves produced other crops as well.

[22] Lowe and Campbell [31]

[23] Fogel and Engerman [20], 2:497

[24] Lewis [29], p.832, based on data by Sanderson. Slave price estimates using the Fogel and Engerman and Sanderson fertility rates are very similar. The Fogel and Engerman distribution is used in this paper.

Field Productivity

Cotton production

The prime-aged male field hand, or "full-hand", has traditionally been the starting point for the measurement of productivity. Fogel and Engerman place this peak productivity between the ages of 30 and 34. I will denote with an asterisk, "$*$", those attributes relative to prime-aged male field hands.

There are several methodological challenges to the accurate measurement of productivity. Conrad and Meyer, for example, estimate a full-hand as producing, on average, 3.5 to 4 bales of cotton per year. But actual output varied from 2 to 8 bales, in part due to the quality of the land.[25] Furthermore, these point estimates mask the large increase in productivity that took place over the first half of the nineteenth century. Some attempts to measure productivity over time used macro-level data, dividing total production by the working-age slave population. Other attempts, like Foust and Swan, use loose rules to adjust for the number of full-hand-equivalents.[26] In addition, bale weights varied over time and region, making estimates and comparisons even less precise.

Recent research by Olmstead and Rhode[27] attempts to address these challenges and provides 400-pound bale equivalent estimates of output per working-age slave using county-level data. They find an increase of output from 1.04 to 4.26 bales per worker aged 10 and over, implying a 2.4% annual increase in slave productivity between 1800 and 1860. This impressive productivity growth was due, in part, to improved cotton varieties and technological improvements in production.

The marginal revenue generated by all slaves did not grow at the same brisk pace. Measuring marginal productivity at its highest, in the cotton field during harvest, would lead to inflated estimates. From an asset allocation point of view, the owner of a large cotton plantation could only expect to reap a portion of the overall productivity increase, simply because cotton picking and other cotton-related activities are seasonal in nature. Other crops were grown, even on "cotton farms". Therefore, despite the leading role of "King Cotton", it is important to account for the diversity of output produced by slaves.

Non-cotton production

I address the issue of multiple crops in the following way. Let Q, overall produc-

[25] Conrad and Meyer [10], Table 6, p. 105
[26] Foust and Swan [22]
[27] Olmstead and Rhode [36]

tion, include cotton and non-cotton output. If L_c is labour in cotton and L_{nc} labour in non-cotton (i.e. other crops), we can write

$$Q = aL_c + bL_{nc} \tag{5}$$

where a (b) is labour productivity in cotton (non-cotton). The elasticity of overall output with respect to cotton productivity is

$$\epsilon_c = \frac{dQ}{da} \cdot \frac{a}{Q} = L_c \cdot \frac{a}{Q} = a\frac{L_c}{Q}$$

I weight the cotton productivity figures by the share of the total slave population working in farms (.73), multiplied by the share of the farm workers on cotton plantations (.73).[28] All in all, we have $\frac{L_c}{Q} = .73 \times .73 = .53$

I take 1800-1810 as a base decade, and assume the labor used for non-cotton production (1-.53=.47) had constant productivity over time ($\frac{db}{dt} = 0$), and assume the productivity of labor in cotton production grew at 2.4% per annum ($\frac{da}{dt} = 0.024$). Allowing for this adjustment, the marginal product of a prime-aged male slave more than doubled over the period, increasing at 1.64% per year.[29]

The Olmstead and Rhode figures are, however, expressed in terms of the "average hand", which I convert to full-hand measures. Field productivity varied over time and across gender due to the physical nature of the tasks. Prime-aged females have been said to be "one half to two-thirds as productive".[30] Subsequent research by Fogel and Engerman improved on this rule of thumb.[31] Productivity for women peaked in their late twenties, at about 80% of peak male productivity. Lifecycle relative productivity is shown in Figure 1.

We are now equipped to adjust the Olmstead and Rhode figures and obtain productivity measures for full-hands. If the average hand produced 100 pounds per year,

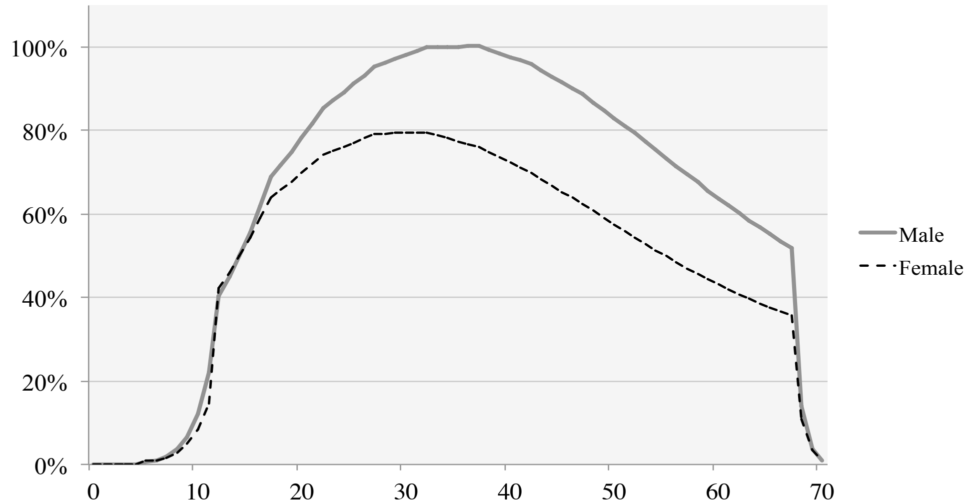
[28]An alternative approach to (5) would be to look at output mix at the farm level and compute the weighted average of productivity increases of individual crops.

[29]If instead we assume $\frac{da}{dt} = 0.024$ and $\frac{db}{dt} = 0.01$, productivity increases at 1.87% annually, or 14% faster. A one percent annual productivity increase may seem low, but a quick look at USDA data for corn yield per acre shows, for example, *no* productivity increase for the entire period 1866-1936 (no earlier data available from the USDA).

[30]Conrad and Meyer [10], not adjusted for time lost due to pregnancy

[31]Fogel and Engerman [21], Table 24.1, p. 206. It is worth mentioning an unpublished draft by Olmstead and Rhode [37] based on micro-data from 114 plantations and 5,598 slaves over 61 years that points to a narrower productivity gap than previous literature. For the period 1801-1839, the gender gap is not statistically different from zero. From 1840 to 1862, females are found to be 11% less productive than males. Model sensitivity to gender productivity differential assumptions is presented in the next section.

Figure 1: Field productivity over lifecycle, relative to that of a full (male) hand



Source: Adapted from Fogel and Engerman [21], Table 24.1, p. 206. Smoothed assuming a constant rate of change within 5-year periods.

and the average hand was half as productive as a full-hand (as would be the case if, for instance, the workforce consisted entirely of slaves of about 15 years of age), then full-hand productivity would be $\frac{100}{.5} = 200$ lb. The simplest way to compute the relative productivity of the average hand would be to have a profile of slaves by age and productivity.

I approximate this profile using Census data.[32] Combining the age-specific productivity estimates of Fogel and Engerman (Figure 1) with the population by age group, I find that the average slave, aged 10 and over, would have been almost three quarters of a full-hand.[33] This figure is remarkably stable over time, ranging from .70 to .72 between 1820 and 1860. Average and full-hand annual output are presented in Table 3. When it comes to productivity during pregnancy, we have, as expected, $MR^o < MR^f$. The productivity of pregnant women was about 85% of that of non-pregnant women.[34] As pointed out earlier, this productivity loss lasted for about four months. This implies $MR^o_t = (\frac{2}{3} + \frac{0.85}{3})MR^f_t = 0.95MR^f_t$. Butlin uses $MR^o_t = 0.75MR^f_t$.[35] I will use 0.85.

[32] Carter et al. [7], B112-143

[33] Average hand = $\sum$ (productivity of age group) $\times$ (proportion of population by age group). This computation yields .71 in 1820, .72 in 1830 and 1840 and .70 in 1850 and 1860.

[34] Fogel [21], p. 323

[35] Butlin [6] p. 4

Table 3: Annual output in pounds of cotton

year	average hand	output per hand	full-hand equivalent
1800	.71	416	587
1810	.71	448	632
1820	.71	518	732
1830	.72	650	904
1840	.72	821	1 139
1850	.70	906	1 302
1860	.70	1102	1 584

Note: Average hand from Fogel and Engerman [21], Table 24.1, p. 206, weighted by Census age groups, Carter et al. [7], B112-143 (value of .71 assumed for 1800 and 1810 when data is not available); output per hand from Olmstead and Rhode [36]; full-hand equivalent is equal to output per hand divided by average hand.

The Price of Cotton

Between 1800 and 1862, the real price of cotton in New York had a mean of 11¢ per pound and a standard deviation of 4¢.[36] Cotton prices were highest at the beginning and the very end of the period, and fluctuated around 10¢ between 1820 and 1860. This price series is consistent with those used by Conrad and Meyer and Fogel and Engerman.[37] Conrad and Meyer calculate freight, insurance, and other costs as seven to eight cents per pound, which I use to adjust the New York series, presented in Table 4.

Table 4: Price of cotton at the farm, in 1830 ¢ per pound

year	price
1800	19.2
1810	10.6
1820	13.9
1830	9.2
1840	7.8
1850	12.5
1860	10.0

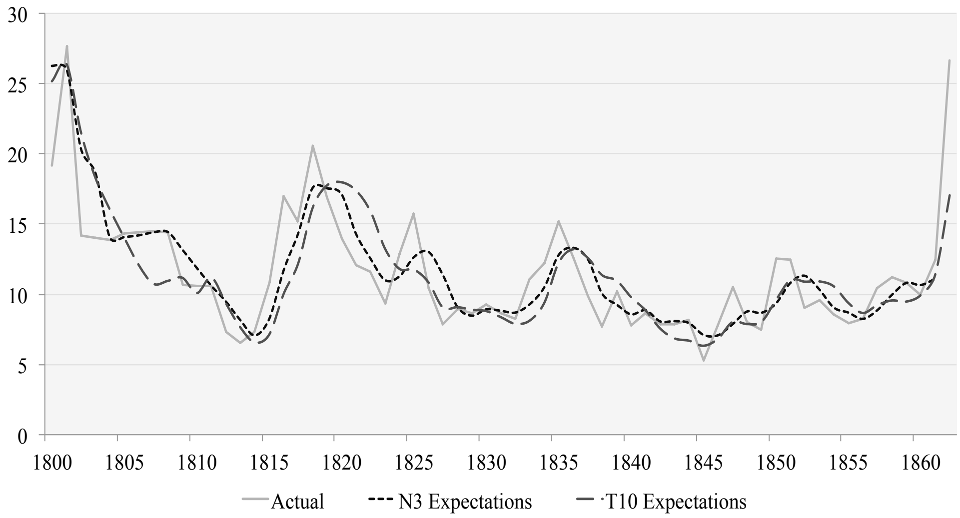
Source: U.S. Department of Agriculture [40], for select years, reduced by 0.8 ¢ per pound to obtain a 'farm price', following Conrad and Meyer [10], p. 105.

