"Wait a Cotton Pickin' Minute!"
A New View of Slave Productivity

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Abstract: Questions concerning slave efficiency have long fascinated economists and historians, and over the past 30 years few, if any, issues have been more contentious. Cliometricians have generally focused on cross sectional questions such as whether slave plantations were more efficient than free-labor farms in the North and South. In doing so, the cliometrics literature has ignored the findings of an older generation of economic historians who pointed to the importance of biological innovations in propelling the South's growth. Resurrecting this older and more literary tradition, our primary interest is decidedly dynamic. Our scaffolding is built on the solid foundation of over 360 thousand cotton picking samples drawn from the archives of over 50 slave plantations. We show that in the 50 years preceding the Civil War the average amount of cotton picked per slave in a day increased by two and one-half times. This finding bears on a wide range of issues discussed in the cliometrics literature including the movements in slave, cotton, and land prices, the factors responsible for the growth of cotton output and the spread of cotton cultivation, the sources of the differences in regional production and productivity between the Old and New South, the movement of slaves out of urban employment into cotton production, as well as the traditional static comparisons of plantation and non-plantation efficiency.

After a lengthy absence, slavery is reclaiming a share of the spotlight in American economic history research. The "Peculiar Institution" is the subject of a number of recent works by leading economic historians including Robert Fogel's *Slavery Debates*, Gavin Wright's forthcoming Louisiana State University lectures, and several contributions to the festschrift honoring Stanley Engerman, *Factor Endowments, Labor and Economic Growth in the Americas*.[1] In addition, in an important series of papers, Engerman together with Ken Sokoloff have placed the prevalence of slavery and highly unequal wealth distribution at the center of their macro-level explanation for why some European colonies achieved modern economic growth early whereas others lagged. Much of this literature synthesizes and reinterprets existing evidence with the aim of providing perspective and even closure on long-standing debates. We pursue a different tack. Drawing on a new and extensive dataset on slave cotton picking rates, this paper takes a

[1] Robert W. Fogel, *The Slavery Debates, 1952-1990: A Memoir* (Baton Rouge: Louisiana State University Press, 2003); Frank Lewis, and Kenneth Sokoloff, eds., *Factor Endowments, Labor and Economic Growth in the Americas* (Cambridge: Cambridge Univ. Press, forthcoming 2005).

fresh look at changes in slave and plantation efficiency over the half century before the Great Emancipation.

Our work builds on a productivity story that has long been part of the broader economic history literature asserting that a succession of biological innovations significantly improved cotton yields, quality, and picking efficiency in the antebellum years. The innovations included the introduction, selection, and diffusion of new cotton varieties and a complex process of biological learning as planters adjusted their day-to-day practices and perfected varieties suitable to an ever wider range of cultivation. The mainstream economic history debate on slave and plantation efficiency has largely ignored this evidence and assumed that cotton raising technologies were unchanged over the antebellum years. While this economics literature has concentrated on cross sectional questions such as whether slave plantations were more efficient than free-labor farms in the North and South, our interest is decidedly more dynamic.

The story of the improvement of cotton varieties has great significance for understanding southern economic development. For a period when many have decried the lack of indigenous technological advances in the South, the region was the undisputed world leader in the creation and diffusion of new, superior cotton varieties. The achievements of antebellum southern breeders far surpassed anything accomplished by northern wheat breeders in the pre-Civil War era. Employing a sample of over 360,000 individual picking entries, we show that in the 50 years preceding the Civil War the average amount of cotton picked per slave in a day increased by two and one-half times. This finding bears on a wide range of issues discussed in the mainstream economics literature including the movements in slave, cotton, and land prices, the factors responsible for the growth of cotton output and the spread of cotton cultivation, the sources of the differences in regional production and productivity between the Old and New South, the movement of slaves out of urban employment into cotton production, as well as the traditional static comparisons of plantation and non-plantation efficiency. But, most importantly we direct attention to the hitherto neglected issue of the dynamic changes in slave productivity.

The Cliometric Mainstream

To cite all those who have participated in the debate on slave efficiency over the past thirty years would make for a very long footnote. Addressing the population of economic historians over 40 years of age, it might be easier to cite those who have not published on this subject. We are on that shorter list and thus are green hands in the field of slavery studies. The longer list of seasoned hands would include Fogel and Engerman for *Time on the Cross*, and Fogel and many others for four volumes of *Without Consent or Contract.*[2] Gavin Wright, Peter Temin, Paul David, Roger Ransom and Richard Sutch, William Parker, Robert Gallman, Chris Hanes, Claudia Goldin, Lee Craig, Tom Weiss, Fred Bateman, James Foust, and well over a score of other prominent scholars have made substantive contributions. Parker and Gallman (along with their students) played a key role in shaping the contours of the debate by providing their much-cited sample of over 5,000 farms drawn from the 1859 manuscript census. In *The Slavery Debates* (2003) Robert Fogel offered his view on the state of knowledge of slave and plantation efficiency. Notwithstanding all of the fireworks concerning *Time on the Cross*, Fogel concludes that its major findings remain intact. Among the essential facts according to Fogel are:

- The plantation South was a rapidly growing, economically dynamic region, slavery was a viable and robust labor system, and slave plantations were highly profitable, efficient, and fully capable of out-competing free farms. *Slavery Debates*, pp. 28-39.
- In *Slavery Debates* Fogel repeatedly asserts the claim first espoused in *Time on the Cross* that the overriding reason for the greater efficiency of plantations was their ability to exploit the gang system.[3]

[2] Robert W. Fogel and Stanley L. Engerman, *Time on the Cross: The Economics of American Negro Slavery* (Boston: Little, Brown, 1974); Robert W. Fogel, *Without Consent or Contract: The Rise and Fall of American Slavery* (New York: W. W. Norton, 1989); *Without Consent or Contract: The Rise and Fall of American Slavery; Vol. 2, Evidence and Methods* (with others) (New York: W. W. Norton, 1992); *Without Consent or Contract: The Rise and Fall of American Slavery. Vol. 3, Technical Papers. Vol. 1, Markets and Production* (with S. L. Engerman and others) (New York: W. W. Norton, 1992); *Without Consent or Contract: The Rise and Fall of American Slavery. Vol. 4, Technical Papers. Vol. 2, Conditions of Slave Life and the Transition to Freedom* (with S. L. Engerman and others) (New York: W. W. Norton, 1992).

[3] Drawing on his earlier work for the details, Fogel argues that small slaveholders (those with 1-15 slaves) could not effectively capture the benefits of the gang system, so plantations with more than 15 slaves

- Slaves "who toiled in the gangs of the intermediate and large plantations were on average over 70 per cent more productive than either free farmers or slaves on small plantations. These gang laborers, who in 1860 constituted about half of the adult slave population, worked so intensely that they produced as much output in roughly thirty-five minutes as did free farmers in a full hour." *Slavery Debates*, p. 36. The productivity advantage existed for gang-system slaves over free farms in both the North and the South after adjusting for soil quality, labor quality, the existence of work animals, and other farm capital. *Slavery Debates*, pp. 29-30.
- The old adage "to work like a slave" really meant to toil very hard but with the benefit of considerable free time. "As it turns out, free northern farmers worked about 10 percent more hours than southern slaves...." (*Slavery Debates*, p. 33) The main reason for the longer hours in the North was the added time needed to care for animals and the greater importance of dairy farming and livestock rearing.[4] The work schedule was the result of a conscious decision of slave owners. Long rest periods during the day and more time off on the weekend were not "boons that slaveholders granted to their chattel but ...conditions for achieving the desired level of intensity." (*Without Consent or Contract*, p. 79)

