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Efficient markets: land and slave prices in Henrico County, Virginia, 1782-1863

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Abstract

Asset market efficiency fosters rational decisions on allocating resources, both individually and socially, and thus helps determine individuals' wealth accumulation and nations' economic growth. To date, however, there are little systematic data available for, and even less analysis of, US capital markets during the late eighteenth and mid-nineteenth centuries, a period of great transformation and growth. This paper is a preliminary exploration of market efficiency in two early US asset markets, looking at prices of land and slaves in Henrico County, Virginia, from the 1780s to the 1860s. Our hypothesis tests on both the price of and returns to Henrico County land and slaves provide evidence that land and slave markets in late eighteenth and early nineteenth century US were weak-form efficient, suggesting that available information was quickly and fully incorporated into prices in these early North American asset markets.

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1. Introduction

Asset accumulation plays a primary role in individual welfare and economic development. In particular, asset market efficiency fosters rational decisions on allocating resources, both individually and socially, and thus helps determine individuals' wealth accumulation and nations' economic growth. To date, however, there is little in the way of systematic data available for, and even less analysis of, US capital markets during the late eighteenth and mid-nineteenth centuries, a period of great transformation and growth.[1]

Although numerous studies have investigated the efficiency of various asset markets, most of these studies have focused on post World War II stock markets. Empirical results of efficiency tests on these markets are generally consistent. Although anomalies have been detected, stock markets appear to be, by and large, efficient.[2]

Under investigation in this study, however, are markets for real estate and human capital. The results from the literature on real estate market efficiency are mixed. In studies of some twentieth century real estate markets, it appears that all available information is not incorporated into current prices. But others suggest that trying to take advantage of such information would not yield abnormal returns once transaction costs are taken into account.[3] To date, we know of no tests of market efficiency in pricing human capital. This is hardly surprising since in contemporary economies property rights in human capital are inalienable. However, in the US South before the Civil War markets explicitly priced human capital and the issue of market efficiency is germane there.

This paper is a preliminary exploration of market efficiency in early US asset markets, looking at prices of land and slaves in Henrico County Virginia from the 1780s to the 1860s.[4] The study's contribution is twofold. First, this research provides the first systematic analysis of efficiency in human capital markets. Second, this study adds to our understanding of the portfolio decisions made by early American wealth holders by providing insight on how quickly and fully these early American asset markets for land and slaves incorporated available information into prices.

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[1] See, for example, Sylla (1975), James (1978), and Snowden (1990) for discussions of nineteenth century capital markets.

[2] See Malkiel (2003) for a defense of efficient markets theory in light of empirical anomalies found in the stock market and Lo (2008) for a summary of the current state of market efficiency research.

[3] See Gatzlaff and Tirtiroglu (1995) for a summary of early work done on real estate market efficiency. There does appear to be limited evidence of short-run autocorrelation in returns, indicating that all available information is <u>not</u> incorporated into current price. However, some of the studies indicate that trying to take advantage of this information does not yield abnormal returns once transaction costs are taken into account. See Hardin, Liano and Huang (2005), Linneman (1986), Guntermann and Smith (1987), and Rayburn, Devaney and Evans (1987) for evidence supporting efficiency in the real estate market. See Hamilton and Schwab (1985), Krashinsky and Milne (1987), and Case and Shiller (1989) for studies that do not support the efficient market hypothesis for the real estate market.

[4] Henrico County is located in Eastern Virginia and surrounds the better known city of Richmond. Richmond was a large city by the standards of the 19th Century US so perhaps we would expect the area to have had well-functioning asset markets.

2. Efficient Market Basics

Market efficiency is a fundamental concept in economics. A market is efficient if existing information is completely reflected in prices. Three types of market efficiency are identified, differentiated by the information set assumed and the efficiency tests performed. Checks for weak-form market efficiency, assuming knowledge only about past prices and returns of the variable under investigation, include tests for random walks, as well as autocorrelation, runs and trading schemes (including transaction costs), to examine whether using past realizations can yield an abnormal return. Semistrong-form tests are typically event studies investigating whether new public information is immediately integrated into prices or whether past values of publically available information contain additional information. Finally, strong-form efficiency tests examine whether abnormal returns can be made from inside information about a market (Eatwell, Milgate, and Newman 1989: 127).[5]

Looking back to one county in nineteenth century Virginia, we have constructed price series for land and slaves. Here, these series are used to investigate weak-form efficiency, represented as prices following a random walk.

The idea that “imperfect” nineteenth century asset markets operated in ways similar to twenty-first century financial markets may seem questionable. One might expect that sporadic trading of relatively heterogeneic, illiquid, indivisible assets in non-centralized, physically separated markets, may have led to market inefficiency.[6] However, it is important to note that as long as any market imperfections are “fully and rationally reflected in market price,” the market is efficient (Gatzlaff and Tirtiroglu 1995: 162). Although these issues may provide a challenge to the belief that eighteenth and nineteenth century land and slave markets were efficient, we take the question of market efficiency to be an empirical one.