[36] Watkins, U.S. Department of Agriculture [40]. Henceforth, all prices are expressed in constant 1830 $, using the Warren-Pearson Wholesale Price Index, All Comodities (Carter et al., [7], Table E52), unless otherwise specified. Prices were high at the beginning of the century before stabilizing around their 1830 levels until the eve of the Civil War.

[37] Conrad and Meyer [10], based on New Orleans prices, 1830-1860; Fogel and Engerman [17], Table 1, p. 316.

Figure 2 presents the evolution of cotton prices and their *expectations*, calculated according to the two methods presented in Section 1. $N3$ refers to expectations of constant net earnings based on an average of the 3 previous periods, and $T10$ is based on a constant value given by the previous 10-year trend.

Figure 2: Price of Cotton at the farm, actual and expected



Note: Actual and expected farm price of cotton, in ¢ per pound.
Actual: Watkins, U.S. Department of Agriculture [40].
Expected: $N3$: three-year average (t, t_{-1}, t_{-2}) and $T10$: value based on ten-year trend $(t_{-10}, \ldots, t_{-1})$.

Cotton was not the only output, therefore fluctuations in cotton prices only affected the price of some slave output. As with productivity, I take 1800-1810 as the base decade. Non-cotton prices were relatively constant over the period, but they did vary a little more than overall prices[38]. As a result, I take the non-cotton fraction (.47) to vary in value over the period at the rate of the ratio of farm product prices to overall prices.

Combining volume estimates, which increased over the period, and relatively stable farm product prices, full-hand productivity increased from roughly \$100 in 1820 to \$164 at the start of the Civil War.

2.4 C | Costs

Several formulations have been used to incorporate costs, which often exceeded mere subsistence wages. In Jamaica, planters would allow slaves to cultivate a plot of land,

[38] As measured by the Warren Pearson index for overall prices and farm products prices (Warren-Pearson Wholesale Price Index, All Commodities and Farm Products, Carter et al. [7], Table E53). The price indexes, both taking the value of 100 in 1830, have the following standard deviations: $\sigma_{cotton} = 29.15$, $\sigma_{farm\ products} = 38.81$

whose produce they could sell. Fogel estimates that the best performing field hands received 2.5 times the subsistence income. Rather than promoting freedom or independence,[39] American planters rewarded the most productive slaves through in-kind payments (e.g. clothing, tobacco) or, in some instances, cash bonuses.[40]

In the absence of incentives, the cost of a slave is constant ($C_t = s_t$). But at the other extreme costs can be treated as a share of output ($C_t = \beta MR_t$).[41] Findlay reconciles these alternatives: slave owners, as the principal in a principal-agent framework, design incentives to optimize their return in the agency relationship. Incentives are of two forms: carrot (income beyond subsistence) and stick (supervision). Economic theory dictates that incentives be used until the marginal cost is equal to the marginal productivity of labor. Therefore, Findlay's model puts forward a combination of incentives: $C_t = s_t + \beta MR_t$, where s is the subsistence wage (which includes the cost of supervising the slave[42]) and βMR_t is the output received as an incentive payment.[43] I will follow Findlay in his formulation because we have evidence of the use of both kinds of incentives.

Conrad and Meyer estimate annual maintenance costs at $20-21.[44] Fogel and Engerman value a basket of consumption goods for slaves in 1860 at farm prices and estimate total slave income for prime-aged field hands at $48.12.[45] Accordingly, I will combine the Conrad and Meyer's and Fogel and Engerman's estimates: $C^*_{1860} = \$20 + \beta MR^*_{1860}$. Solving for β, the share of output a slave received as incentive payment, I have $\beta_{1860} = \frac{48.12-20}{MR^*_{1860}} \approx .2$. Costs are presented in Table 5.

Conrad and Meyer estimate pregnancy and nursery costs at $50 (45.9 in 1830 $) for the period 1840-1860[46] and Fogel and Engerman discuss the equivalence of including them in the child's costs or mother's costs.[47] For the purpose of valuing children, however, pregnancy costs should be seen as sunk costs and will therefore be attributed to mothers through C^o. Having estimated both marginal revenue and costs, I proceed to net earnings.

[39] As noted by Lewis [30], "In the United States, emancipation through manumission was rare" (p. 152). Findlay [16] attributes this to the fact that "U.S. slavery, unlike the systems of antiquity and contemporary Latin America, did not generally permit manumission" (p. 932).
[40] Fogel [19], p. 191. See also Crawford [20], 2:536.
[41] See Eltis, Lewis and Richardson [13], p. 681 for a brief discussion.
[42] Conrad and Meyer, [10], Table 5, p. 104
[43] Findlay [16], p. 928
[44] Conrad and Meyer [10], p. 108
[45] Fogel and Engerman [21], p. 117
[46] Conrad and Meyer [10], p. 108
[47] Fogel and Engerman [18], 2:84

Table 5: Annual Costs for a prime-aged field hand, in 1830 $

year	**subsistence** s_t	**incentive payments** βMR_t
1800	19.6†	24.9
1810	19.6	14.9
1820	19.6	20.2
1830	19.6	18.4
1840	19.6	22.4
1850	19.6	24.1
1860	19.6	27.5‡

Note: Adapted from from Fogel and Engerman, [18], 2:117; includes food, fuel, clothing, medical care, supervision and incentive payment.
†equivalent of 20.0$ in 1850 $ adjusted to 1830 $.
‡equivalent of 48.12$ – 20.00$ adjusted to 1830 $.

2.5 Net earnings

Estimated annual earnings (MR) and costs (C) over the life of a male slave for the year 1852 are shown in Figure 3. They are consistent with the lifecycle earnings pattern estimated by Fogel and Engerman, with net earnings turning positive around age ten, peaking in the mid-thirties and remaining positive well into the slave's sixties.

Table 6: Net earnings for a full-hand (1830 $)

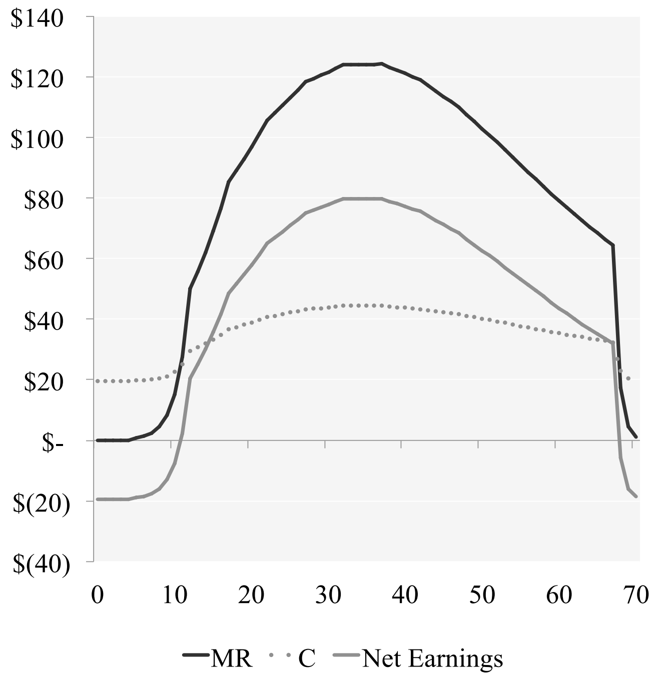
year	**net earnings**	**Evans hire rates**
1800	80	
1810	40	
1820	61	
1830	54	62 to 127
1840	70	82 to 142
1850	77	108 to 183
1860	112	120 to 166

Note: 10-year average of net earnings. Hire rates used by Evans are presented for comparison (Evans [14], Table 5, adjusted to 1830 $).

Net earnings for a full-hand over time are presented in Table 6. These estimates are lower than the hire rates reported by Evans.[48] Evans argues that hire rates are a reliable proxy for net earnings because, in the typical arrangement, the employer of the rented slave had to cover all ongoing expenses while the owner simply collected the rent. However, Butlin notes that hire rates tended to be above net earnings due to transaction costs (typical broker fee of 7.5%, which Evans did not account for), risk of late return for

[48]Evans [14]

Figure 3: Revenue, costs and net earnings of male slaves of varying ages for the year 1852, (1830 $)



Note: Annual marginal revenue (MR) net of costs (C) yield Net Earnings. $N3$ model.

the harvest, losses caused by discontinuities in rental contracts, and possible issues with the treatment of slaves, since the employer might favor short term gains at the expense of the long term health prospects of the slave.[49]

2.6 O | Price of a newborn

Before the 1808 ban on the international slave trade, the supply of slaves was highly elastic. The price of adult slaves in the U.S. was a function of the cost of acquiring slaves in Africa and transporting them. As a result, the price, or value, of a newborn depended on these same costs, adjusted for time discounting and survival rates.

After 1808 the market for human capital in the antebellum South changed.[50] Yasuba draws our attention to *frictions* on the supply side.[51] Not only was slave importation banned, but the local workforce was fully utilized: younger slaves were already in the field as early as possible and female slaves worked until the last week of pregnancy. The ban created a rent for then-owners of female slaves, who could produce another

[49]Butlin [6], p. 89. Butlin is also concerned with Evans' small sample sizes, p. 90-91.
[50]Fogel and Engerman [21], p. 60
[51]Yasuba [44]

generation of slaves. The market price of mothers took into account this rent, making it impossible to "buy into" slavery at an excess profit. The value of a newborn was no longer a function of the "African price", but of the market value of a local adult slave, which itself was driven by cotton prices and productivity.

Fogel and Engerman note that sales involving newborns were rarely observed, and when they were, newborns were not sold separately or itemized on the bill of sale. As a result, we must approximate their value. Fogel and Engerman estimate $O = \alpha P_{20}^f$, with $\alpha = 0.05$, i.e. 5% of the price of a prime age female.[52]

Kotlikoff reports a premium of 10.4% for mothers sold with children aged 1 to 2 years.[53] Adjusted for a survival probability of $\pi_{1:0} = 0.686$, this yields an expected value at birth of 7% of the price of a prime aged female, before accounting for potential death in the second year of life. It is therefore consistent with the Fogel and Engerman estimate. But Kotlikoff also shows that this premium fluctuated over time, ranging from 0 in 1830-1839 to 16.5% in 1820-1829.

Here I estimate α, by formalizing the expected value of offspring as follows:[54]

$$O = \textit{survival rate to age 20} \times \textit{value at age 20} - \textit{net rearing costs to age 20}$$

$$O = \pi_{20:0} \frac{P_{20}}{(1+i)^{20}} - \sum_{t=0}^{19} \pi_{t:0} \frac{E(C_t - MR_t)}{(1+i')^t} \qquad \textit{and} \qquad \alpha \equiv \frac{O}{P_{20}} \tag{6}$$

In the limit case where a child covers his costs through his own labor by age 20, we have $\alpha = \frac{\pi_{20:0}}{(1+i)^{20}} \approx 0.15$. As such, it is likely that the true value of α lies between 0 and $\frac{1}{6}$. An example following (6) is presented in Table 7. I obtain:

$$O_{1840} = 0.49 \frac{595.5}{(1.06)^{20}} - 71.2 = 90.2 - 71.2 = 19.1 \qquad \textit{and} \qquad \alpha = \frac{19.1}{595.5} = 0.03$$

[52] Fogel and Engerman [20], 2:472, note #9

[53] Kotlikoff [20], 1:48

[54] Alternatively, and equivalently, we have:

$$O = \frac{\textit{value at age 20} - \textit{net rearing costs to age 20}}{\textit{number of births required to see one child reach adulthood}}$$

$$O = \pi_{20:0} \left(\frac{P_{20}}{(1+i)^{20}} - \sum_{t=0}^{19} \frac{\pi_{t:0}}{\pi_{20:0}} \frac{E(C_t - MR_t)}{(1+i)^t} \right)$$

This formulation is based on Butlin: he starts with the number of births required to have one saleable slave at age 20 rather than with the survival rate. Indeed, the two approaches yield identical results, for the survival rate to age 20 is equal to the inverse of number of births needed to see one child reach age 20 ($\pi_{20:0} = .486 = \frac{1}{2.06}$). Butlin [6], Table 9, p. 55

As a result of fluctuations in α due to the second term in (6), I depart from Fogel and Engerman and compute O for each year.