The mainstream literature on slave efficiency is for the most part static, focusing on cross-sectional comparisons in 1859. This is no doubt in large part due to the heavy lifting done by Gallman and Parker and their students in providing the census data for that year. As Wright has noted, the focus on a single crop year raises possibility that the results may be unrepresentative because 1859 was an exceptional year for cotton production and southern income and a relatively poor year for northern agriculture. (Relying on cross-section data also presents difficulties in controlling for unobserved

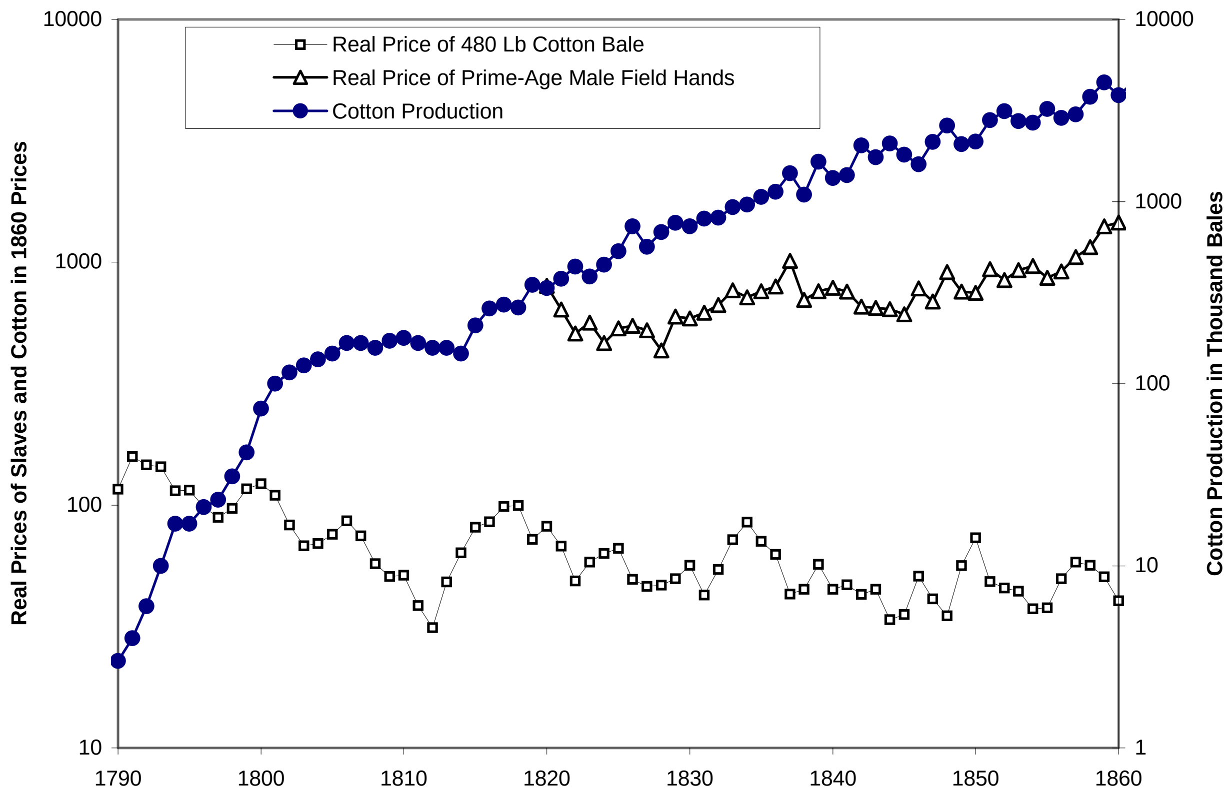
account for nearly all of the productivity advantage. Large plantations were only slightly more efficient than intermediate size units. The gang system propelled slaves to work with "less wasted motion," with an "unremitting, machine-like quality." *Without Consent or Contract,* Vol. 1, p. 79. "It was the gang system that forced men to work at the pace of an assembly line (called the gang) that made slave laborers more efficient than free laborers." *Without Consent or Contract,* Vol. 1, p. 79

4 "The available evidence indicates that greater intensity of labor per hour, rather than more hours of labor per day or more days of labor per year, is the reason the index of total factor productivity is 39 percent higher for the gang-system plantations than for free farms." Fogel, *Without Consent or Contract,* Vol. 1, p. 78.

differences or heterogeneity across farms/plantations that cause problems of endogeneity.) The economics literature does use census data to discuss the changes in cotton output and southern income between 1840 and 1860.

Figure 1 plots the long run trends in cotton production (in logs) along with the real prices of both cotton and prime-age male slaves. The data depict a dynamic and

Figure 1: The Evolution of the Real Prices of Slaves and Cotton, and of Cotton Production



Sources: Slave Prices from Laurence J. Kotlikoff, "Quantitative Description of the New Orleans Slave Market, 1804 to 1862," Ch. 3, pp. 31-53 in Robert W. Fogel and Stanley L. Engerman (eds.) *Without Consent or Contract: The Rise and Fall of American Slavery, Markets and Production: Technical Papers,* Vol. I (New York: W. W. Norton, 1992.); Other Series from *Historical Statistics of the United States.*

expanding economy. Over the 1820-60 period, the quantity of cotton produced increased by almost 6.0 percent per annum whereas the real price of cotton fell by 0.8 percent per year and the real price of prime age male slaves rose by 1.8 percent. In *Time on the Cross*, Fogel and Engerman observed that productivity must have been rising: “The basic cause of this long-term decline [in cotton prices] was the steady increase in productivity.

Among the developments which made cotton farming increasingly more efficient were the improvements in the varieties of cottonseeds, the introduction of the cotton gin, the reduction in transportation and other marketing costs, and the reallocation of cotton production in the more fertile lands of the New South."[5] But this passage is their only acknowledgement of the possible impact of new cotton varieties.

In a 1977 article, they address the question: "What then explains the big increase in the output of cotton between 1850 and 1860?" Making a number of plausible assumptions, Fogel and Engerman estimated that "the shift in the geological locus of cotton production from the Old to the New South explains about 8 percent of the increase in cotton output between 1850 and 1860. Assuming that within each state cotton just maintained its share of improved land, the increase in improved land explains 41 percent of the growth in the cotton crop." After further assumptions they deduce that 42 percent of the increase in output resulted from a substitution of land within states from other crops to cotton. "These estimates leave a residual of 9 percent to be explained by all other factors including increases in the use of fertilizers, increases in the labor-to-land ratio, and random fluctuations in yields."[6] The subsequent debate on the sources of the increase in cotton output offered various refinements, but no hint of the possibility that biological innovations may have played an important role.

A handful of economic historians have recognized the significance of productivity growth, but this work hardly caused a ripple, let alone altered the flow of the mainstream literature. William Parker pondered changes in cotton picking efficiency in his quest to construct a decomposition of the changes in labor productivity in cotton farming (much like his estimates with Judith Klein for grains) between 1840-60 and 1900-20. Parker examined a large number of plantation records and developed estimates of the labor requirements for 10 major cotton growing activities, including breaking, bedding, planting, and the like, but he was stymied by the picking question and simply assumed that picking efficiency remained constant. In doing so he noted that this assumption had

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[5] *Time on the Cross*, pp. 91-93, and *Without Consent or Contract*, Vol. 1, p. 71.