3. Data

The Henrico land prices are hedonic prices constructed from McDevitt’s (2008) random sample of 1,356 deeds, handwritten records of land transactions from Henrico County *Deed Books* for the period 1782 to 1858. Various determinants of land prices, such as property, trader and exchange characteristics, are controlled for in construction of the index.[7] A new set of slave data is from Irwin’s comprehensive collection of over 8,200 slaves appraised in the probate records of the Henrico County Courts for the period 1782 to 1863.[8] The value of the slaves is the average of the appraised values, including males and females of various ages. Although there was no systematic inflation over this period, David and Solar's (1977) index of consumer prices is used for comparative purposes as an estimate of the general price level.

Table I summarizes the data, presenting the mean, maximum, minimum, standard deviation and median values for Henrico land and slave prices and returns, and the level and growth rate in prices in general. Figures 1-3 illustrate the time pattern of land and slave prices and the general price level. Although the prices vary over time, similarities in their movements can be seen. First, the low price levels in the late 1780’s and early 1790’s potentially indicate a

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[5] See Gatzlaff and Tirtiroglu (1995: 159-160) for a discussion of various forms and tests of informational efficiency.

[6] See Atteberry and Rutherford (1993: 377) for a discussion of these real estate asset characteristics.

[7] See McDevitt (2008) for a description of construction of the land price index.

[8] See Irwin (2004) for a description of the Virginia probates data.

Table I: Average Price and Return in Henrico County Land Market and Consumer Price Index, 1782-1863

	Mean	Maximum	Minimum	Standard Deviation	Median	Obs.
Henrico Land Prices (1782-1858)						
Nominal Price	152	640	7	111	128	77
Nominal Return	0.0005	2.213	-3.078	0.714	0.004	76
Henrico Slave Prices (1782-1863)						
Nominal Price	267	723	108	136	226	80
Nominal Return	0.0114	0.501	-0.466	0.184	0.0098	79
General Price Level (1782-1863)						
Consumer Price Index	124	211	89	26.1	115.5	82
Growth Rate in CPI	0.0004	0.221	-0.171	0.065	0.000	81

Sources: see text.

period of “economic difficulty” (Engerman and Gallman 1983: 18, 8). Second, the nation-wide inflations experienced during the War of 1812 and again in the period 1816 to1817 related to specie payment suspension (1814) and resumption (1817) are evident in the dramatic increase and subsequent decrease in asset prices and general price level. Finally, Adams’s (1986: 627) statement about meat and grain prices, that “the 1850s appear to reflect the pattern of rising prices which preceded the Panic of 1857,” appears to hold true for asset prices, as well.

The return on an asset is comprised of two parts: the income from using the property, plus the capital gain. In this paper, we abstract from the incomes to land or slaves and look only at the capital gains component. Changes in factor incomes would obviously drive changes in factor prices, but the issue for us is simply whether the price changes were unpredictable, as in an efficient market. Thus, throughout this paper the return on an asset refers to the change in the log-price of the asset. Figures 4-6 illustrate the time pattern of the returns to land and slaves, and the growth rate in the general price level.

The return to land in Henrico County, VA, for the period 1782 to 1858 shows great variation, with a mean annual capital gain on land of 0.05% and a standard deviation of 0.71 (see Table I). The median annual return on land was 0.4%. Given the standard error, the mean annual return was essentially zero

In comparison, from 1782 to 1863 the return on slaves also varied greatly. The mean capital gain on slaves for the period was 1.98% with a standard deviation of 0.19 (see Table I). The median return on slaves was 1.2%. In contrast to land returns, the evidence indicates a small positive and statistically significant capital gain on slaves.

Inflation is measured as the log change in David and Solar's (1977) index of consumer prices. Although there were periods of high inflation and deflation, there was no general inflation over the period 1782 to 1863. The mean annual growth rate in the general price level was 0.04%; the standard error of the mean was 0.065, so the average annual inflation rate was indistinguishable from zero (moreover, the median inflation rate was zero percent (see Table I)).

4. Tests & Results

If asset markets in the US in the long century before the Civil War were well-functioning, we would expect the level of asset prices to have followed a random walk. With inflation essentially zero during the period (see Table I), asset prices from year to year represented real values. Simple systematic movements in the prices over time would have left open arbitrage opportunities. By the same reasoning, we expect that annual capital gains or losses from the assets will be well-described as a simple white noise process. The proportionate price changes from year to year should have been zero on average, and unpredictable one year to the next. In sum, our simple prediction is that if Henrico land and slaves markets were efficient then the prices will appear as random walks.

We perform two sorts of unit-root tests to evaluate our characterization of prices in an efficient market, the now conventional Dickey-Fuller (Dickey and Fuller 1979, 1981) and KPSS (Kwiatkowski, Phillips, Schmidt and Shin 1992) tests. We start with the level of (log) prices and test for market inefficiency using a Dickey-Fuller test. Here the null hypothesis is that the log-price followed a random walk and rejecting the null is evidence that the market was inefficient. We next use a KPSS test for market efficiency: now the null hypothesis is that the log-price was a short memory time-series and therefore not a random walk.[9] If we reject the null of short memory then we have direct evidence that the market was efficient.[10]

After looking at the level of log-price we turn to changes of log-price, which we denote “returns” for convenience. “Returns” is a misnomer of course, because capital gains were likely small compared to the factor incomes from owning land or slaves. Looking at returns instead of prices, the roles of the Dickey-Fuller and KPSS tests are reversed. Now the null hypothesis of the Dickey-Fuller test is that the market was inefficient, because returns in an efficient market should be white noise. Rejecting the null that the returns series has a unit root provides evidence that the market was efficient. On the other hand, applying the KPSS test to returns gives us a test for inefficiency: here the null is that the series is white noise. Rejecting the null in favor of an alternative of long memory in the returns series would be evidence of market inefficiency. We conclude with point estimates of long memory in the returns series, in a model of asset returns as a fractionally integrated process.