Table 7: Costs and revenues per male child (p. c.), in 1840 (1830 $)

year	costs p. c.	revenues p. c.	net costs p. c.	survival rate	sale at age 20
1840	(19.57)		(19.57)	1.00	
1841	(19.57)		(19.57)	0.686	
1842	(19.57)		(19.57)	0.652	
1843	(19.57)		(19.57)	0.617	
1844	(19.57)		(19.57)	0.583	
1845	(19.57)	0.85	(18.72)	0.548	
1846	(19.67)	0.85	(18.83)	0.542	
1847	(19.76)	1.44	(18.31)	0.536	
1848	(19.91)	2.47	(17.44)	0.530	
1849	(20.19)	4.21	(15.97)	0.524	
1850	(20.70)	7.19	(13.50)	0.518	
1851	(21.63)	12.29	(9.34)	0.515	
1852	(23.32)	35.84	12.52	0.512	
1853	(26.42)	38.91	12.49	0.510	
1854	(27.18)	42.23	15.05	0.507	
1855	(28.03)	45.85	17.81	0.504	
1856	(28.98)	49.77	20.78	0.500	
1857	(30.03)	54.02	23.99	0.497	
1858	(31.20)	55.64	24.44	0.493	
1859	(31.71)	57.32	25.60	0.490	
1860	-	-	-	0.486	595.48
			(71.15)†		90.25‡

Note: Male child, $N3$ model, $\rho = 0$
Child survival calculated according to Table 1.
Revenues and costs follow the first 20 years of Figure 3 for 1840.
Net costs = revenues - costs
†net present value of net costs stream discounted at 6% per year and accounting for survival rate each year
‡sale price of 595.48 discounted at 6% per year over 20 years and accounting for survival rate to age 20

2.7 i | Discount rate

When dealing with an individual investor, such as a southern planter, it is typical to use the opportunity cost of capital. Evans describes the following investment opportunities: short-term money (three- to six-month paper in Boston or sixty- to ninety-day bills in New York) yielded 6.1 to 13.0%, whereas railroad stock yielded 4.9 to 9.8%.[55] A review of the relevant period points to a discount rate of 6%.[56] These investments are

[55]Evans [14], Table 25, p. 220

[56]Carter et al. [7], Table Cj1198-1222 – Bank rates on short-term business loans: 1815-1997. Since the variable of interest is *variations* in prices, as opposed to price levels, an incorrect discount rate would

not equivalent to slave assets in terms of risk level and liquidity, a point I will address in the last section.

3 Slave Prices: Estimated and Observed

Estimating the theoretical model discussed in Section 1 using the parameters presented in Section 2 produces slave prices over the period. I present estimated prices in this section, along with observed (actual) slave prices.

3.1 Estimated slave prices

Male

Consider a male slave, aged 20, and assume neutral expectations, $\rho = 0$. From (3), reproduced below, I derive the discounted sum of expected net earnings from a male slave.

$$P_{20}^m = \sum_{t=20}^{70} \pi_{t:20} \frac{E(MR_t^m - C_t^m)}{(1+i)^{t-20}}$$

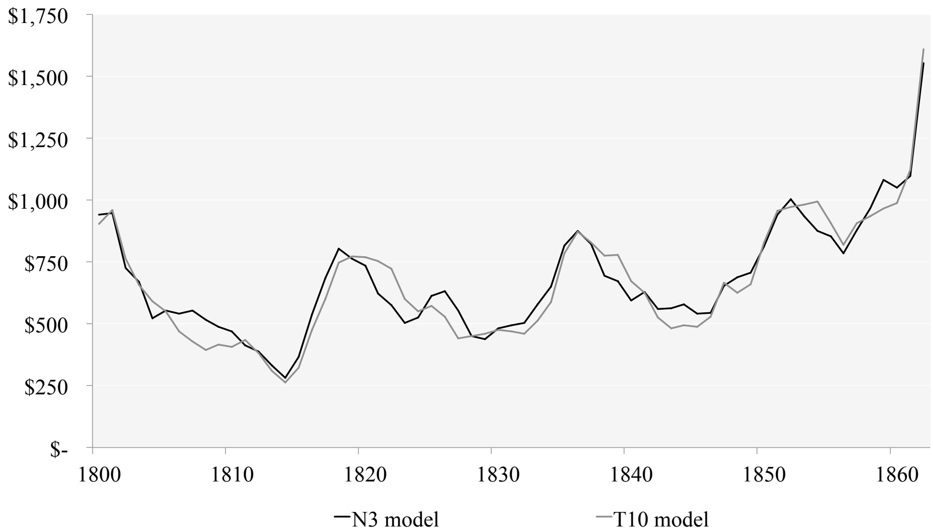
The predicted price for a male slave is approximately \$500 in 1810, increasing to \$600 by the 1840 and surpassing \$1,000 by 1860. I estimate prices over the period using the two different kinds of buyer expectation formation regarding future cotton prices. In both cases cotton prices are expected to remain constant, but the initial estimates are derived in two different ways: the last three years' cotton price average ($N3$) and the last ten years' cotton price trend ($T10$) (see Figure 4).

As noted earlier, Olmstead and Rhode claim the gender productivity gap is overestimated. There is a risk that my estimates are sensitive to the measurement of this gap. The starting point are the differentials as documented by Fogel and Engerman (see my Figure 1, p. 10). I explore three scenarios: taking these estimates at face value ('full gap'), a hypothetical gap reduced by half ('half gap') and a scenario where male and female slaves are equally productive ('no gap'). Reducing the productivity gap increases value of the average hand *relative* to that of the full-hand, thereby decreasing output per full-hand[57] and lowering marginal revenue and slave prices for males. It increases

not affect our ability to interpret the results.

[57] Here is a simplified example: Suppose we originally believe our work force is composed of 50% prime aged males (full-hands = 1) and 50% women (half-hands = .5), our average hand is .75 full-hand. ($.5 \times 1 + .5 \times 0.5$). If women were 20% more productive that previously thought, our average hand was actually .80 full-hand ($.5 \times 1 + .5 \times 0.6$). Since neither total output or the number of slave has changed,

Figure 4: Estimated prices, 20-year old male slaves, 1800 to 1862 ($\rho = 0$)



the output per hand of female slaves, and the overall effect on female slave prices is positive. The models are not very sensitive to relative productivity assumptions, with the elimination of the gender productivity gap causing only limited changes in estimated prices, roughly $100.

The model is driven by two main factors: cotton prices and output per hand. These two series are shown in Figures 5 and 6, along with model estimates for $N3$ and $T10$. Output per hand dominates the long term upward trend, while cotton prices drive short term fluctuations, in addition to a long term moderate downward pressure on the slave price estimates.

output attributable to prime-aged male (full-hand) is now lower. Reducing the gender productivity gap reduces the amount of output attributed to male slaves and increases the amount attributed to female slaves.

Figure 5: Cotton price, output per prime-aged male and estimated slave price ($a = 20$, $N3$ model), 1800-1862

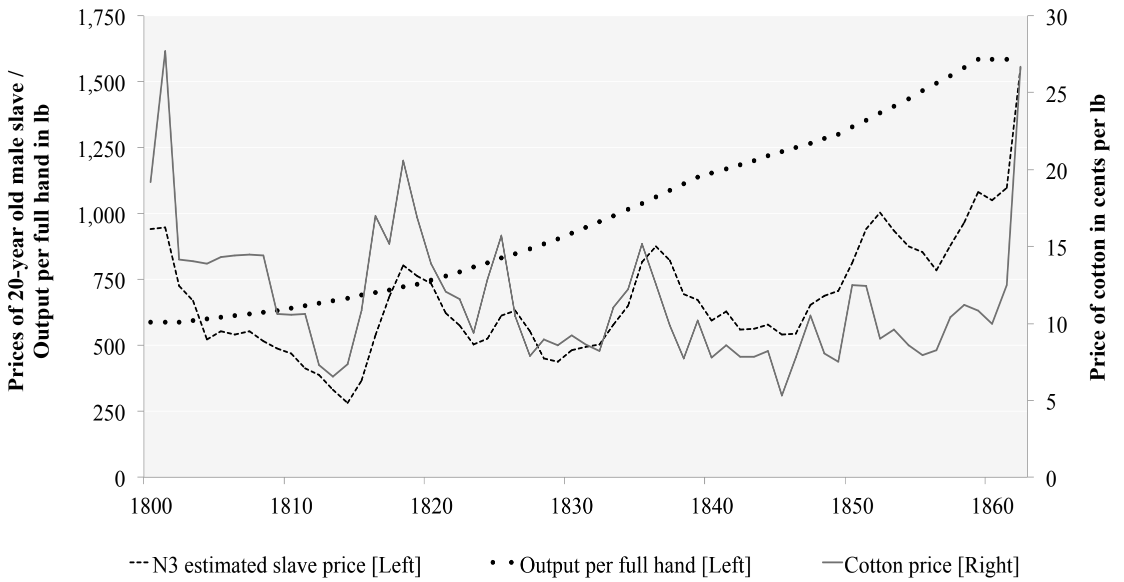
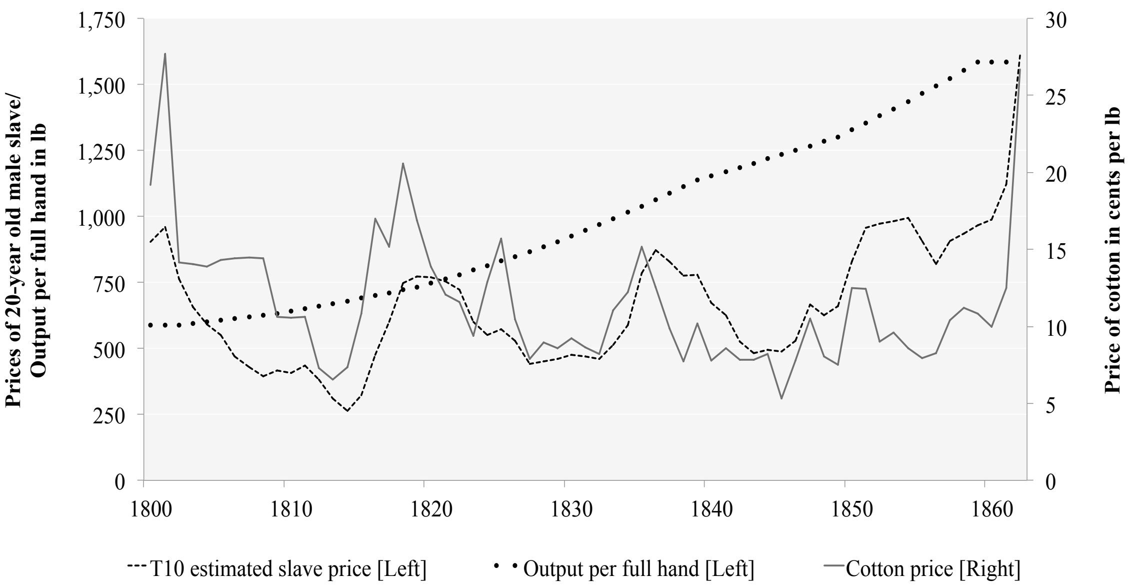