[6] Robert W. Fogel and Stanley L. Engerman, "Explaining the Relative Efficiency of Slave Agriculture in the Antebellum South," *American Economic Review* 12 (1977), pp. 275-96, quote is on p. 282. The above estimate purportedly deals with a number of criticisms of *Time on the Cross* by Gavin Wright, Paul David, Peter Temin and others dealing with such issues as varying land quality, and the likelihood of sample bias in relying on the 1849 and 1859 census.

to be checked and that he had located but not analyzed an abundant sample of picking times in plantation records.[7]

The most serious economic history investigation of antebellum productivity growth is Franklee Whartenby's *Land and Labor Productivity in United States Cotton Production, 1800-1840*, a University of North Carolina dissertation written under Parker's guidance. Her findings offer a quantitative estimation of what an older generation of economic historians had long been saying. Between 1800 and 1840, a period when annual southern cotton production increased from 40 to 871 million pounds, Whartenby estimates that yields per acre increased by 46 to 78 percent.[8] Relying on the earlier literature, Whartenby also commented on the change in picking efficiency due to the introduction of new varieties. "With the advent of Petit Gulf cotton in the late 1820's, the daily picking averages jumped from about fifty or sixty to about 125 to 150, with as much as 300 or more sometimes reported."[9] Looking at all tasks, Whartenby's lower bound estimate is that output per worker in 1840 was about double that of 1800. She, however, regarded her sources as too limited to allow drawing firm conclusions.

Stanley Lebergott took the analysis of the change in picking rates a step further in his 1984 textbook. In his characteristic fashion, Lebergott pieced together fragmentary evidence from secondary sources to produce the enlightening data in Table 1.

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[7] W. N. Parker, "Labor Productivity in Cotton Farming: The History of a Research," *Agricultural History*, 53: 1 (January 1979), pp. 228-244, esp. p. 235.

Jacob Metzer, "Rational Management, Modern Business Practices, and Economies of Scale in Antebellum Southern Plantations," *Explorations in Economic History*, 12 (1975), pp. 123-50 did examine daily picking rates on the Leak plantation in Tippah, MS over the 1841-60 period in order to investigate the treatment of pregnant women.

[8] Franklee Gilbert Whartenby, *Land and Labor Productivity in United States Cotton Production, 1800-1840* (New York: Arno Press, 1977), pp. 54, 104-105. Many other factors in addition to a change in varieties were at play because the center of cotton production moved onto more fertile western lands, but production was also moving from high yielding valleys to upland regions.

[9] Whartenby, *Land*, pp. 104-05. In the spirit of our work on wheat published in the *Journal of Economic History* these calculations do not fully capture the effects of biological innovations because they do not account for the strong likelihood that without the infusion of new varieties, yields would have declined significantly due to a changing disease, pest, and weed environment. In particular, the cotton worm evidently first appeared in 1804 and the spread of Johnson grass, which was introduced in 1840s, significantly increased the problem of weed control. In addition to maintenance problems, Whartenby's estimates do not account for the difficulties growers would have faced pushing out the frontiers of the cotton belt without varieties tailored for the new geoclimatic conditions.

Table 1: Lebergott's Observations on Pounds of Cotton Picked per Day, 1800-1958

Year	Average	Sources:
1800	50	Wailes (1854) for "Early nineteenth century"
1810	69	Southern Cultivator (1861) quoted in Gates
1825	100-175	NC, Niles Register, 29 (Dec 24 1825) 259
1841	107	Hand and Machine Labor (1899) Vo. II, p. 443
1850s	100 plus	Southern Cultivator (1861) quoted in Gates
1850s	200	Solomon Northrup, Twelve Years A Slave, p. 125
1850s	200	Louisiana Historical Quarterly (Oct 1950) 33: 362
1854	200	Waile (1854)
1866	200	Wheeler (1866) Madras Versus America p. 96
1868	100-200	Lyman (1868) Cotton Culture p. 15
1895	200	Hand and Machine Labor (1899) Vo. II, p. 443
1896	240	Watkins, Cost Approach
1958	225	US Congress, Farm Labor

Source and Notes: Stanley Lebergott, *The Americans: An Economic Record*, pp. 168, 176. The Cost Approach used by Lebergott compares the cost or piece rate for picking 100 pounds of seed cotton with the farm wage rate to determine the implicit amount picked.

The assembled data indicate that cotton picking rates increased from 50 pounds a day in 1800 to 200 pounds a day in 1860.[10] The scattered nature of the sources, the dependence on retrospective estimates, and the prevalence of round numbers suggest these results are best not considered definitive. While the direction of the change is clear, its timing and magnitude are not. Whartenby and Lebergott's work serves as a natural bridge to our next section, in a sense a bridge between two cultures.[11]

Less Charted Waters

The "broader economic history literature" that we alluded to in the introduction emphasizes the impact of biological innovations in the antebellum cotton industry. The most recent proponent is John Hebron Moore (1956, 1958, and 1988), who argued that that a succession of new cotton varieties revolutionized American cotton production by

[10] Stanley Lebergott, *The Americans: An Economic Record* (New York: W. W. Norton , 1984), pp. 168; 176-77.

[11] The only other reference to biological innovation in antebellum cotton production that we have found in the economic history literature appears in a textbook published in 1976. Harry N. Scheiber, Harold G. Vatter, and Harold U. Faulkner, *American Economic History* (New York: Harper & Row, 1976), p. 131. This brief discussion of cotton varieties did not appear in the previous (1960) edition of this text. Outside the mainstream of economic history, Hayami and Ruttan give prominence to the findings of historians on this subject. Yujiro Hayami and Vernon Ruttan, *Agricultural Development: An International Perspective*, revised and expanded edition (Baltimore: Johns Hopkins Univ. Press, 1985), p. 209.

increasing yields per acre, picking efficiency, and the average quality of upland cotton.[12] Moore is only the most recent of a long line of prominent scholars who have espoused this view. The essential ingredients of Moore's argument are readily available in the classic accounts of James L. Watkins and Louis Cecil Gray.[13] These authors are widely cited in the cliometrics literature on myriad issues, but not on the importance of biological innovation.

It is important to note that no cliometrician has ever disputed, the claims that picking efficiency soared. Rather these claims have simply been ignored in the debates focusing on the relative efficiency of slavery. Moore, Watkins, Gray, and others based their claims on a wide variety of independent contemporary sources and first hand accounts that clearly and forcefully testified to the events in question. Sources include antebellum agricultural journals, newspaper articles, archival testimony, and B. C. L. Wailes' well-known 1854 *Report of the Agriculture and Geology of Mississippi Embracing a Sketch of the Social and Natural History of the State*.[14]

De Bow's (1852) commentary on the 1817 Cotton Book of G.W. Lovelace of Sicily Island, Louisiana offers a clear indication of the quality of the nineteenth century sources attesting to how changes in cotton varieties affected picking efficiency, yields, and ease of ginning.[15]

> In the time we speak of, i.e., the few last years of the past century, and upwards, to about 1810, the *black seed* cotton was the only kind raised here, or, in fact, any where in our country. This was not so productive as the Tennessee *green seed*, which came into use about this latter date. … The little *green seed* was harder to pick than the *black seed*, and also harder to gin on the roller, or saw gin either.
> We give here an extract from the Cotton Book of G.W. Lovelace for October, 1817 when he raised the *green seed* cotton. He was a good thrifty planter in his time, and had some choice negroes; and here now is a specimen of their day's pickings for one week:

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[12] John Hebron Moore, "Cotton Breeding in the Old South," *Agricultural History* 30:3 (July 1956), p. 96; *Agriculture in Ante-Bellum Mississippi* (New York: Bookman Associates, 1958), pp. 13-36; *The Emergence of the Cotton Kingdom in the Old Southwest, Mississippi, 1770-1860* (Baton Rouge: Louisiana State University Press, 1988), pp. 30-34

[13] James L. Watkins, *King Cotton* (New York: Negro Universities Press, 1908, reprinted in 1969); Lewis Cecil Gray, *History of Agriculture in the Southern United States to 1860* 2 Vol. (Washington, DC: Carnegie Institution, 1933).

[14] B. C. L. Wailes, *Report of the Agriculture and Geology of Mississippi Embracing a Sketch of the Social and Natural History of the State* (Jackson, MS: E. Barksdale, State Printer, 1854). Wailes was a prominent antebellum Mississippi planter and the founding president of the Mississippi Historical Society. His account is based on personal observation and on the testimony of older planters.