We consider first the land price index. Testing for inefficiency, we adopt the null that the log-price of land (P_t) followed a random walk and perform the now familiar Dickey-Fuller t-test in the following equation:

$$(P_t - P_{t-1}) = (\rho-1)\, P_{t-1} + e_t \qquad (1)$$

The null hypothesis is that the first-order autoregressive coefficient is one ($\rho=1$) and our Dickey-Fuller test does not challenge that null (see Table II). The point estimate of ($\rho-1$) is just -0.0107, with a standard error of 0.0169 and a t-statistic of -0.63. That result is certainly consistent with the null hypothesis, with an asymptotic p-value of 44%.[11] Looked at another way, it is worth noting that the implied value of the autoregressive co-efficient is 0.9803 so our point estimate very much accords with the hypothesized value of 1. In sum, the test offers no suggestion of inefficiency; our first land price regression is consistent with the proposition that the Henrico land market priced land efficiently.

[9] Kwiatkowski, Phillips, Schmidt and Shin (1992) focus on testing the null of stationarity against the alternative of a unit root; but as Lee and Schmidt (1996) explain, the KPSS test is better described as a test of "the null hypothesis of short memory" (p. 300) against long memory alternatives. Our thanks go to an anonymous referee for directing our attention to this point.

[10] Note that we are cleaving to the logic of classical hypothesis testing: to advance an argument we grant it the benefit of the doubt and then attack it. See e.g. Murray (2006: 275) for a reminder of the logic of classical hypothesis testing.

[11] Note that the standard t-statistic is biased toward rejecting the null, so even without referring to the Dickey-Fuller critical values we know the null survives this test (on the bias, see e.g. Greene (2008: 745-46)). The approximate asymptotic p-values are from the software Gretl, which uses the algorithm of MacKinnon (1996) (Cottrell and Lucchetti (2008: 2)).

Table II: Dickey-Fuller Tests, Land and Slave Prices and Returns

Regression: $\Delta Y_t = (b-1)\ Y_{t-1} + e_t$

Variable	(b-1)	t-statistic	p-value	n
Land Price	-0.0107	- 0.630	0.441	76
Land Return	-1.540	-16.10	0.0000	75
Slave Price	0.00331	0.860	0.894	81
Slave Return	-1.293	-12.13	0.0000	80

Notes: Price refers to Ln(price); return refers to first difference of Ln(price). The model is a pure random walk (without drift or autocorrelation). For the price, the null corresponds to an efficient market; for the return, the null corresponds to an inefficient market. The t-statistic is for the null hypothesis that (b-1)=0; asymptotic p-values. Sources: see text.

Turning to the Henrico slave price series, the Dickey-Fuller test once again provides no indication of inefficiency. Estimating equation (1) with the log-price of slaves, the estimated autoregressive coefficient is almost indistinguishable from 1. The point estimate of $(\rho-1)$ is just 0.0033, with a standard error of 0.038 and an asymptotic p-value of 89%. That result offers no indication of market inefficiency, no basis for challenging the null hypothesis that the slave price series followed a random walk. In sum, the Dickey-Fuller results for both the slave price and land price series comport well with the efficient market hypothesis, with no suggestion of inefficiency.

Of course, failing to reject does not provide evidence for the null hypothesis. Perhaps the null is true, but it could instead be that the test lacked the power to reveal a false null. To find evidence for efficiency we turn to the KPSS test. Now we adopt market inefficiency as the null and see whether there is evidence to reject it. Specifically, we use KPSS tests of the null hypothesis that the (log) price is a short memory series, against the alternative hypothesis that it followed a random walk (as in an efficient market). The results are given in Table III.

The KPSS tests provide quite substantial support for the proposition that land and slave markets in Henrico were efficient. For each market we look at the basic KPSS test and two variants; in the six tests, there is only one time that a null hypothesis of inefficiency survives at the conventional 5% significance level. The basic KPSS test estimates a regression of the form:

$$P_t = P_0 + e_t \qquad (2)$$

For a null hypothesis of inefficiency, we assume e_t is a short memory process. Under the efficient-markets alternative, that the price followed a random walk, e_t has a unit root and the variance increases without bound as t increases. Our first KPSS test adopts the conventional bandwidth for calculating the estimated variance of e_t, which is a bandwidth of 3 years for our sample sizes.[12] Our first variant of the basic KPSS test increases the bandwidth to 5 years, which allows for more persistence in e_t and thus a more flexible specification of the price series, one that more resembles a unit-root process while maintaining the null of short memory. Thus increasing the bandwidth reduces the power of our test of inefficiency, but if we still reject we have a more convincing finding for the efficient markets hypothesis. Our second variant of the KPSS test also offers the null of inefficiency more protection from rejection: here we allow the price series to include a deterministic trend (g·t), as in equation (3).

$$P_t = P_0 + g \cdot t + e_t \qquad (3)$$

This less restrictive specification of the price series accommodates a wider range of possible inefficiencies in the asset market and thereby strengthens the case for market efficiency if we reject the null with a given confidence level. Of course the potential gain in the credibility of our case comes at the expense of power. The more flexible specification increases the probability that a false null will survive the hypothesis test.