Figure 6: Cotton price, output per prime-aged male and estimated slave price ($a = 20$, $T10$ model), 1800-1862

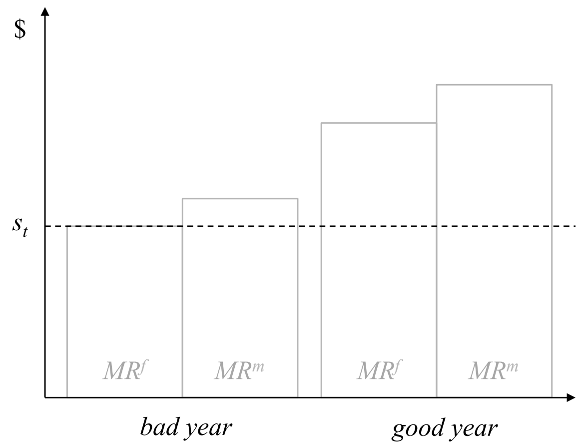


Female

Estimated prices for prime-aged female slaves, again assuming $a = 20$ and $\rho = 0$, follow much the same pattern as their male counterparts. The average value over the period is about \$100 lower than male slave prices. The calculated price for female slaves is approximately \$550 in 1820, decreasing to \$350 by 1840 and reaching \$1,000 by mid-century. On the whole, estimated female slave prices exhibit more relative variation than male prices. This is due to two elements: high fixed costs and synchronous expectations.

The first factor leading to greater variability in female prices, in proportion to male prices, is the cost structure. Subsistence costs (s_t = \$19.6) for female slaves were a higher share of their gross earnings than male slaves.[58] As a result, a decrease in the price of cotton could quickly erase any earnings above the subsistence level. Conversely, a good year can more easily lead to a doubling of net earnings for a female than for a male slave. This is illustrated graphically in Figure 7.

Figure 7: Illustration of the impact of high fixed costs in the variation of female net earnings



Let us turn to the second factor, synchronous expectations, by taking a look at two typical years, 1812 and 1835. In 1812, cotton prices were slightly lower than average and productivity half of that reached by 1860. In 1835, both prices and productivity were higher. This translates into higher current revenue from the mother, and higher expected future revenue from the child. The impact of each on net earnings is presented in Figure 8.[59]

[58] One would expect women to need less calories per day than men, but this does not factor in breast-feeding, which requires about 1000 calories a day. See Hopkins and Cardell [21], p.310 for a discussion.

[59] Such estimation required the computation of the price of female newborn, a source of endogeneity since adult and newborn prices are estimated simultaneously. The price of male newborn (O^m) can

As exemplified by earnings for the years 1812 and 1835, the two streams go up and down *together*, driven by synchronous expectations regarding cotton prices and productivity. In 1812 the value of offspring does not compensate for the loss of productivity and the pregnancy costs ($O < X$) and we see a drop in total net earnings in pregnancy years (20 to 42). In 1835 income from offspring boosts total net earnings to a level higher than that of an infecund woman ($O > X$).

As a result of these two factors, estimated female prices exhibit substantial variation, regardless of the expectation formation mechanism. Over the period 1820-1860, estimated female prices reach higher peaks ($\max P^f_{20}$ =1,097 while $\max P^m_{20}$ =1,081, both in 1859) and lower troughs ($\min P^f_{20} = 25$ while $\min P^m_{20} = 438$, both in 1829). Overall, female prices are more volatile ($\hat{\sigma}^f_{N3} = 293, \hat{\sigma}^m_{N3} = 176, \hat{\sigma}^f_{T10} = 310, \hat{\sigma}^m_{T10} = 185$).

When we compare the share of the variation in male and female prices due to the long term trend, for instance by fitting a linear or second-degree time trend, we obtain similar values for R^2. All the gender-specific variation in the model originates in cotton prices, since survival rate and relative productivity estimates are assumed to be constant over the period. Therefore, as a result of their cost structure and synchronous expectations, estimated female prices take a wider range of values. In a sense, these factors *magnify* the underlying randomness of cotton prices shared by both male and female prices. Figure 9 shows estimates of female slave prices over the period using the two different buyer expectation formation mechanisms.

We note that the theoretical price of female slaves was actually negative from 1811 to 1815. This period of negative prices coincides with the Napoleonic Wars, which depressed U.S. exports by limiting access to ports in Britain and Continental Europe.[60] Figure 8 (a) provides the intuition: in such years of lower than average cotton prices, the value of children was close to zero, or even negative. Meanwhile, the net earning of women barely covered their subsistence costs. In such years, and based on neutral expectations regarding net earnings growth ($\rho = 0$), it would be rational to free female slaves. Since this is not what happened, it may imply that slave owners expected the

be calculated exogenously, as per (6), but the price of female newborn (O^f) cannot. Assuming equal probability at birth for each gender, I tested various heuristics for the price of children. There is no material difference between the simple and constant $O^f = \gamma O^m$, where γ is the average gender premium observed over the period, $\gamma = 0.85$, on one hand, and the more sophisticated

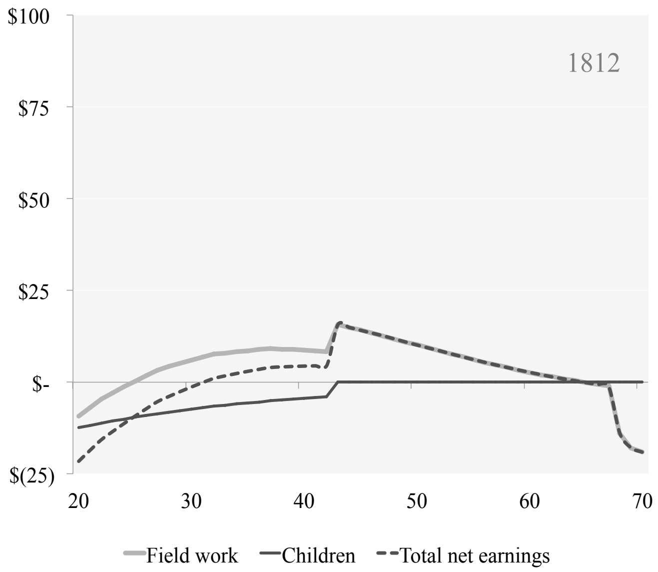
$$\frac{O^f}{O^m} = [\frac{P^f_{20}}{P^m_{20}}]_{t-1}$$

where the gender premium for children is a function of the gender premium for adult observed the previous year, on the other. As a result, I used the simpler version in both $N3$ and $T10$ models.

[60] North [35], Table 1, p.577

Figure 8: Estimated net earnings, from field work and children, for a female slave (N3 model, $\rho = 0$)

(a) 1812: Cotton at 7.3 ¢/lb., output per full-hand of 661 lb, $O = -9.18\$$



(b) 1835: Cotton at 15.2 ¢/lb., output per full-hand of 1039 lb, $O = 106.48\$$

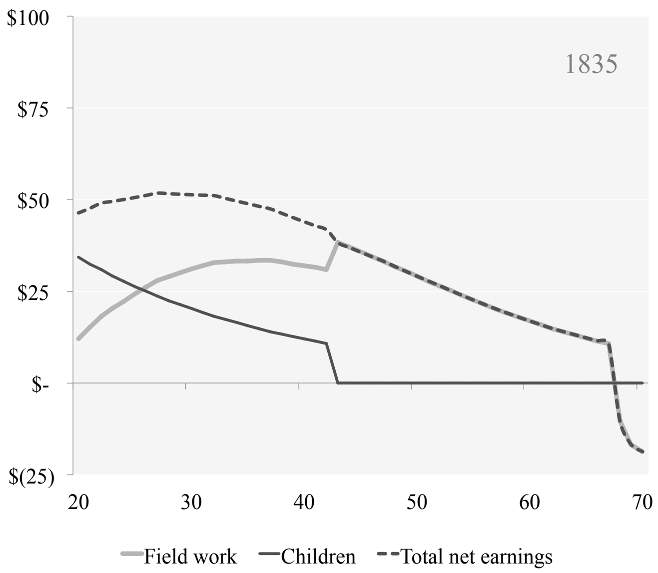
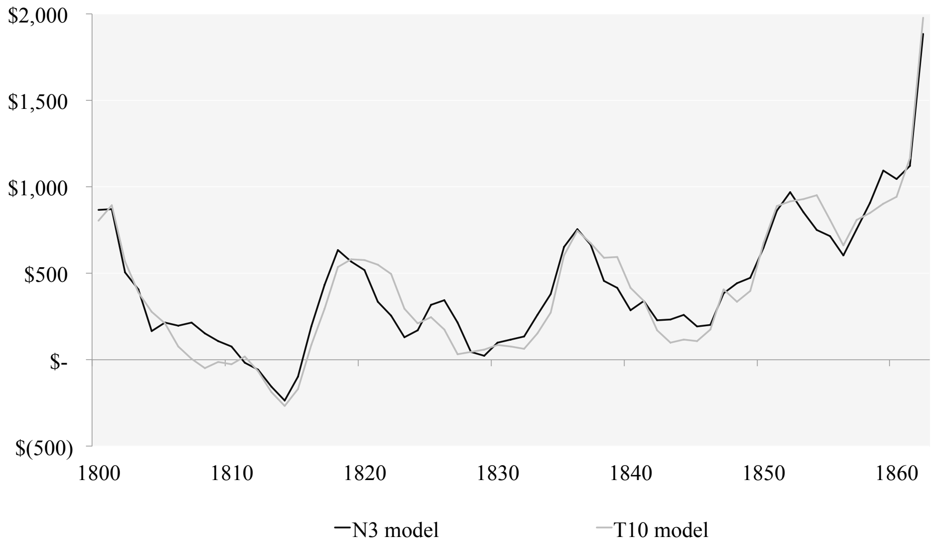


Figure 9: Estimated prices, 20-year old female slaves, 1800 to 1862 ($\rho = 0$)



investment outlook to brighten ($\rho > 0$). More importantly, we must keep in mind the impracticality of selectively freeing slaves, and the relatively small importance of cotton at the beginning of the century.

To my knowledge, there exists only one estimate of pregnancy costs, from Conrad and Meyer, placing it at $50.[61] So far in this paper, I have used the work of Conrad and Meyer, the earliest paper on slave prices with an asset pricing theory foundation (1958) as an inspiration rather than a source, and preferred more recent sources whenever available. Do price projections rely too heavily on this assumption? Reducing or increasing these costs by 50% does not greatly impact the predicted prices, with changes of about $100.