[15] *Dr. Kilpatrick*, "Historical and Statistical Collections of Louisiana: The Parish of Catahoula," Part 2, *De Bow's Review* 12 (1852), pp. 632-633

	Mon.	Tues.	Wed'y.	Thurs.	Fri.	Sat.	Totals.
Sally	57	49	58	51	52	58	325
Bill	66	55	56	59	58	57	351
Charles	46	45	48	54	55	62	310
Elsy	31	37	26	28	31	39	192
Nancy	42	49	54	53	42	52	293
Dave	19	20	18	22	27	23	129
Harry	68	68	44	69	78	78	405
Joe	34	41	50	51	49	52	277
Lewis	23	38	34	33	44	43	215

On looking over the same book for the month of December, when the weather was colder, there is a proportional falling off in the picking.

De Bow's further commented that by 1852 many slaves, who were of comparable quality to Lovelace's hands, could pick as much in a day as pickers 35 years before could pick in a week. Thus the general outline of the argument we are advancing has a strong quantitative pedigree and was widely accepted in the antebellum South. Before empirically investigating the antebellum growth in picking efficiency, it is important to gain a longer view of the history of the cotton plant in the American South. Such a perspective reveals cotton producing technologies were never constant.

The Creation of American Upland Cotton Varieties

There is voluminous, albeit sometimes contradictory, information about the introduction of cotton varieties into what would become the United States. Cotton of the *Gossypium arboreum* species was purportedly grown in Jamestown as early as 1607.[16] And the colonists who emigrated from Barbados to settle the Carolinas under the Lords Proprietors brought *G. barbadense* seed with them. The planters cultivated this variety, originally from Brazil, extensively in the 1690s before shifting to rice and indigo.[17] In Georgia, botanists at the Trustees' Gardens in Savannah, an early type of agricultural experiment station, grew several varieties of cotton from the 1730s on. During the colonial period, the search to find suitable cotton varieties became truly a global

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[16] See Angele Lakwete, *Inventing the Cotton Gin: Machine and Myth in Antebellum America* (Baltimore: Johns Hopkins Univ. Press, 2003) who notes pp. 22-23 that Richard Haklukt's 1607 report claimed the colonists grew this Old World cotton species and that the Records of the Virginia Company included cotton eighth on a 1620 list of 54 commodities grown in the colony. Native peoples in the Southwest had grown *G. hirsutum* varieties for over one thousand years by the time of European contact.
[17] Lakwete, *Inventing*, p. 24.

undertaking. Planters experimented with seeds imported from the West Indies, Mexico, Central America, Brazil, Peru, the Middle East, South East Asia, and China. Table 2 itemizes some of the major imports after 1700. Foreign introductions, once adapted to local conditions, provided the foundation stock for the American domestic varieties.

The usual stylized rendition of the early development of the American upland cotton industry has several important elements. Changes in spinning technologies led to an increase in the demand for upland cotton. Try as planters might to expand production, supply did not keep pace with demand largely because of the cost of separating the cotton lint from its fuzzy seeds. Eli Whitney's cotton gin broke this bottleneck making possible the expansion of production and breathing new life into the slave system.[18] When judged against the realities of the antebellum era, this picture is seriously out of focus.

Learning to improve the seeds was every bit as important as learning to remove them. In the words of J. O. Ware, one of the leading breeders and students of cotton in the early twentieth century, the varieties that became the basis for the South's economic development were a local invention, a distinctive "Dixie product." "Although the stocks of the species were brought from elsewhere, new types, through [a] series of adaptational changes, formed this distinctive group the final characteristics of which are a product of the Cotton Belt of the United States."[19] Plant scientists John Poehlman and David Sleper observe that the cotton stocks initially introduced into the South

> were largely mixed populations with varying amounts of cross-pollination and heterozygosity that gave them plasticity and potential for genetic change. They were tropical in origin, perennial, photoperiod-sensitive, and did not flower under the long days of the United States Cotton Belt. Yet, following generations of repeated selection, these initial stocks were molded into early maturing, photoperiod-insensitive cultivars adapted for production in the southern United States Cotton Belt. 20

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[18] Lakwete, *Inventing, pp.* 1-96 makes a strong case that the ginning bottleneck was not as server as generally thought.

[19] J. O. Ware, "Origin, Rise and Development of American Upland Cotton Varieties and their Status at Present," *Mimeo*, University Of Arkansas College of Agriculture, Agricultural Experiment Station, Fayetteville, Arkansas, 1951, p. 1. Our treatment (as do the published works of a number of plant scientists) relies heavily on Ware, so a short note to his expertise is in order. Ware was one of the USDA's most prominent plant breeders and agronomists. He published extensively on a number of issues related to cotton culture. This unpublished manuscript is probably the single best account of the origins and evolution of upland cotton.

[20] John M. Poehlman and David A. Sleper, *Breeding Field Crops*, 4th Ed. (Ames, IA: Iowa State Univ. Press, 1995), p. 376. They note on p. 374 "The early history of American Upland cotton is complex due to the genetic diversity of the early cottons introduced into the southern states; the frequent occurrence of cross-pollination among the different types; and the rapid genetic adjustment in cotton to climatic differences and cultural practices in the southern states in comparison to the tropical climate and primitive

Table 2:Major Introductions of Foreign Cotton Varieties

Name	Date of Introduction	Comments
Sea Island	By 1720's By 1786	In Louisiana. In the South East.
Siamese Black Seed	By 1733	In Louisiana.
Green Seed	By 1733/34	Georgia and elsewhere.
Mexican Burr	1806	A Mexican highland stock with a cluster phenotype – Imported to Mississippi by Walter Burling; Leads to Belle Creole.
Hollingshead	1818	Mexican introduction.
Alvarado	1825	Spread into Georgia by about 1848.
Various Mexican Varieties	1846-48	It is presumed that the new varieties were introduced by the soldiers returning from Mexico.
Wyche	1857	Came from Algeria but presumed to have originated in Mexico. A parent of Eastern Big Boll Type.

Compiled from C. Wayne Smith et al., "History of Cultivar Development in the United States," in C. Wayne Smith and J. Tom Cothren, eds., *Cotton: Origin, History, Technology, and Production* (New York: John Wiley, 1999), pp. 99-171; J. O. Ware, "Origin, Rise and Development of American Upland Cotton Varieties and their Status at Present," typed manuscript, D.H. Hill Library, North Carolina State University; J. O. Ware, "Plant Breeding and the Cotton Industry," in the *USDA Yearbook of* Agriculture 1936 (Washington, DC: GPO, 1936), pp. 657-744.

In its native environment in Central America, upland cotton, *G. hirsutum*, was a frost-intolerant, perennial shrub with short-day photoperiod response. As a short day plant, its flowering was triggered when the nights began to grow longer in the late summer or autumn. This strategy was adapted to a semi-tropic, semi-arid environment where the rains came in the autumn. At higher latitudes of the American South, there is greater variation in day length over the seasons and the day with the right light to trigger flowering occurred later in the year**.** This delayed maturation in an environment where the first frost occurred earlier. (The wet summers of the American South also served to relax the moisture constraint on the flowering and fruiting processes.) Initial attempts to

cultural practices in the regions where the cottons originated. A major adjustment that had to be made was the adaptation to longer photoperiods. The adjustments were hastened by the contributions of large numbers of early cotton breeders who worked without the genetic guidelines available to cotton-breeders today."

grow upland cotton in the areas that now constitute the United States faced severe difficulties. Success depended on finding a mutation/cross or introducing a variety with the appropriate photosensitivity characteristics.[21] The varieties eventually prevailing in the United States typically flowered in early to mid-summer and began to reach maturity by the end of August or early September.