Looking first at the land prices, the KPSS tests provide some strong evidence of an efficient market (see Table III). The basic KPSS test statistic is 0.619, much larger than the 5% critical value of 0.463 (indeed it is greater the 2.5% critical value, 0.574). If we expand the bandwidth from 3 to 5 years the KPPS statistic falls to 0.488, still larger than the 5% critical value. So with either bandwidth we reject the null of short memory in favor of the random walk alternative. This is strong evidence to make the case that the land market was efficient.

The case for an efficient market in land is not strengthened if we allow for a deterministic trend when modeling the land price. The OLS regression estimate is that land prices grew 1.40% per year on average. The KPSS statistic is 0.079, which is less than even the 10% critical value (0.121), so here we cannot reject the null of an inefficient market at conventional significance levels. In sum, the KPSS tests on land prices provide some strong evidence against the null of inefficiency, but we can’t rule the possibility that land prices were growing systematically (if slowly) over time with random fluctuations. Historically this doesn’t seem implausible: the implication is that if a buyer moved her purchase up by 1 year she could have saved 1.4%, a small advantage compared to likely transaction and credit costs. Moreover, our results could simply reflect a lack of power in test given the small sample size.[13] Either way, the results are inconsistent with the existence of unexploited profit opportunities in the Henrico land market.

[12] The standard bandwidth is the integer part of $4(n/100)^{1/4}$, Cottrell and Luchetti (2008: 154).
[13] Referring to the power of the KPSS test, Lee and Schmidt (1996, p 285) find "that a rather large sample size, such as T=1000, will be necessary to distinguish reliably between a long memory process and a short memory process with comparable short-term autocorrelation." Recall that our samples are on the order of T=80.

Table III: KPSS Tests, Land and Slave Prices

Regression: $Y_t = \overline{Y}_t + e_t$

		Significance Levels:	10%	5%	2.5%	1%
Land Prices (n=77)						
$P_t = \underset{(0.0817)}{4.792} + e_t$		Critical values:	0.347	0.463	0.574	0.739
	Bw=3 KPSS statistic=0.619					
	Bw=5 KPSS statistic=0.488					
$P_t = \underset{(0.739)}{4.245} + \underset{(0.00333)}{0.0140}\, t + e_t$		Critical values:	0.119	0.146	0.176	0.216
	Bw=3 KPSS statistic=0.079					
Slave Prices (n=82)						
$P_t = \underset{(0.0532)}{5.508} + e_t$		Critical values:	0.347	0.463	0.574	0.739
	Bw=3 KPSS statistic=1.664					
	Bw=5 KPSS statistic=1.168					
$P_t = \underset{(0.056)}{4.791} + \underset{(0.00117)}{0.0173}\, t + e_t$		Critical values:	0.119	0.146	0.176	0.216
	Bw=3 KPSS statistic=0.159					

Notes: The dependent variable is Ln(price). The null hypothesis is that the asset price is a stationary series, which corresponds to an inefficient market; the alternative hypothesis is that the price is a random walk. Rejecting the null is evidence of efficiency. Source: see text.

Turning to the slave price series we get even stronger results in favor of the efficient markets hypothesis. Each of the three KPSS tests leads us to reject the null hypothesis of short memory in favor of the random walk alternative. The basic KPSS test statistic is 1.664, much larger than the 5% critical value of 0.463 (and larger than the 1% critical value of 0.739). Expanding the bandwidth for the slave price test to 5 years reduces the KPSS statistic to 1.168, but that still clearly exceeds the 5% critical value (and the 1% critical value, see Table III). In fact, with at least 99% confidence we can reject the null of a short memory in slave prices in favor of the random walk alternative. Allowing for a trend in slave prices gives us slightly weaker results, but again we reject the short memory null at the 5% significance level. The OLS estimate has slave prices growing 1.73% per year (again, a small rate compared to interest or transactions costs). Here the KPSS statistic is 0.159, which exceeds than the 5% critical value of

0.146 (see Table III). In sum with the slave price series we have strong and consistent evidence of an efficient market.

Taken together, the Dickey-Fuller and KPSS tests on land and slave prices tell quite a consistent story of market efficiency. The Dickey-Fuller tests fail to provide evidence to argue for market inefficiency. The KPSS tests provide compelling evidence to argue for market efficiency. For our next steps, we turn to the returns series for land and slaves, applying similar sets of tests to the changes of log price of land and slaves. Given our characterization of prices as random walks in an efficient market, the Dickey-Fuller and KPSS tests reverse roles when we look at returns. With the (log) price a random walk, the change in (log) price should be white noise. Thus the Dickey-Fuller null hypothesis of a unit-root is a null of market inefficiency and rejecting that gives us evidence of an efficient market. Symmetrically, the KPSS null of a short memory time-series is now a null of market efficiency and rejecting it is evidence of an inefficient market. As we describe below, the returns results substantiate the finding of efficient markets in nineteenth century Henrico County.