As with male projections, the main drivers of estimated female prices are output per hand and productivity. We now turn to actual prices, as observed on the New Orleans slave market between 1820 and 1862.

3.2 Observed slave prices

The main reference for empirically observed slave prices is a paper by Laurence Kotlikoff.[62] Kotlikoff explores the *New Orleans Invoices*, a sample of 5,000 slave trades covering 1804 to 1862.

[61] Conrad and Meyer [10]
[62] Kotlikoff [26]

New Orleans Invoices

This dataset was originally used in Fogel and Engerman[63] and is one of the most comprehensive on slave trades. New Orleans was the largest slave market and was a predominantly local market on the buy-side (90% of buyers were Louisiana residents) but the sell-side had a large interregional component (one in three slave sold originated outside the state and were disproportionately male and of prime age).

Was New Orleans representative of the entire South? Ewing, Payne, Thornton and Yanochik analyze price shock propagation in four regional markets (Richmond, VA, Charleston, SC, Macon, GA and New Orleans, LA) from 1800 to 1860.[64] There was no legal prohibition to the trade of slaves over state lines, no tariff, quota or other barrier. One possible hindrance to trade was the moral stigma attached to breaking up families. This possibility was mitigated by the fact that many owners themselves moved westward (accounting for 50% of slave movements), and many slave sales occurred at the owner's death or in case of bankruptcy. They conclude: "the antebellum market for slaves had few barriers to slave trading other than normal transport and transaction cost" (p. 277).

In the context of a westward expansion, most importing was into western markets (New Orleans, Macon) and most exporting from eastern markets (Charleston, Richmond). As described by the authors, "[t]he American slave economy followed a westward, expansionary path and, given the cost of transportation and communication, we would expect the impact of price shocks to be the greatest when a market lies the immediate east of the location in question" (p. 286). This is what their results exhibit for Charleston and Macon. In the case of New Orleans, however, the strongest reaction to a price shock is found in Richmond. There is indeed a well-documented history of exchange between the two cities, mainly due to "a relatively efficient coastwise shipping network" (p. 286).

The authors point out that the timing of shock absorption is consistent with supply-side constraints: crop seasonality, transportation over land or sea, and the "production" of new slaves. While some marketplaces reacted more strongly than others, regressions show synchronous propagation of shocks in the 2-8% range, supporting the thesis that the slave market was regionally integrated.

The New Orleans slave market was therefore large enough and well integrated enough to capture the main market trends for the entire South. 135,000 slaves were traded over

[63] Fogel and Engerman [18]
[64] Ewing, Bradley T., et al.[15]

the period. The *Invoices* are a random sample of 5,000 trades, or 2.5% to 5% of the total depending on the year, that provide information on the gender, age, skin color, skills and defects of the slave, as well as the date and price of the slave.[65]

Observed slave prices

The price of prime age male hand was in the $400 to $1,400 range between 1820 and 1860. It increased over the period, including in the run up to the Civil war.[66] Prices for select years are presented in Table 8.

Table 8: Price of prime-aged male slaves, New Orleans (1830 $)

year	**price**
1820	751
1830	579
1840	766
1850	755
1860	1,420

Source: Kotlikoff [26], Chart I, p. 498.
Average of prices for slaves between ages 21 and 38.

The key price determinants are: gender (male premium of 9.1%), age (peak of slave values around age 22), skills (skill premiums of 23.6% to 48.8%) and certainty (guarantee[67] premium of 26.0% for females and 31.9% for males). Together, these factors explain approximately half of the variation in prices.

Kotlikoff's price series for prime-aged male slaves is based on an *average* of prices for slaves age 21 to 38.[68] This is only indirectly comparable to my estimated prices, due to a difference in the age range. I test the validity of using the Kotlikoff series as a proxy for actual prices by going back to the original *New Orleans Invoices* dataset, predicting prices for slaves aged 20 years old, and comparing the two series.

The original sample contains 5,009 trades. Following Kotlikoff and Levendis[69], I exclude trades with no price reported on the bill of sale (689 observations), and trades including multiple slaves, because each slave is not itemized (1,599 observations). This leaves 2,721 to estimate actual prices, or 20 to 70 observations per year. Given the small

[65] Invoices documented the slave owner's title. The stakes were high enough to warrant accuracy.

[66] The price did fall by 70% in real terms between 1861 and 1862 "indicating growing concerns about the ultimate outcome of the War" (Kotlikoff [26], p. 501).

[67] 84% of slaves were fully guaranteed by the seller, typically for a year. Some guarantees included provisions for known defects, such as rheumatism or alcoholism. See Kotlikoff [26], p. 504 for a short discussion.

[68] Kotlikoff [26], p. 500

[69] Levendis [27], p.162

sample size for each year, I group trades by three-year periods, which leads to a sample size of 60 and over, 19 times out of 20. I estimate the following model by OLS:

$$price_t = \beta_0 + \beta_1 male + \beta_2 skill + \beta_3 credit + \beta_4 guarantee + \beta_5 age + \ldots + \beta_{10} age^6 \quad (7)$$

where *male* is a gender dummy, *skill* takes a value of 1 for skilled slaves (cook, engineer, etc.) and 0 for slaves without skill or labelled as field hands, *credit* is a dummy variable for trades not paid upfront, *guarantee* is a dummy variable taking a value of 1 for guaranteed slaves, and $age - age^6$ is a six-degree polynomial for age.[70] This is a simplification of the Kotlikoff model, which contained over 30 variables, including skin colour, skill-age interactions, etc.

A regression on the whole sample, unrealistically assuming a constant price-structure over the sixty year period, shows all variables are significant at 98% level, except for the constant and *age* (first degree of the polynomial) variable.[71] The Kotlikoff averages and the fitted values from the 3-period regression are presented in Figure 10. We see that the fitted values are very close to the Kotlikoff averages series. Consequently, I will use the Kotlikoff series as a proxy for slave prices because, unlike the fitted values, the averages are available on a annual basis. I note the average applies to ages 21 to 38; it is therefore no surprise that the fitted values for twenty-year olds are slightly (2.5%) higher. The Kotlikoff series is adjusted accordingly.

A similar regression was run for female prices. As shown in Figure 11, the Kotlikoff average male price adjusted for the decennial gender premiums are also a valid proxy for the female price series. The fitted values for twenty-year old female slaves are also higher, this time by 5.8%. Accordingly, the Kotlikoff series is adjusted upward in the subsequent analysis.

[70] As used by Kotlikoff [26]

[71] The parameter estimates for the 1804-1862 period are $price_t = -24.94 + 82.38 male + 76.61 skill + 73.82 credit + 157.59 guarantee - 38.32 age + 10.93 age^2 - 0.61 age^3 + 1.46 \times 10^{-2} age^4 - 1.623 \times 10^{-4} age^5 + 6.89 \times 10^{-7} age^6$.

Figure 10: Price of prime-aged male slaves, yearly averages (ages 21 to 38) compared to fitted values (age 20), nominal $, 1800-1862

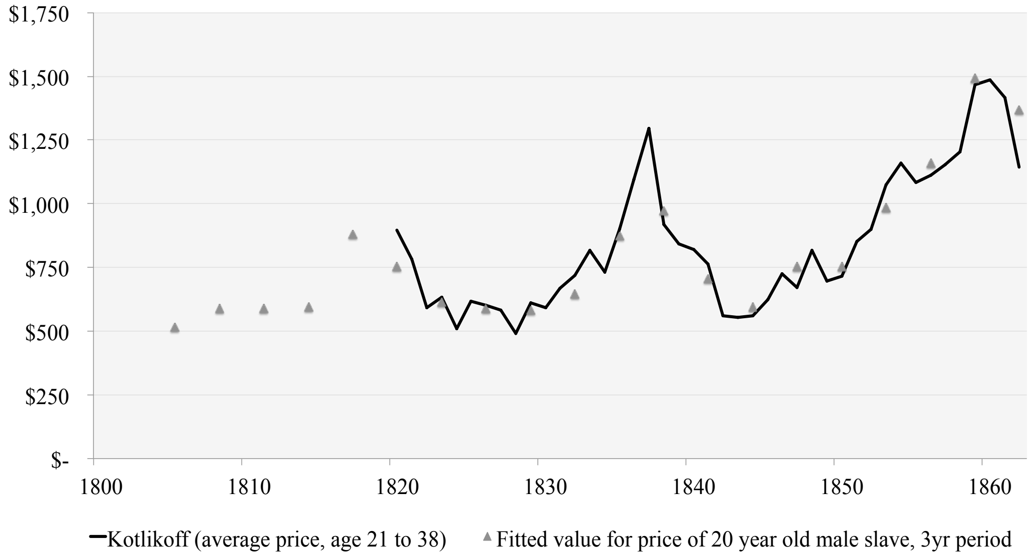
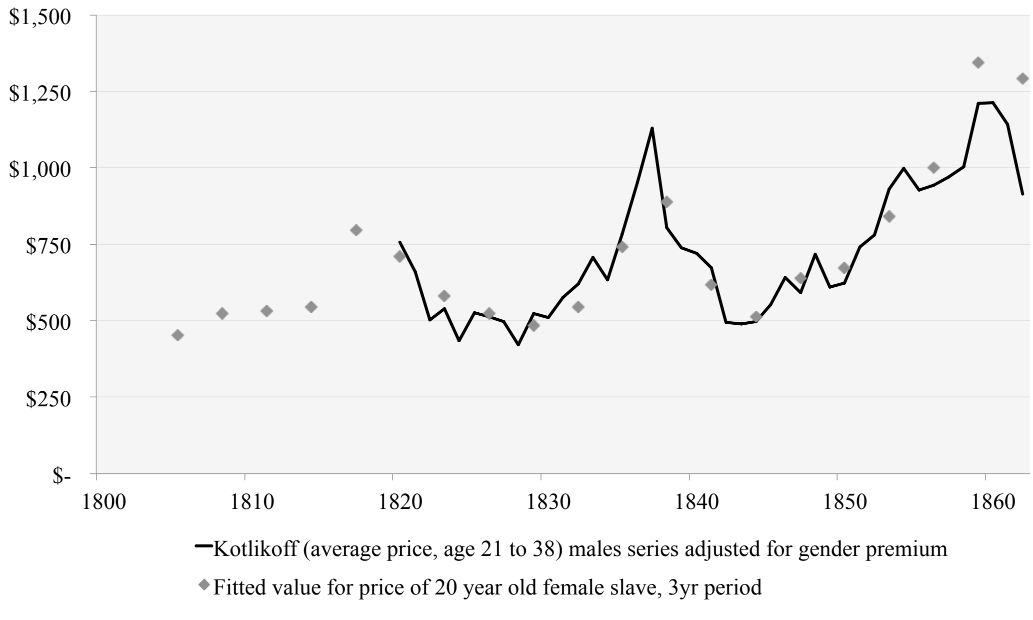


Figure 11: Price of prime-aged female slaves, yearly averages (age 21 to 38) compared to fitted values (age 20), nominal $, 1800-1862