The process of molding upland cotton to the environment was repeated over and over again as new varieties were introduced and as cotton production moved into new areas. In Lebergott's words it was a matter of "try and try again."[22] According to Ware, "The vast differences in climate and soil that obtain over the Cotton Belt undoubtedly brought about a kind of natural selection which eliminated many of the kinds that were tried, while others became adapted to the several conditions under which they were grown and selected over a period of years."[23] American upland cotton was relatively late to come onto the world market, but its characteristics made it "much more suitable, than any other kind, for general factory use."[24]

The most common upland variety in the Colonial period was Georgia Upland (aka Green Seed, Georgia Green Seed). Several accounts assert that Green Seed was first grown in North America in 1733/34 at the Trustee's Garden of the Georgia colony. It is likely that this variety made its way to Georgia from the Isle of Guadeloupe via England. By later standards, Georgia Green Seed was a low quality, low yielding, low value, short staple variety that was hard to pick. As with most upland varieties its seeds were

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[21] S. G. Stephens, a leading cotton expert, has suggested two paths for the development of day-neutral upland cotton. The first is a cross with of *G. hirsutum* with a day-neutral *G. barbadense* variety from the West Indies. The second is the importation from Guatamala or Mexico of the race *latifolium* of *G. hirsutum* (e.g. Acala), the only form of "day-neutral" upland cotton. S. G. Stephens, "Some Observations of Photoperiodism and the Development of Annual Forms of Domesticated Cottons," *Economic Botany* 30 (1975): 409-18. Stephens concluded p. 17: "Annual Upland cottons, grown in the southern United States since the mid-eighteenth century, were probably derived from perennial day-neutral forms of the Mexican race *latifolium*, though not necessarily by direct introduction from Mexico into the United States."
[22] Regarding such efforts, Lebergott, *Americans*, p. 176 observed "Science was at work, sometimes. Coarse empiricism—try and try again—was at work, many times. (The distinction between the laborious laboratory work of the one and the random ventures of the other was not particularly obvious in the nineteenth century. Nor was it analytically clear at any time.)"
[23] J. O. Ware, "Plant Breeding and the Cotton Industry," *Yearbook of Agriculture, 1936* (Washington, DC: GPO, 1936), p. 659 (657-744); R. B. Handy, "History and General Statistics of Cotton," in USDA, Office of Experiment Stations, Bulletin No. 33, *The Cotton Plant: Its History, Botany, Chemistry, Culture, Enemies, and Uses* (Washington, DC: GPO, 1896), pp. 17-66.
[24] This American advantage changed over time as varieties developed in the United States were adopted in other regions. J. O. Ware, "Origin," pp. 1-2.

"fuzzy," meaning that they adhered to the fiber, making them difficult and labor intensive to separate from the lint. Eli Whitney's achievement was to develop a saw-gin that could more economically remove the seeds of fuzzy-seed cotton varieties.[25] There was a continued evolution in upland cottons as farmers attempted to adapt the standard Georgia Green Seed to different conditions. Some accounts maintain that by 1800 a new and improved variety, Tennessee Green Seed, had been developed in the Cumberland Valley.[26] Although the evidence is scanty, this variety appears to have rapidly gained favor outside the Valley because it could be picked about 20 to 25 percent faster than the older upland varieties.

There were two other parallel developments, one focused on Sea Island varieties and the other on Creole Black Seed varieties. In the late eighteenth century (circa 1786) a milestone was passed when high quality Sea Island varieties (*G. barbadense*) were introduced into Georgia, possibly from the Bahamas or Jamaica.[27] Sea Island cottons

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[25] Again, see Lakwete, *Inventing*, for an assessment of Whitney's contribution. Variants of upland cotton could have naked, black seeds much like Sea Island cotton. But these upland strains were typically less productive and more disease-prone than the green or brown fuzzy seeded variants. A small number of alleles controlled these characteristics and the black trait is recessive. Thus, while it would be technically possible to produce an Upland crop that did not need a saw gin (or its equivalent), it would be associated with lower yields and subject to "invasion" by greenseed germplasm. In the green seed cotton, black seeds would occasionally appear (as Mendel's laws predict). Frederick J. Tyler, *Varieties of American Upland Cotton*, USDA Bureau of Plant Industry Bulletin 163, (Washington, DC: GPO, 1910), p. 17 stated that growers and breeders generally believe that "entirely naked seeds should be picked out and discarded from choice seed intended for planting." He further reported the results from a test comparing fuzzy and naked seed from the same row of plants which revealed that the plants grown from fuzzy seed yielded 40 percent lint whereas those from naked seeds yielded 28 percent.

[26] Watkins, *King Cotton*, pp. 100 and 254; Ware, "Plant Breeding," pp. 658-59; *De Bow's Review* 12 (1852), 632-633.

[27] A widely accepted account is based on a letter from Patrick Walsh of Jamaica who asserts he sent three sacks of seed to Frank Leavet (aka Levett) in Georgia. E. J. Donnell, *Chronological and Statistical History of Cotton* (Wilmington, DE: Scholarly Resources, 1973), p. 48. (Note, first published New York: James Sutton, 1872). Smith's account of the introduction of Sea Island suggests that although the shipment in question came to North America from Jamaica, it was native to Brazil. C. Wayne Smith, *Crop Production: Evolution, History, and Technology* (New York: John Wiley, 1995), p.296. Although many historians have adopted the Walsh-Leavet story, there appears to be at least three other contemporary claims of first introduction. Other accounts have Sea Island coming to Georgia from the Bahamas, and it is possible it came to South Carolina several decades before the more generally dated introduction into Georgia. George Watt, *The Wild and Cultivated Cotton Plants of the World* (London: Longmans, Green, 1907), pp. 272-73. Hammond, pp. 16-17. Stephens' case for an anonymous introduction, probably from the Bahamas, is most persuasive. S. G. Stephens, "The Origins of Sea Island Cotton," *Agricultural History* 50: 2 (April, 1976), pp. 391-399. Theodore Rosengraten offers yet another possibility based on a source published in 1844. He maintains that Sea Island cotton came to Georgia from the Bahamas, but that it had originally come from the Near East, perhaps Persia. Theodore Rosengraten, *Tombee: Portrait of a Cotton Planter* (New York: William Morrow, 1986), p. 50. The USDA reintroduced Sea Island type cottons into the United States early in the twentieth century from Egypt. The variety had earlier been introduced into Egypt from the

soon prospered in the coastal regions of South Carolina and Georgia and became the basis for a fledgling export industry. Not only did Sea Island produce a much longer and finer fiber than upland varieties, its seeds were smooth and could be removed with the traditional roller gin. Persistent attempts to extend the range of Sea Island by acclimating it to upland growing conditions met with little success.

It would be a mistake to regard Sea Island cotton as either a uniform or an invariant product. Ware speculated that "more than one species and no doubt several varieties were brought in during the early period…. From these introductions the sea-island growers doubtless developed their own distinct varieties and strains…." [28] Just as early mechanical inventors whose genius stimulated the Industrial Revolution knew little of the laws of mechanics,

> these early breeders knew little of genetics or the science of plant breeding, but they were artists in knowing their plants. They sought practical ends and concentrated on the development of the long silky types of cotton that the English spinners of the time demanded. Their ideas were based on philosophical biology rather than on scientific biology, taxonomy, or genetics. They felt that environment had considerable effect in producing changes in plants but that heredity transcended all external influences, and that like did really beget like. With this philosophy as a guide, and expertness in observing, sorting, and selecting, they were equipped to build up a great enterprise through plant breeding. Among these growers a particular variety was considered the personal property of the originator and seed was not exchanged or sold unless something better was at hand. The result was the development of many special strains of the finest cotton the world has ever known.[29]

It is common to think of crops and farm technologies as spreading from the east to west, but French colonists in the Gulf regions of lower Louisiana and southern Mississippi actually began continuous commercial production of cotton before planters in the Carolinas and Georgia. During the early 1720s, French settlers experimented with Sea Island cotton with limited success in a narrow band along the Gulf. The repeated failure of Sea Island elsewhere in the lower Mississippi Valley led farmers to test other options. By 1733 a variety imported from Siam called Black Seed or Creole had become the dominant cotton in the region. Like Sea Island, it had smooth seeds that could be separated from the lint with a roller gin. Creole out-yielded Sea Island in this area but produced lower quality fiber. Creole was difficult to pick due to its small bolls and

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Americas. G. A. Niles and C. V. Feaster, "Breeding," pp. 201-231in R. J. Kohel and C. F. Lewis, eds., *Cotton* (Madison, WI: American Society of Agronomy, 1984).