Table II presents the Dickey-Fuller test results for land and price returns. The null hypothesis is that the returns series contain a unit root, which would correspond to an inefficient market with predictable capital gains. That null is rejected at about any significance level when we test. For land returns, the Dickey-Fuller t-statistic is -16.1; for slave returns the t-stat is -12.1. In both cases, the null hypothesis of a unit root is starkly contradicted by the regression results. Given our results for asset prices, these returns results are perhaps unremarkable. However it is worth showing that the finding of market efficiency is a consistent result that survives the change of specification.

Table IV presents the KPSS tests of asset returns. Here the null hypothesis is short memory, which corresponds to efficient markets with the return series being white noise. Once again the results contribute to the view that the markets were efficient. Looking first at the land returns, none of our three specifications yields a KPSS test statistic of any statistical significance. In each test, the KPSS statistic is less than ½ the magnitude of the 10% critical value. Turning to the slave returns, the results are similar with none of the test statistics being statistically significant at even the 10% level. For example, the closest we get to challenging the null of efficiency in the slave market is with the standard bandwidth of 3 in the basic KPSS test: here the KPSS statistic of 0.21 is less than two-thirds the 10% critical value. In sum, looking at asset returns serves to corroborate our results from the tests of asset prices. Taken together the results paint a consistent picture of market efficiency.[14]

[14] As noted by an anonymous referee, it is evident in Figures 1 and 3 that prices in the period 1813-1819 were sharply higher, raising concerns about outliers or structural change that could affect our test results. However controlling for such outliers has no effect on the results of our hypothesis tests (i.e. reject or not); detailed results are available upon request from the authors.

Table IV: KPSS Tests, Land and Slave Returns

Regression: $Y_t = \overline{Y}_t + e_t$

Significance Levels: 10% 5% 2.5% 1%

Land Returns (n=76)

$\Delta P_t = \underset{(0.0819)}{0.0005} + e_t$ Critical values: 0.347 0.463 0.574 0.739

Bw=3 KPSS statistic=0.093
Bw=5 KPSS statistic=0.100

$\Delta P_t = \underset{(0.170)}{-0.0746} + \underset{(0.0038)}{0.0019}\, t + e_t$ Critical values: 0.119 0.146 0.176 0.216

Bw=3 KPSS statistic=0.047
Bw=5 KPSS statistic=0.051

Slave Returns (n=81)

$\Delta P_t = \underset{(0.0212)}{0.0198} + e_t$ Critical values: 0.347 0.463 0.574 0.739

Bw=3 KPSS statistic=0.196
Bw=5 KPSS statistic=0.206

$\Delta P_t = \underset{(0.0436)}{-0.0173} + \underset{(0.00091)}{0.00088}\, t + e_t$ Critical values: 0.119 0.146 0.176 0.216

Bw=3 KPSS statistic=0.052
Bw=5 KPSS statistic=0.057

Notes: Returns refers to the change of natural log of price. The null hypothesis is that the asset return is white noise, which corresponds to an efficient market. Rejecting the null would be evidence of inefficiency. Source: see text.

We conclude our empirical work with point estimates of long memory in the returns series.[15] We model asset returns (r_t) as a fractionally integrated process as in equation (4), where ε_t is white noise:

$$(1-L)^d r_t = \varepsilon_t \tag{4}$$

The parameter d captures long-term dependence in returns: with short memory d=0; non-zero values of d are long memory (given our results so far, we presume returns are stationary so $|d|<1/2$). Positive values indicate persistence in the innovations to returns, and a predictability inconsistent with an efficient market. A negative value of d indicates a different sort of long memory. Here the returns will "exhibit anti-persistence, in the sense that positive shocks are on average followed by negative ones" and innovations dissipate more rapidly than in a white noise process (Amsler 1999: 693). Anti-persistence is also not consistent with strict market efficiency.[16]

We use the two commonly used estimators of the memory parameter: the local whittle (LW) and the Geweke and Porter- Hudak (GPH) estimators.[17] Table V reports our results, which are quite different for the two returns series. The results for the slave returns series are simple, with no hint of long memory. With either estimator, the results are entirely consistent with the efficient markets null: the point estimates of the memory parameter are close to zero, and their p-values are over seventy-four percent.

Table V: Fractional Integration in Returns

Model: $(1-L)^d r_t = \varepsilon_t$; d is the estimated degree of fractional integration

	LW Estimate	P-value	GPH Estimate	P-value
Land Returns	-0.227	9.0%	-0.401	6.2%
Slave Returns	-0.043	74.9%	0.057	85.4%

Note: P-values are for the null d=0 (returns are white noise). LW refers to the local whittle estimator; GPH refers to the Geweke and Porter-Hudak estimator (see note 15). For both the order of the test is 14. Source: see text.