3.3 Comparative analysis of slave prices

Male

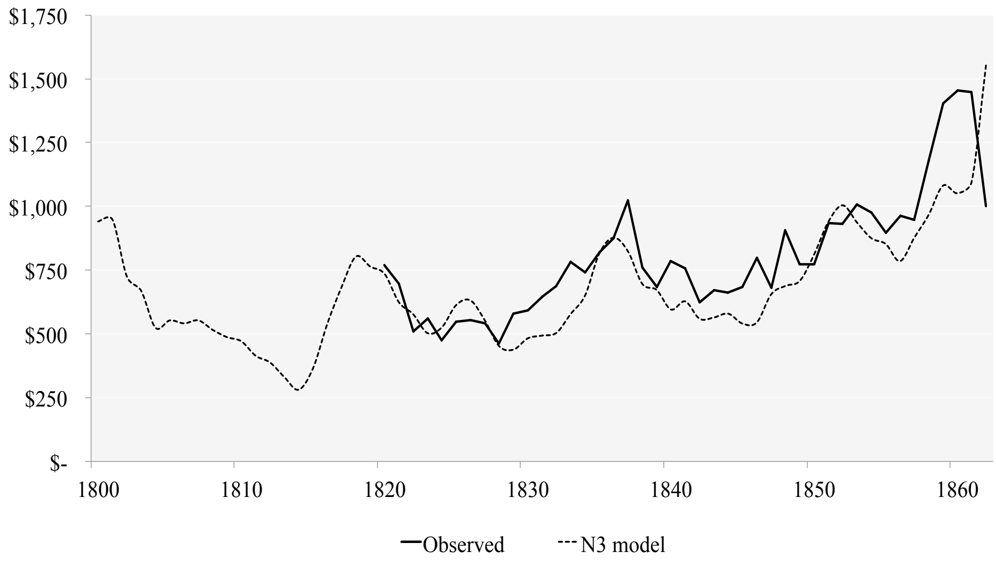
Let us compare the fit of two models, $N3$ and $T10$. Both series are highly correlated with actual prices: the Pearson product-moment correlation coefficient is 0.85 for $N3$ and 0.78 for $T10$. Figure 12 displays the evolution of estimated and actual prices.

I use the Mean Square Error (MSE) to measure their relative performance. MSE is a valuable tool in estimating the performance of competing models because it penalizes the two potential negative aspects of a model:[72] lack of precision (variance of observed vs. variance of estimated prices) and bias (mean of observed vs. mean of estimated prices):

$$MSE(\hat{P}) = E[(\hat{P} - P)^2] = Var(\hat{P}) + [Bias(\hat{P})]^2 \tag{8}$$

Figure 12: Price of 20-year old male slaves, estimated and observed, 1800-1862 ($\rho = 0$)

(a) N3



(b) T10

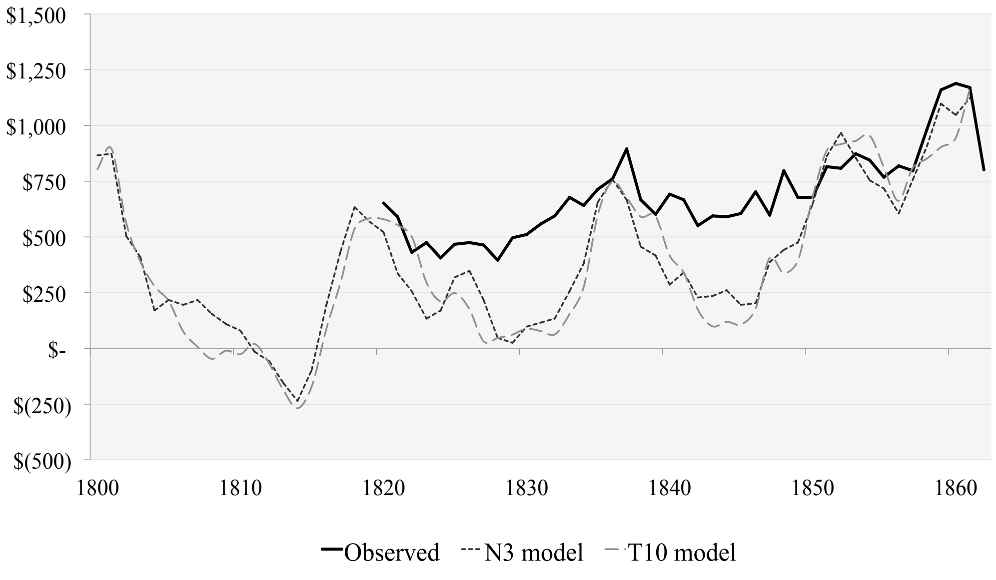
[72]A drawback of MSE is that it imposes a 1:1 trade-off between accuracy and precision.

The Root Mean Square Error ($RMSE = \sqrt{MSE}$) is more convenient to discuss because it is expressed in the same units as the variables of interest. With $\rho = 0$, we find $RMSE_{N3}(\hat{P}) = 139.5$ and $RMSE_{T10}(\hat{P}) = 165.9$ for the period 1820-1860. The model consistently underestimates prices, by roughly 10%.[73]

Female

The female prices series, shown in Figure 13, also move in sync with actual prices, with correlations of 0.84 ($N3$) and 0.76 ($T10$). One major difference with the male model fit is the variance. It appears actual prices were less volatile than theory would predict. As a result, the RMSE values are higher. With $\rho = 0$, we have $RMSE_{N3}(\hat{P}) = 272.4$ and $RMSE_{T10}(\hat{P}) = 301.7$. Once again, the model estimates are lower than observed values, this time by approximately 35%. Figure 13 shows estimated and actual prices for female slaves.

Figure 13: Price of 20-year old female slaves, estimated and observed, 1800-1862 ($\rho = 0$)



Note: Observed female series obtained by deducting the gender premium estimated by Kotlikoff from the male price series.

With our theoretical pricing model on firm footing, we now turn to the changes in buyer's beliefs that emerge from comparing theoretical to actual prices.

[73]This is the Mean Percentage Error $MPE = \frac{100\%}{n} \sum_{t=1}^{n} \frac{\hat{P}_t - P_t}{P_t}$

4 Revealed Expectations & Changes in Investor Sentiment

In this final section, I briefly discuss the changes in investor sentiment implied by the gap between the estimated and observed prices and the historical context in which these changes took place. For example, in the first years of the Civil War, the price of cotton increased, lifting estimated slave prices. Buyer expectations, however, taking into account the current disruptions and future risks caused by the war, heavily discounted future payoffs, leading to a large wedge between estimated and observed prices.

4.1 Implied expectations regarding slave prices

Let us rewrite the general version of the model, from (2).

$$P_{20} = \sum_{t=20}^{T} \pi_{t:20} \frac{(1+\rho)^{t-20} E(MR_t - C_t)}{(1+i)^{t-20}}$$

In order to identify the implied beliefs of buyers, we must find the parameter ρ that will make the estimated price (right-hand side) and the observed price ($\mathring{P}$) coincide. That is, we must solve (2) for ρ and $P_{20} = \mathring{P}$. The higher the value of ρ, the more sanguine, or bullish, the investor sentiment.

Over the period I obtain, on average, $\bar{\rho}^m_{N3} = 0.83\%, \bar{\rho}^f_{N3} = 1.38\%$, $\bar{\rho}^m_{T10} = 0.37\%$, and $\bar{\rho}^f_{T10} = 2.60\%$. Investor sentiment was, therefore, broadly positive. This is in line with the steady annual productivity increase of 1.64% described in Section 2. Furthermore, for both models, the average value for female slaves is higher than for male slaves, consistent with the previous discussion of the more volatile, riskier nature of female slaves. The evolution of this expectation ρ over time, for both genders and both models, is presented in Figure 14, where expectations are expressed as deviations from $\bar{\rho}$.

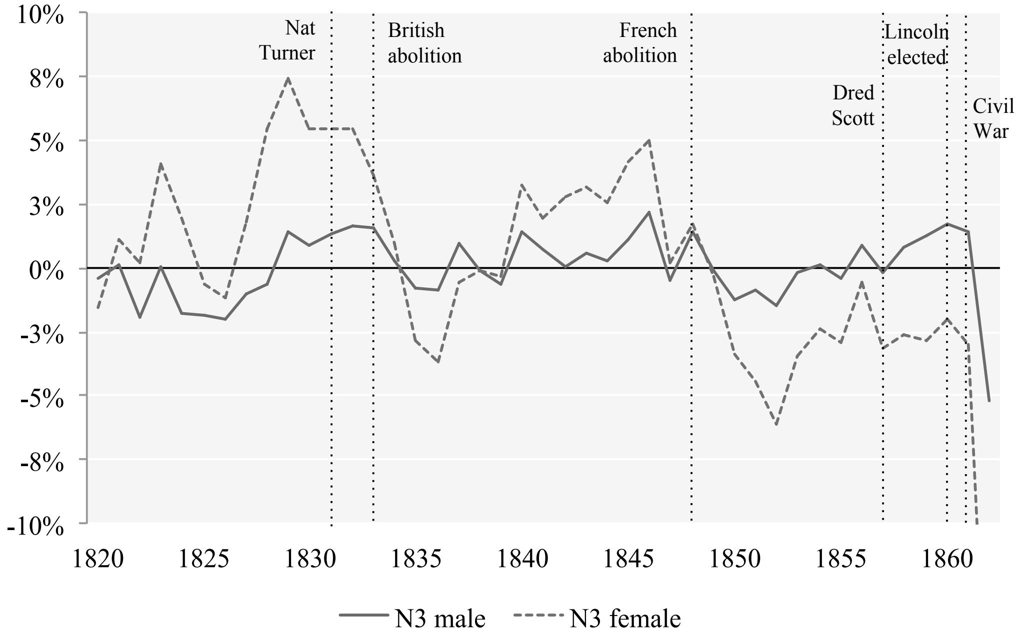
The slave market saw two bull runs over the period, from the mid-twenties to the mid-thirties and for the better part of the forties. This results contrasts with Kotlikoff's discussion of depressed slave prices (p. 500). In these two periods, price might have been low but once fluctuations in output prices is taken into account, the decrease was moderate and sentiment was positive.