[28] Ware, "Plant Breeding," p. 658; Rosengraten, *Tombee*, p. 76.

[29] Ware, "Plant Breeding," p. 658.

because the lint clung to the pods. But Creole was superior in many respects to the Green Seed Upland cottons and commanded a far higher price.[30] The Black Seed varieties first developed in the Gulf states moved eastward and were widely diffused in the Carolinas early in the nineteenth century.

After 1793, cotton production soared in response to the booming demand in Great Britain and technical improvements associated with Whitney's gin, but in the second decade of the nineteenth century disaster threatened. According to a number of accounts, "cotton rot" first mentioned around 1810, spread through Mississippi and neighboring areas over the next 15 years, causing devastating losses. In response, growers in the Lower South imported seeds from Tennessee and Georgia and increased their plantings of Green Seed that was initially resistant to rot.[31] This transition from Creole Black Seed to Green Seed varieties represented a clear case of technological regress, one dictated by the new environmental realities. The situation deteriorated further when the Green Seed varieties became susceptible to rot. It was precisely at this juncture that the pace of biological innovation accelerated.

The first of a long chain of events that would revolutionize southern cotton production occurred in 1806. While visiting Mexico City, Walter Burling, a Natchez area planter, obtained seeds of a high quality cotton variety which he promptly smuggled out

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[30] Moore, *Agriculture*, pp. 13-36. There is some disagreement regarding the relative yields of the Black Seed and Green Seed Upland cottons. Some accounts have the Green Seed producing higher yields. It is possible that the Black Seed grown in the southern fertile valleys was a different variety than that grown upland or was better adapted to more fertile lands. If so, this could account for the discrepancies. Other details of this story vary. For example, Moore notes that Creole was grown as an annual while others argue it was farmed as a perennial. C. Wayne Smith, Roy G. Cantrell, Hal S. Moser, Stephen R. Oakley, "History of Cultivar Development in the United States," in C. Wayne Smith and J. Tom Cothren, ed., *Cotton: Origin, History, Technology, and Production* (New York: John Wiley, 1999), pp. 102-3.

[31] Moore, *Emergence*, pp. 12-13; Moore, *Agriculture*, pp. 13-36. Watkins, *King Cotton*, notes pp. 98-99 that according to an 1810 contribution in the *Southern Cultivator* "the first cotton seed used in Georgia was the black seed. It was subject to rot and was supplanted in 1810 by the Tennessee green seed…." It is likely that the cotton referred to by Watkins was an upland black seed and not the same variety referred to above. The timing of the appearance of the rot also varies in different accounts. For example Gray asserts that the black-seed type was probably superseded in the uplands about 1800-1810 by the down-covered green-seed cotton." p. 677. This is about a decade after Moore and Wailes date the arrival. There is no consensus about which disease caused the boll rot. Moore, *Agriculture*, p. 31, speculates that the rot was due to a bacterial disease, *Bacillus Gossypium Stedman*. But is could have been one of the fungal diseases that still plague cotton cultivation in damp areas. According to A. A. Bell, "The greatest boll rot losses in the United States occur in the lower Mississippi River Delta of Louisiana and Mississippi, where over half the crop is lost in some years." These losses have been largely due to *Diplodia*, *Fusarium*, and in wet years *Colletotrichum*, and there is some speculation that one of these was the source of the early nineteenth century problems. A. A. Bell, "Diseases of Cotton," pp. 553-597 in Smith and Cothren, *Cotton*, p. 572.

of the country. Burling passed the seeds on to a fellow planter and amateur scientist, William Dunbar, who began the tedious process of experimenting and increasing the seed.[32] The experimental process involved far more than just planting the foreign seeds and letting Mother Nature do the rest. According to Ware, "All Mexican stocks required some reselection for adaptation before satisfactory responses under Mississippi Valley conditions were obtained. Fresh seed from Mexico during the first year or two of planting was said to produce no more than one-half crop."[33] Dunbar also sent samples of fiber to Liverpool to be tested for spinning quality and received a positive response.

By 1820, southern breeders had out-crossed Mexican highland cotton with the Green Seed, Creole, and possibly even with Sea Island varieties, creating many new genotypes.[34] Some of the hybrids that emerged represented vast improvements on the existing stock:

> Its staple was longer and the grade of the lint higher than Creole or Green Seed. It ripened earlier in the fall than any other type then in cultivation in the United States, and it displayed a noticeable tendency to mature many of its bolls simultaneously. Even more importantly, it possessed exceptional picking properties. Its large four or five-sectioned bolls opened so widely upon ripening that their lint could be plucked from the pod more easily than any other known variety of the staple. Because of this unusual quality, pickers could gather three to four times as much Mexican in a day as they could the common Georgia Green Seed cotton. Most important of all, the Mexican strain was totally immune to the rot, the dreaded plant disease that was then destroying both the Creole and Georgia Green Seed crops in the Mississippi Valley.[35]

Watkins was so impressed with the improved attributes of the Mexican cotton that he proclaimed that "From an economic point of view the introduction of this seed was second in importance to the invention of the saw gin."[36]

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[32] Dunbar was also experimenting with other varieties, including one from China. Moore, "Cotton Breeding," p. 96. Also see Gray, *History,* pp. 673-677. Burling was on an official mission to Mexico and smuggled the seeds out of the country hidden in a number of dolls. More generally, the unauthorized transfer of "intellectual property" was a major ingredient in the development of American agriculture. Gilbeart H. Collings, *Production of Cotton* (New York: John Wiley, 1926), p. 201; Watkins, *King Cotton*, p. 165. Moore, *Agriculture*, pp. 32-33. In his authoritative treatment of cotton history, James Street confuses Petit Gulf with Mexican cottons imported earlier. He also attributes the smuggling of seeds to a General James Wilkinson. James H. Street, *New Revolution in the Cotton Economy* (Chapel Hill: University of North Carolina Press, 1957), p. 8.

[33] Ware, "Origin," p. 50.

[34] Smith, *Cotton Production*, pp. 296-97.

[35] Moore, "Cotton Breeding," p. 97; also see Gray, *History,* pp. 689-90; Moore, *Agriculture*, pp. 13-36.