15 Thanks to an anonymous referee for suggesting that we include estimates of the memory parameter. The results here point the way to next steps in our research.

16 We follow Lo (1991: 1285) and use the phrases "long memory" and "long-term dependent" for a process with a non-zero memory parameter (i.e. negative or positive values of d). In contrast, to describe a process with ($-0.5<d<0$) Baillie (1996 : 14) uses "intermediate memory" or "antipersistent" while Hosking (1981: 169) uses "short memory" and "antipersistent" (referring to Mandelbrot (1977) for the latter term).

17 The GPH estimator is also known as log periodogram (LP) regression (Phillips 2007: 105). According to Shimotsu and Phillips (2005: 1890) "LW estimation is known to be more efficient than LP regression in the stationary ($|d| < 1/2$) case." As noted above, our previous results indicate returns are stationary.

The results for land returns do not fit so well with a strict efficient markets view. Here the point estimates of the memory parameter are quite far from zero (-0.23 or -0.4; and recall that stationarity requires $|d| < 1/2$). Under the null of short-memory (d=0) those point estimates are quite unlikely, with p=values of just 9% or 6%, depending on the estimator. Either way, these results on the land returns series could be used toward a claim of market inefficiency, rejecting the efficient markets null at the 10% significant level. This stands out among all our results, as the only result that directly challenges the efficient markets null. The estimated memory parameter is negative, so the series displays anti-persistence and some negative autocorrelation. That result points the way to our future research. It may be that the real estate market exhibited a degree of mean reversion in returns that reflects unexploited profit opportunities and market inefficiency. However we suspect that the measured anti-persistence will turn out to be a product of random measurement error in our land price index.[18] In any event, the anti-persistence in our land returns series is a high priority for our future research.

5. Conclusion

The empirical tests in this study provide some compelling evidence that land and slave markets in the late eighteenth and early nineteenth century US were weak-form efficient. Our hypothesis tests on both the price of and returns to Henrico County land and slaves suggest that available information was quickly and fully incorporated into prices in these early North American asset markets. Given the importance of asset accumulation in individual welfare and national economic development, this new systematic evidence on the markets for land and slaves and the insights into the portfolio decisions made by early American wealth holders contribute to our understanding of the workings of two US asset markets during a period of great transformation and growth.

[18] Our land price index is constructed using a log-linear regression model similar to that of Margo (1996). In that framework, random measurement error in price in year t will show up oppositely in the returns for years t and t+1. That would generate negative autocorrelation in returns and anti-persistence in the returns series.

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Figure 1: Henrico County Land Prices, 1782-1858