A note on risk and liquidity

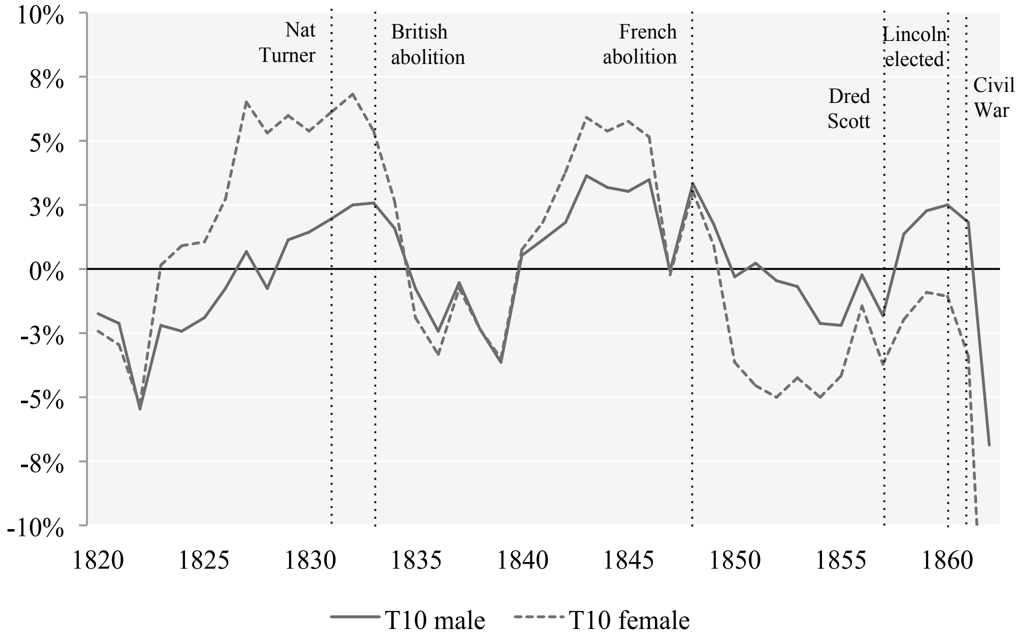
The risk-neutrality assumption can be relaxed, affecting estimates of ρ as follows: Cochrane, in his discussion of "risk corrections", outlines the importance not of the

Figure 14: Evolution of expectations regarding slave prices (deviations from $\bar{\rho}$), 1820-1862

(a) N3 model, $a = 20$



(b) T10 model, $a = 20$



variance of the expected return, but of the *co*variance of the expected return and the utility of the investor. In a world of risk aversion and concave utility functions, "[i]f you buy an asset whose payoff covaries positively with consumption, one that pays off well when you are already feeling wealthy, and pays off badly when you are already feeling poor, that asset will make your consumption stream more volatile".[74] Theoretically, we know from (2) that $\frac{dP}{dEarnings} > 0$. Naturally, this relationship holds empirically as well, with $corr(\textit{farm prices, slave prices}) = 0.76$ for the period 1820 to 1862. In comparison, investing in more traditional asset prices, such as those offered by banks, has in many cases a negative and weaker correlation to consumption (e.g. $corr(\textit{cotton prices, Philadelphia asset prices}^{75}) \approx -0.06$). As a result, asset pricing models based on utility functions predict risk-averse investors will be willing to pay a higher price for assets less correlated with their overall consumption, as appears to have been the case for southern plantation owners.

Another aspect to keep in mind is liquidity preference. Slaves, albeit frequently traded at New Orleans, required transportation and there were other trading costs. This made slaves less liquid than alternative assets, such as municipal bonds or railroad stocks.

Since we have $\bar{\rho} > 0$ (i.e. on average, $P_{20}(\rho = 0) < \mathring{P}$), it follows from risk and liquidity preferences of investors that the values of $\bar{\rho}$ implied by the model are likely biased downwards. This, however, does not prevent us from analyzing our variable of interest: the changes in investor sentiment, in the form of deviations from $\bar{\rho}$. In the last section, I will therefore focus on this measure.

4.2 Historical context and changes in investor sentiment

I now use the index of investor sentiment for the period 1800-1862, as described in Figure 14, to investigate its relation to the traditional historical narrative. I take two approaches: historical and econometric.

First, I list important historical events that may have impacted the expectations of investors and relate those to my estimated changes in sentiment. Second, I take a more agnostic approach, and, without making assumptions regarding the historical "turning

[74] Cochrane [9], p. 13

[75] Bodenhorn and Rockoff [5], Table 5.2, p. 167. The correlation coefficient presented here is that of cotton prices as presented in Table 4 and the inverse of the rate of return on earning of Philadelphia bank assets. While the inverse of the rate of return is an imperfect proxy for asset prices, it illustrates the lack of correlation of the two series.

points", test for structural changes in the four series (one for each gender or "asset type" and model). In other words, I look for fundamental changes in sentiment in the form of a significant deviation from $\bar{\rho}$.

Historical approach: impact of key events

Willard, Guinnane and Rosen, in their analysis of Civil War events through the lens of the Greenback market, consider several possibilities in comparing the historical record to asset prices.[76] On the one hand, some turning points in asset prices coincide with well-documented historical events ("type A"). For example, Willard et al. find the dates of the Battle of Gettysburg, July 1-3 1863, to coincide with short-term and long-term increase in the value of Greenbacks. On the other, other events generally regarded to have been of great significance did not have a large impact on asset prices ("type B").[77]

My measure of the impact of historical events on investor sentiment is the one-year change in ρ, adjusted for the standard deviation of the series:

$$\Delta\rho = \frac{\rho_{t+1} - \rho_t}{\sigma_\rho} \tag{9}$$

Table 9 presents the main events of the period, associated changes in investor sentiment and event type. But first, below is a short description of select events: the largest domestic slave rebellion on record (Nat Turner's); two large abolitions overseas (British and French); a landmark Supreme Court decision (Dred Scott v. Sandford); a disputed presidential election (1860); the start of the Civil War.

1831 - Nat Turner's rebellion

The Southampton insurrection, as it is also known, was "the greatest slave rebellion in United States history."[78] In August 1831, Nat Turner led a group of seven slaves, killing his masters in their sleep before spreading violence to neighbouring whites, In total there were 57 white victims. Only 75 slaves joined the revolt, which was suppressed by the state militia within days. The short-lived rebellion nonetheless sparked in the state's assembly, the "great slavery debate of 1831".[79] As Drescher notes, "[t]here appears to

[76] Willard, Guinnane and Rosen [43]

[77] Willard, Guinnane and Rosen work with daily data and can therefore, adjusting for the time the news would take to reach New York, test these scenarios. In my case, annual data is not precise enough to warrant event studies.

[78] Howe [25], p. 323

[79] Howe [25], p. 326

be a fairly broad consensus that the mid-1830s were a pivotal moment in the development of pro-slavery, [...] Drew Gilpin Faust places the turning point a few years earlier, with Thomas Roderick Dew's meditation on Virginia's debate over emancipation in the wake of Nat Turner's rebellion."[80] The immediate reaction of the Virginia legislature "increased repression: tighter pass rules for slave travelers and more patrols to enforce them, further restraints on the free colored population, and, specifically to inhibit the emergence of more Nat Turners, restrictions on slave literacy and religious gatherings."[81]

1833 - British abolition of slavery

After first banning the transatlantic slave trade in 1807, the British Parliament abolished slavery in 1833. This followed pressure from civil society in the form of petitions[82] and elections, supported by the Jamaican rebellion of 1831: "[t]he Slave Emancipation Bill came before Parliament after three years of increasing pressure from without."[83] Over 700 000 slaves became 'apprentices' under obligation to serve their former masters for a certain number of years before eventual emancipation. Slaveowners received compensation for their loss of property.

1848 - French abolition of slavery

France first attempted to abolish slavery in 1794, but it was restored by Napoleon in 1802, both in the context of the battle over St-Domingue and the Haitian revolution. Slavery was finally abolished in the French colonies in the wake of the 1848 revolution.[84]

Dred Scott v. Sandford

Dred Scott, a Virginia-born slave, sued his master for his freedom, having lived in free Illinois and Wisconsin. His request was denied. "The Supreme Court's Dred Scott decision held that the federal constitution was indeed a document that implicitly protected slavery throughout the nation. It definitively ruled that the Constitution prevented congressional interference with southern property rights in the territories. The decision also attempted to define the status of African Americans, ruling that blacks had not been nor could they be citizens of the United States."[85]

[80] Drescher [12], p. 309, footnote 36
[81] Howe [25], p.326
[82] Over 1.3 million signatures were collected in that year alone.
[83] Drescher [11], p. 121
[84] Drescher [12], p. 282
[85] Drescher [12], p. 327

Lincoln election, Secession and Civil war

In November 1860, Republican Abraham Lincoln is elected president of the United States, winning all of the free states and not a single slave state. His Democratic opposition was divided between North and South. According to McPherson, "Democrats below the Potomac considered Lincoln a relentless, dogged, free-soil border ruffian ... a vulgar mobocrat and a Southern hater ... an illiterate partisan ... possessed only of his inveterate hatred of slavery and his openly avowed predilections of negro equality' ".[86] South Carolina was first to secede, on December 20, 1860, followed by Mississippi on January 9, Florida the next day, Alabama two days later, and Georgia, Louisiana and Texas within a few weeks.[87] War erupted on April 12, 1861.

Table 9: Impact of key historical events on investor sentiment ρ, antebellum South, 1820-1862

year	**event**	**expected effect**	$\Delta\rho_{N3}$ male	$\Delta\rho_{N3}$ female	$\Delta\rho_{T10}$ male	$\Delta\rho_{T10}$ female	**event type**
1831	Nat Turner's Rebellion	−	+0.22	−0.01	+0.21	+0.14	B
1833	British abolition	−	−0.98	−0.60	−0.42	−0.55	A
1848	French abolition	−	−1.07	−0.45	−0.64	−0.43	A
1857	Dred Scott v. Sandford	+	+0.71	+0.11	+1.32	+0.35	A
1860	Lincoln elected	−	−0.25	−0.22	−0.27	−0.48	A
1861	Civil War declared	−	−4.79	−3.75	−3.62	−3.26	A

Note: Changes in ρ measured in standard deviations from reference year: $\Delta\rho = \frac{\rho_{t+1}-\rho_t}{\sigma_\rho}$

Of these six critical events in the History of Slavery in the United States, five are Type A events. Both British and French slavery abolitions were followed by a worsening of investor sentiment in the United States. In 1834, there is a decline in investor sentiment of .42 to .98 standard deviations in all four series ending bull runs that had lasted five to ten years. The French emancipation coincides with declines of .43 to 1.07 standard deviations the following year, marking an end to the second bull run of the period.

The year following the Dred Scott Decision, which strengthened the institution of slavery throughout the United States, investor sentiment rose, from .11 to 1.32, depending on the model, as could be expected.

The election of Lincoln and the start of the Civil War caused sentiment, as captured

[86] McPherson [34], p. 228
[87] McPherson [34], p. 235

by the models, to fall by .22 to .48 in 1861 and by a shocking 3.26 to 4.79 in 1862. The deeply bearish view adopted was, by far, the lowest sentiment on record. According to a working paper by Calomiris and Pritchett, the pessimism was not gender-specific, which would have revealed a 'shorting' of slavery by investors, but rather an across the board downgrade of future prospects due to the cost and disruptions caused by war.[88]

The only event not to create the expected impact is the Ned Turner Rebellion. It appears the reaction of the legislature pacified investors, since the data shows no overall negative impact on investor sentiment, making it a Type B event, according to the framework.

Econometric approach: Structural change tests

Willard, Guinnane and Rosen distinguish a third type of event ("C"), not easily reconciled with recorded history, and point to potential gaps: these events changed the views of historical actors and should be further studied. In order to search for such an event, I will now take a different approach, by searching for breaks in the investor sentiment series without presuposing a specific break date. The null hypothesis is that investor sentiment is constant over the period, that is, $\bar{\rho}$ is constant. The alternative hypothesis is that there exist one or more breaks in the series[89], meaning that sentiment fundamentally changed at some point over the period, reaching a 'new normal', for instance taking a *permanently* more bearish stance. In this sense, the econometric approach is complementary to the historical approach outlined earlier, because it looks for sustained changes, not year-on-year swings.