[36] Watkins, *King Cotton*, p. 13. Watkins probably took this comparison with the cotton gin from an 1851 account. See Thomas Affleck, "The Early Days of Cotton Growing in the South-West," *De Bow's Review*, 10: 6 (1851), pp. 668-69. Gray, *History,* p. 689 and Moore, *Emergence*, p. 28 both reproduce this comparison with the saw gin. Watkins, *King Cotton*, p. 13 notes that "the average day's picking for a hand

The commentary on the diffusion of the Mexican and the new hybrid varieties is cloudy and often contradictory, but we do know general outlines of the process. For all of its advantages, Mexican cotton did not spread immediately. Moore asserts that an increasing number of growers in the Lower Mississippi Valley were taking up its cultivation in the 1820s. Seed from Natchez evidently first arrived in the Gulf Hills region near Rodney, Mississippi in 1824. Ware reports that the Mexican cotton first appeared in South Carolina in 1816, but at this date the older varieties would still have dominated in that region and at least according to some accounts, it probably was not until roughly 17 years later that commercial seed of the Mexican hybrids was being marketed in the Southeast. In 1834 the rot that had earlier infected the Mississippi region evidently appeared in the eastern states badly damaging the Green Seed crop. This is credited with hastening the adoption of the Mexican hybrids.[37]

The key point is that from the mid-1820s to at least the mid-1830s and maybe longer there likely was a distinct difference in the *modal* types of cotton grown in the Lower Mississippi Valley and of those grown in South Atlantic states. Over this period the western cottons offered higher yields, were of better quality, fetched higher prices, and were significantly easier to pick.[38] In addition it is likely that the spread of the new varieties widened yield and picking efficiency differences separating the nitrogen rich alluvial and black soil lands of the New South from the poorer lands in the hill country and the East. Although the early Mexican hybrids were evidently more productive than Green Seed on almost all types of soils, the productivity differential was far greater on good soils.

Lest there be any doubt that the physical formation and fruiting qualities of the cotton plant might result in dramatically different picking rates, we offer photographs from the slave era or its immediate aftermath showing pickers working in low cotton and high cotton. The size of the bolls suggests that all of these photos show "modern" cottons as of the Civil War era. Neither the green seed nor black seed cottons would have

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was 30 to 40 pounds of black seed and 75 to 100 pounds of the Tennessee green seed variety. At first a hand could pick 150 pounds of the Mexican, and this gradually increased to several hundred pounds."

[37] Moore, "Cotton Breeding," pp. 97-98.

[38] Watkins, *King Cotton*, p. 13; Ware, "Plant Breeding," p. 659.

had such large plump bolls. The descriptions of the early black seed varieties (which grew tall) depict small bolls the size of a pigeon's egg.[39]

Slaves or recently freed workers picking in low cotton

versus working in high cotton.

By the early 1830s a succession of improved hybrids became commercially available throughout the South. Among the most popular were Petit Gulf introduced by Dr. Rush Nutt of Rodney Mississippi in the late 1820s (it was reportedly on sale in market towns across the Cotton South by 1833) and One Hundred Seed bred and distributed by Col. Henry W. Vick of Vicksburg, Mississippi in the mid 1840s.[40] In 1839

[39] Moore, *Mississippi*, p. 31.

[40] Moore, "Cotton Breeding," pp. 95-104; Moore, *Emergence*, pp. 12-16. From reading Moore and other standard accounts, one might surmise that the rot disease wiped out the Green Seed varieties. To the contrary, in 1880 Tennessee farmers reported that "Green Seed" varieties were widely grown in the state. U.S. Census, "Cotton Production in the United States," p. 99. Tyler's 1907 survey of varieties notes that pockets of Tennessee Green Seed and other older varieties continued to be grown throughout the Cotton Belt. Ware, "Origins," pp. 17, 45-46. There is a problem interpreting these accounts because there is no way of knowing if the Green Seed of 1810 bore a close resemblance to that of 1880 or 1907.

Vick began an annual process of having his most able slaves make special pickings of the finest bolls from the largest and most prolific plants. This cotton was ginned separately and then grown in isolated fields. Not trusting his slaves or overseers to do the job, Vick often ventured into the fields himself in search of valuable mutations and crosses. Vick personally selected the progenitor of the One Hundred Seed cultivar in 1843 from the particularly appealing bolls of a single plant that he had discovered while visiting another plantation in the Lower Mississippi Valley.[41] He then increased this seed and began selling it locally a few years later. Petit Gulf and One Hundred Seed spread across a wide area and were noted for high quality, good yields, ease of picking, and rot resistance. Planters faced problems maintaining seed quality given the prevalence of cross-pollination in the field and the mixing of seeds at gins. The desire of planters to avoid exerting special care in seed selection and ginning encouraged the growth of specialized seed producers in Mississippi who shipped throughout the South.[42]

In addition to Petit Gulf and One Hundred Seed, other important varieties produced by the antebellum Mississippi Valley breeders were Sugar Loaf (1843), Banana (<1848), Mastodon(<1849), and Boyd's Prolific (<1847). Sugar Loaf, developed in 1843, was first in the line of cluster types (that is, the plant tended to have multiple bolls at each node on its short fruiting limbs, making the bolls cluster together). Boyd's Prolific was another cluster-type cotton; it opened up the line of development of semi-cluster varieties (which possessed the clustering habit in a less pronounced form). Varieties such as Mastodon were highly esteemed in certain regions but were deemed "humbugs" in others.[43]

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[41] Moore, "Cotton Breeding," pp. 99-101; *Vicksburg Sentinel*, July 7, 1847, p. 1.

[42] Moore, *Emergence*, p.13; Ware, "Origins," pp. 12-14; Smith, *Cotton Production*, p. 297. Rush Nutt's entrepreneurial talents were not limited to breeding quality cotton. Moore credits Nutt for being the first to use a steam engine to power a cotton gin around 1830. Moore, *Emergence*, p. 70.

[43] Watkins, *King Cotton*, notes (p.173) that M. W. Phillips of Hinds County, Mississippi considered Mastodon a humbug but that it was among the most common varieties planted in the late 1840s and early 1850s in Louisiana (p. 195), Texas (p. 217), and Arkansas (p. 243).

Colonel Henry W. Vick of Vicksburg, “the most persevering and the most successful of all the Mississippi planters in the art of perfecting cotton. (Lyman, 1868 p. 122)”

In his 1868 book, *Cotton Culture*, Joseph Lyman summed up the impact of the highland Mexican imports and their descendants:

> Beginning with the year 1820, and from that time forward, various planters in different parts of the cotton growing States have devoted themselves to the development and sale of improved varieties of cotton seed, and certain styles of cotton have for two, three, or four years, enjoyed a great, though ephemeral popularity, and, then, as suddenly, been pushed aside for a new reigning favorite.[44]

Antebellum observers were impressed and at times astounded by the high prices the new seeds brought in the market. Whereas, ordinary cottonseed sold for 25 cents per bushel (when used for manure), the Petit Gulf seed regularly marketed for twice as much. Seeds of choice varieties such as Sugar Loaf, Brown, Hundred Seed, Banana, Multibolus, and Prolific, “under ordinary circumstances, command from one to three dollars per bushel.” And when first introduced, Mastodon seed netted five dollars a bushel, Banana “at first sold for a hundred dollars a bushel [and] some paid ten cents apiece [again roughly $100 per bushel] for ‘Hogan’ seeds.”[45] We can take these seed prices as signals of the higher value that planters placed on the new varieties.

[44] He continues: “The improvement of a cotton seed as a business, and sale of the improved varieties, has enabled quite a number of prominent and enterprising planters throughout the South to realize handsome fortunes.” Joseph B. Lyman, *Cotton Culture* (New York: Orange Judd, 1868), p. 121. Although this book was published in the postbellum period, its commentary focuses on antebellum conditions.

[45] Lyman, *Cotton Culture*, pp. 121, 125. Lyman (p. 125) discusses the case of a planter who earned more profits from selling Mastodon seed than his entire crop of cotton. Also see Moore, 1956, pp. 100-102. Lest one think that antebellum planters were engaging in wild speculation, recall Peter Garber’s argument with reference to the Dutch Tulipmania. Given the capacity of bulbs and seeds to multiply, it may be entirely rational to pay “extraordinary sums” for the germplasm for new, rare plant varieties with desirable characteristics. Prices might be expected to fall as quantities multiplied. Peter M. Garber, *Famous First Bubbles: The Fundamentals of Early Manias* (Cambridge MIT Press, 2000), p. ix.