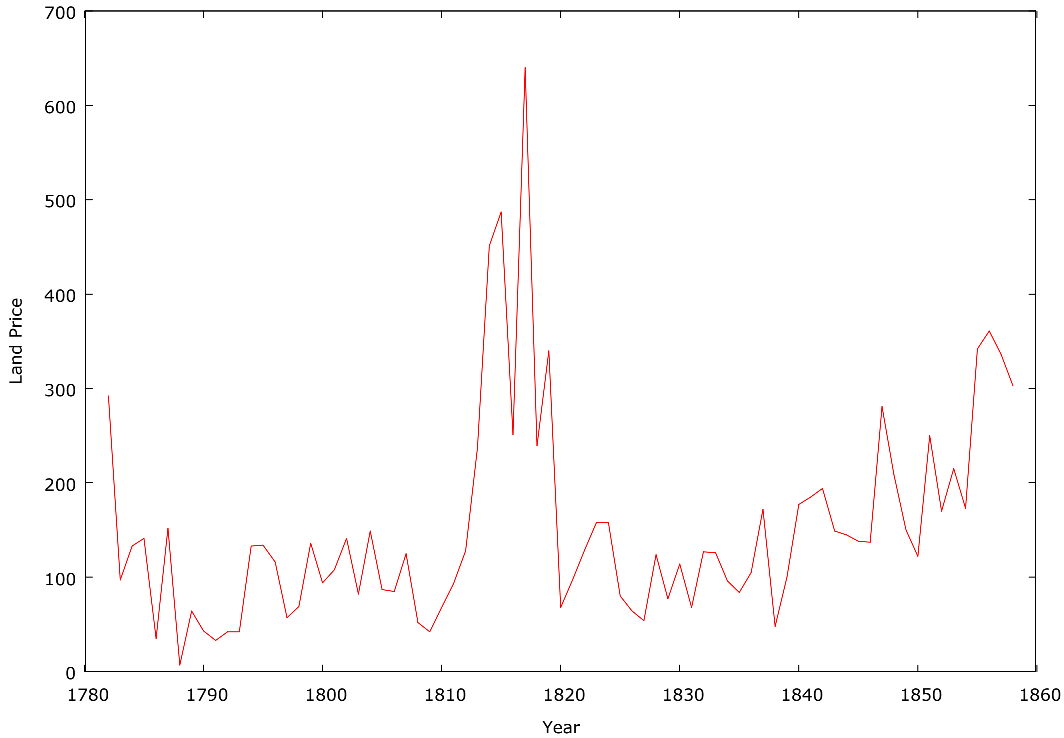

Figure 2: Henrico County Slave Prices, 1782-1863

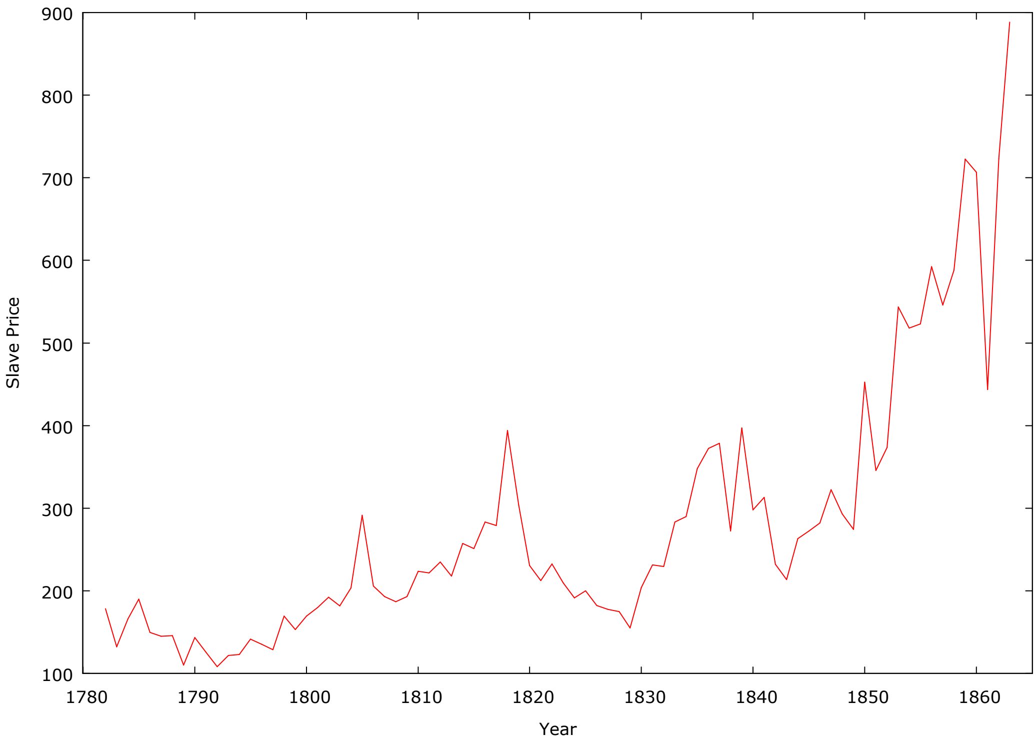

Figure 3: General Price Level, 1782-1863

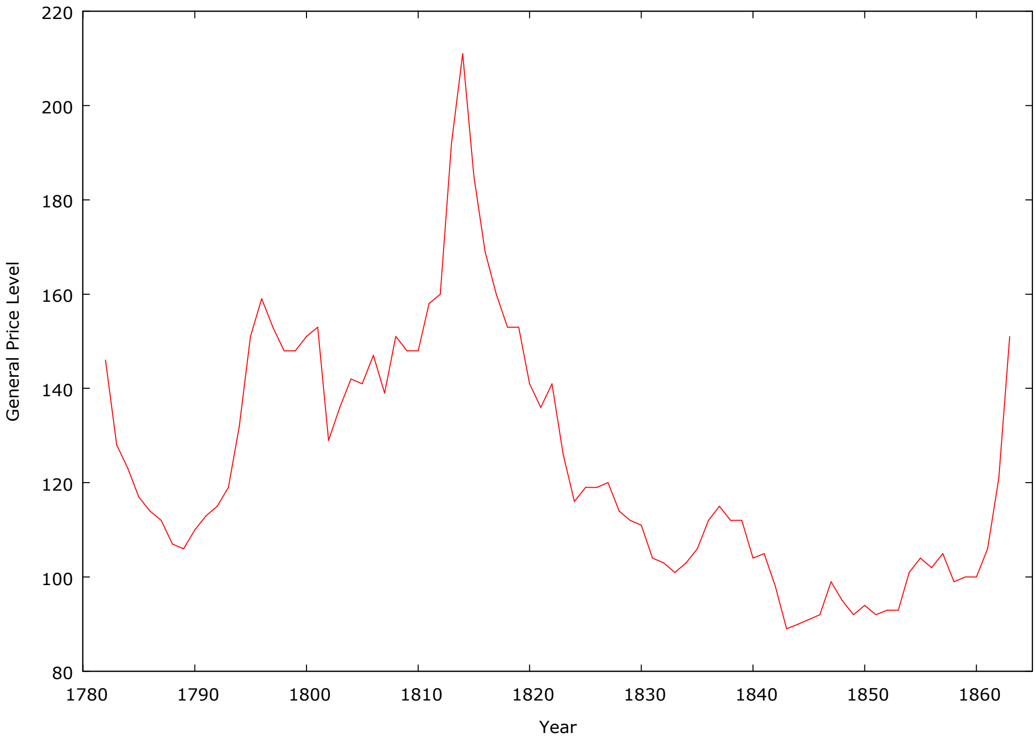