I use the Bai-Perron methodology for estimating and testing for multiple structural breaks.[90] This methodology searches for the break dates in the series parameters that will significantly reduce the sum of squared residuals of the model. In this case, the model is constant-only ($\bar{\rho}$) and Bai-Perron tests for changes in this parameter that improve the fit of the model. In other words, it tests various dates at which the underlying sentiment $\bar{\rho}$ could have changed.

Up to four breaks are tested for each model, and, each time, a test is computed to determine if the additional break makes a significant contribution to the explanatory

[88] Calomiris and Pritchett [8]

[89] To be more precise, there are several tests for m breaks (the null hypothesis) vs. $m+1$ breaks (the alternative hypothesis) for $m = 0, 1, 2, ...$ (This is but one of the many helpful comments I received from James McNeil regarding this subsection).

[90] Bai and Perron [1], [2], [3]

power of the model.[91] Each of the four sentiment series are tested (maleN3, femaleN3, maleT10, femaleT10) for two trim specifications. The trim is the length of the potential break segment, or minimum distance between each break. I test for .05 and .15, that is, 5% and 15% of the series length of 43 years (1820-1862) or 2 years, and 6 years respectively.[92]

The question asked is therefore, when, if at any time, did investor sentiment break from its long term trend ($\bar{\rho}$) for a period of 2 (6) years, between 1821 (1825) and 1860 (1856)?

The male series do not exhibit any significant breaks in any of the specifications tested: investor sentiment regarding male slaves has fluctuated around its average over the period, but there have been no fundamental shifts in underlying sentiment.

The female series each contain a significant break, all pointing to the year 1849 as the most likely structural break in investor sentiment regarding female slave prices. 1848 was the year of the French abolition, the second of its kind by a large colonial empire after Britain in 1833. Therefore I cannot conclude this is a Type C event: it appears that this large change coincides with a noted historical event.

Conclusion

As I have shown, a carefully built model can accurately estimate theoretical prices for slaves throughout the period. The prices obtained correlate with the fluctuation in observed prices by a factor of .76 to .85. From the difference between estimated and actual prices, I construct an investor sentiment index. This index provides a new perspective on the evolution of slave prices. The previous benchmark, past slave prices, led Kotlikoff to conclude that "[b]y 1845 nominal slave prices were trending upward and continued in that direction until the early years of the Civil war" (p. 500). The investor sentiment index shows this increase was more moderate than previously thought given strong cotton price and productivity fundamentals, and sentiment was, on balance, negative for 1845-1862. Furthermore, the "depressed slave prices" (p. 500) of the 1820s

[91] Test results are presented in Appendix A. All critical values are reported at the 5% significance level (denoted **).

[92] The trim, a required feature of Bai-Perron methodology, means segments (of lengths 2 or 6 years) are excluded from the sample at beginning and end of the series. The change in sentiment of over 3 standard deviation noted in the previous section in 1861-1862 is therefore not in the scope of the econometric analysis. Had the Union troops not taken New Orleans in the Spring of 1862, a longer timeframe would have allowed this event to be tested for potential structural break. It is fairly safe to say it would have proved such a turning point. Larger values of the trimming factor lead to more robust test results.

and 1840s were justified by lower output prices and were in reality higher than their fundamentals warranted. In both cases, slave prices do not prove a reliable proxy for the beliefs of slave owners, because they do not account for changes in fundamentals.

Our understanding of buyer beliefs in the U.S. South could be further investigated by applying the approach outlined in this paper to monthly slave prices data, as gathered by Calomiris and Pritchett (data not yet released). This higher frequency data would allow for event studies, as seen with Greenbacks and Graybacks, and help trace investor sentiment during the Civil War.

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A Appendix: Structural Change Tests

maleN3, Bai-Perron test for multiple structural breaks
-15% trim: baip malen3, breaks(4)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	6.5453787	8.58	-247.11666	-250.63906
H0/HA: 1/2 breaks	4.1527564	10.13	-247.94748	-253.23108
H0/HA: 2/3 breaks	1.7133431	11.14	-243.80262	-250.84742
H0/HA: 3/4 breaks	3.1693071	11.83	-240.04229	-248.84829

significant breaks: 0

-5% trim: baip malen3, breaks(4) trim(0.05)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	6.5453787	9.63	-247.11666	-250.63906
H0/HA: 1/2 breaks	6.2105348	11.14	-248.27919	-253.56279
H0/HA: 2/3 breaks	5.71591	12.16	-237.4302	-244.475
H0/HA: 3/4 breaks	4.9791535	12.83	-235.12538	-243.93138

significant breaks: 0

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femaleN3, Bai-Perron test for multiple structural breaks

-15% trim . baip femalen3, breaks(4)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	17.093728**	8.58	-161.53469	-165.05709
H0/HA: 1/2 breaks	1.6458261	10.13	-159.5352	-164.8188
H0/HA: 2/3 breaks	6.4822574	11.14	-144.78102	-151.82582
H0/HA: 3/4 breaks	16.700799†	11.83	-150.44364	-159.24964

significant breaks: 1 (1849)

-5% trim: baip femalen3, breaks(4) trim(0.05)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	17.093728**	9.63	-161.53469	-165.05709
H0/HA: 1/2 breaks	9.7562087	11.14	-163.32896	-168.61256
H0/HA: 2/3 breaks	1.8271305	12.16	-131.85766	-138.90246
H0/HA: 3/4 breaks	17.266821†	12.83	-141.24876	-150.05476

significant breaks: 1 (1849)

maleT10, Bai-Perron test for multiple structural breaks

-15% trim: baip malet10, breaks(4)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	8.33081	8.58	-201.76739	-205.28979
H0/HA: 1/2 breaks	3.687366	10.13	-202.05851	-207.34211
H0/HA: 2/3 breaks	6.7836005	11.14	-201.43774	-208.48254
H0/HA: 3/4 breaks	10.34211	11.83	-199.44302	-208.24903

significant breaks: 0

-5% trim:
baip malet10, breaks(4) trim(0.05)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	8.33081	9.63	-201.76739	-205.28979
H0/HA: 1/2 breaks	3.8732699	11.14	-202.05851	-207.34211
H0/HA: 2/3 breaks	6.7836005	12.16	-195.18595	-202.23075
H0/HA: 3/4 breaks	3.7658416	12.83	-192.64346	-201.44946

significant breaks: 0

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femaleT10, Bai-Perron test for multiple structural breaks

-15% trim: baip femalet10, breaks(4)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	15.140317**	8.58	-149.90358	-153.42598
H0/HA: 1/2 breaks	5.4413939	10.13	-152.26514	-157.54874
H0/HA: 2/3 breaks	6.3604076	11.14	-138.07125	-145.11606
H0/HA: 3/4 breaks	18.595545†	11.83	-141.86452	-150.67052

significant breaks: 1 (1849)

-5% trim: baip femalet10, breaks(4) trim(0.05)

	F(l+1—l)	Crit. Val.	BIC u/HA	AIC u/HA
H0/HA: 0/1 breaks	15.140317**	9.63	-149.90358	-153.42598
H0/HA: 1/2 breaks	7.2807987	11.14	-153.46705	-158.75065
H0/HA: 2/3 breaks	8.4223535	12.16	-124.56918	-131.61398
H0/HA: 3/4 breaks	17.680731†	12.83	-131.66373	-140.46973

significant breaks: 1 (1849)

†The test results also point to a potential 4-break scenario. I discard this possiblity for two reasons: first, the information criteria are inferior to those for the 1-break model. Second, the four years suggested as breaks are inconsistent across different models, unlike 1849, which is the most likely break for all models.

B Appendix: Data Tables

Price of Cotton

Table 10: Price of cotton at the farm, in 1830 ¢ per pound

year	price	year	price
1800	19.2	1840	7.8
1801	27.7	1841	8.6
1802	14.2	1842	7.8
1803	14.0	1843	7.8
1804	13.9	1844	8.2
1805	14.3	1845	5.3
1806	14.4	1846	7.8
1807	14.5	1847	10.5
1808	14.4	1848	8.0
1809	10.6	1849	7.5
1810	10.6	1850	12.5
1811	10.6	1851	12.4
1812	7.3	1852	9.0
1813	6.6	1853	9.6
1814	7.4	1854	8.6
1815	10.8	1855	7.9
1816	17.0	1856	8.2
1817	15.2	1857	10.4
1818	20.6	1858	11.2
1819	16.9	1859	10.8
1820	13.9	1860	10.0
1821	12.1	1861	12.5
1822	11.6	1862	26.7
1823	9.4		
1824	12.9		
1825	15.7		
1826	10.5		
1827	7.9		
1828	8.9		
1829	8.6		
1830	9.2		
1831	8.6		
1832	8.2		
1833	11.0		
1834	12.2		
1835	15.2		
1836	12.5		
1837	9.9		
1838	7.7		
1839	10.2		

Source: U.S. Department of Agriculture [40], reduced by 0.8 ¢ per pound to obtain a 'farm price', following Conrad and Meyer [10], p. 105.

Estimated and Observed Prices - Male

Table 11: Estimated and observed male prices, 1820-1862

year	N3 estimate	T10 estimate	observed price
1820	735	770	770
1821	624	755	697
1822	577	722	509
1823	503	601	560
1824	526	549	474
1825	613	572	546
1826	631	529	553
1827	553	442	541
1828	452	451	461
1829	438	460	579
1830	482	476	593
1831	493	469	647
1832	504	461	688
1833	578	514	783
1834	650	588	740
1835	816	784	822
1836	877	871	875
1837	823	828	1,024
1838	696	777	761
1839	672	780	685
1840	595	673	785
1841	627	626	756
1842	559	526	622
1843	564	483	672
1844	579	495	663
1845	540	487	683
1846	545	528	797
1847	655	666	680
1848	688	625	907
1849	708	661	774
1850	812	829	774
1851	940	955	934
1852	1,004	972	931
1853	936	981	1,008
1854	875	995	976
1855	852	908	897
1856	785	820	964
1857	878	908	946
1858	967	933	1,178
1859	1,081	965	1,405
1860	1,051	988	1,455
1861	1,096	1,122	1,447
1862	1,552	1,610	1,001

Note: $a = 20$, $\rho = 0$

Estimated and Observed Prices - Female

Table 12: Estimated and observed female prices, 1820-1862

year	N3 estimate	T10 estimate	observed price
1820	520	579	650
1821	334	552	590
1822	256	497	432
1823	132	296	475
1824	170	210	403
1825	316	247	466
1826	346	176	472
1827	216	31	463
1828	47	46	395
1829	25	61	497
1830	98	87	510
1831	116	77	557
1832	134	63	594
1833	258	152	676
1834	378	275	641
1835	654	601	713
1836	756	746	761
1837	667	675	894
1838	454	589	665
1839	415	594	601
1840	287	417	691
1841	340	339	666
1842	226	171	550
1843	235	99	595
1844	260	119	588
1845	195	107	605
1846	203	174	703
1847	386	405	599
1848	441	336	796
1849	474	397	677
1850	647	677	676
1851	862	887	813
1852	968	915	808
1853	855	930	872
1854	753	952	842
1855	715	808	768
1856	603	661	818
1857	757	808	796
1858	906	850	982
1859	1,097	903	1,159
1860	1,047	941	1,188
1861	1,122	1,165	1,169
1862	1,882	1,979	799

Note: $a = 20$, $\rho = 0$