Figure 4: Henrico County Land Returns, 1782-1858

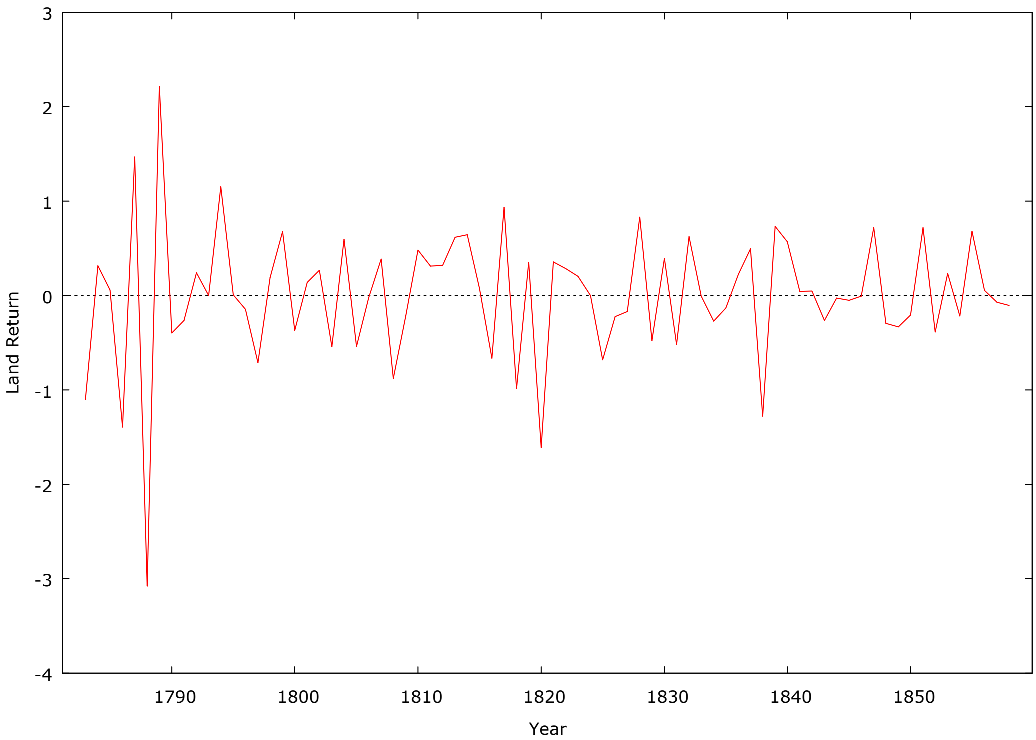

Figure 5: Henrico County Slave Returns, 1782-1863

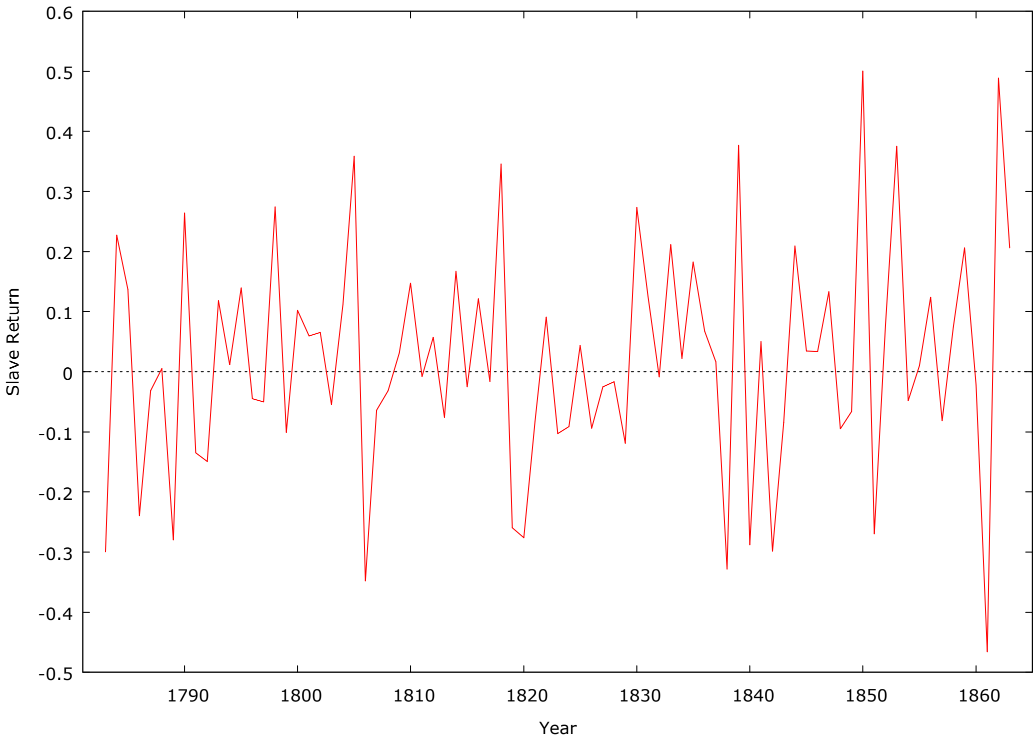

Figure 6: Growth Rates in General Price Level, 1782-1863