To this point we have presented a brief case for the importance of biological innovation. The nineteenth century sources and the secondary literature indicate that there were many important advances, but the scattered and varied sources are not always in agreement on many of the details. To gain a clearer and more textured picture of the diffusion of new Mexican varieties and their impact we have developed a dataset on slave picking rates. Picking was the key bottleneck in the cotton production process. Gallman, Wright, and others have suggested that planters assessed how many acres they could pick and adjusted planting and crop mix decisions accordingly.[46] Thus innovations that relaxed the picking constraint would have had dynamic implications leading to a growth in cotton acreage and an increased specialization in cotton production. While emphasizing the special importance of innovations that saved labor in peak load activities, we reiterate that picking efficiency was only one of the many superior qualities attributed to the Mexican hybrids—they also significantly increased output per acre (although the quantitative evidence on this is less abundant) and yielded a higher quality product.[47]

The resistance of the Mexican cottons to rot contributed to the yield advantage and made them a more reliable crop. Once the older varieties became susceptible to rot it is most likely their yields and picking efficiency would have continued to decline if farmers had persisted in planting them. Thus comparing the observed yield and picking performance of Mexican cottons with "normal" crops of Black or Green Seed cottons would significantly understate what would have happened in a counterfactual world where the diffusion of the Mexican cottons had been long delayed. The observed trend in picking rates that we present later in this paper understates the true productivity impact of the Mexican cottons because an appropriate measure requires accounting for the presumed further decline in the productivity of the older varieties. In addition to these

[46] Robert Gallman, "Self-Sufficiency of the Cotton Economy of the Antebellum South," in William Parker, ed., *The Structure of the Cotton Economy of the Antebellum South* (Washington, DC: Agricultural History Society, 1970), pp. 5-24; Gavin Wright, *Political Economy of the Cotton South* (New York: W. W. Norton, 1978).

[47] The scattered evidence on the yield advantage of the Mexican cottons almost always refers to the yields of seed cotton, and thus understates the true advantage. Gray, *History*, notes that "the older varieties yielded lint weighing only 25 per cent of the total weight of seed cotton." p. 703. The lint-to-seed ratio of the Mexican cottons would have been at least 35 percent, implying a 40 percent premium following ginning on top of the substantial increase in the yield of seed cotton.

considerations our data on picking rates only bear on a part of a larger story because there were a number of important mechanical innovations that effected cotton production. To avoid interrupting the flow of our argument, these important changes are discussed in Appendix A.

Assembling a New Data Set

To assess the performance of their workers, many masters kept logs detailing the daily picking output of individual slaves. Absentee owners often required their overseers to keep such records so that the owners could better assess day-to-day farm activities, but many resident owners also caught the record-keeping bug.[48] The data allowed for comparisons with past years, and helped set expectations for tasking the pickers. As Robert Fogel and Jacob Metzer suggest, the records were precursors to the time-in-motion studies initiated by Frederick Taylor and the "Scientific Management" movement in the early twentieth century.[49] Failing to meet picking standards had consequences. In

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[48] Absentee owners also desired the records to evaluate their managers and overseer and to prevent shirking, malfeasance, and so on. This motivation is suggested in the following passage in a 4 May 1834 letter from President Andrew Jackson in Washington to his son, Andrew Jackson, Jr., back in Tennessee: "My son, when you left me we had a right to believe our cotton crop would have yielded at least fifty thousand pounds baled cotton; we had a right from information to believe we would have 180 thousand in the seed, to 200. Now it appears that there was not raised more than about 114 to 120 thousand in the seed. I name this, that this fall you may guard against such imposition, and have a cotton Book on which must be entered the daily picking of each hand, and make the overseer responsible for the accuracy of the cotton Book." John S. Bassett, ed. *Correspondence of Andrew Jackson*, Vol. V (Washington, DC: Carnegie Institution of Washington, 1931), pp. 263-64 accessed from Lexis-Nexis.

[49] Fogel, *Without Consent or Contract*, p. 27; Metzer, "Rational Management," pp. 123-50. The picking task was performed on an individual basis. Fogel and Engerman observe in *Time on the Cross*, p. 206 "(h)arvest operations do not appear to have offered the opportunities of division and specialization that existed during the planting and cultivation seasons…. In the absence of an interdependence that could be exploited to promote an intense rhythm of work, planters attempted to achieve the same objective by dividing harvest hands into competing groups. There were daily as well as weekly races, with prizes (bonuses) offered to the winning team and to the leading individual picker. There were daily weigh-ins of the cotton picked, and those who did not respond to the positive incentive had to face the abuse, verbal or physical, of the driver, if they fell too far below the expected pace."

"The so-called 'task method' was still another means of promoting the intensity of labor during the harvest period. Under this method, slaves were assigned given plots of land which were to be picked each day. Intensity of labor was promoted by permitting the slave to use his time for his own purposes when the task was completed. One way of ensuring that the work was done well under this system was to reassign the same plot to the same slave in each of the successive rounds of picking. Daily weighing of cotton also served as a check on performance."

Our examination of plantation diaries, cotton books, and Affleck-style accounts covering several hundred picking seasons has revealed several instances of competitions, but they seem the exception rather than the rule. "Weigh-ins," as Fogel and Engerman describe the practice in their 1960-70s lingo recalling the 1830s, Dr. J. W. Monett of Mississippi asserted that after weighing an individual's daily picking, masters would whip slaves for light or trashy picking.[50] And we know that on several occasions, Louisiana planter Bennet Barrow ordered a whipping for all hands because the output was too low. On other occasions, Barrow sponsored picking contests with prizes.

Plantation managers recorded picking data in various documents including plantation journals, diaries, cotton books, ledgers, and the like. In one case we found the records for a part of a season in a letter from an overseer to the owner. Over time record keeping became more formalized with many planters employing bound account books with printed templates designed especially for this purpose. The most popular cotton account book was produced by Thomas Affleck, a noted nurseryman, experimenter, and farm journalist. The first edition of the *Affleck Plantation Journal and Account Book* appeared in 1847. Within a few years he offered three different volumes—one for small plantations with up to 40 slaves, one for mid-size plantations with 80 hands or less, and one for plantations with up to 120 hands.[51] In addition to the pages efficiently laid out for recording picking, the Affleck books provided forms for listing the slaves' names, ages, and values, births and deaths, stock and equipment inventories, the weight of individual bales, and other valuable information. The entries and marginal notes often provide a detailed sense of the pulse of plantation life, including the days lost to rain, and whether or not the slaves worked a full or half day, whether the slaves worked on Saturdays, and the like. Only rarely did the slaves pick cotton on Sundays. The records also indicated which slaves were sick on a given day and which were assigned to other tasks such as

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sit-ins, teach-ins, and be-ins, were far more routine and many times more common than prize competitions. Daily weighing also appears common even if the weights were not recorded.

[50] J. W. Monett, "Cotton Crop" which was an Appendix (pp. 281-94) in Joseph Hilt Ingraham, *The Southwest by a Yankee*, Vol. II (New York, Harper and Brothers), 1835. Monett writes: "After the weighting is over, and the baskets are emptied, or turned bottom upward, upon the scaffolds, the overseer takes the slate, and examines the weights attached to each name. Those who are found to have brought in less than their usual quantity, unless for good reasons, are called in the order of their names; the individual advances, and if his reasons are insufficient, he is ordered to lie down upon his face, with his back exposed; when he receives ten, twenty, or fifty stripes with the whip, according to his deserts. In this way the overseer goes over the list, punishing only those who have idled away their time…. No one knows that he is to be punished until his name is called, when he has an opportunity of giving his reasons for his imperfect day's work."

[51] Robert W. Williams, "Thomas Affleck: Missionary to the Planter, the Farmer, and the Gardener," *Agricultural History*, Vol. 31, No. 3 (July 1957), pp. 40-48. In 1860 Affleck published a fourth book for plantations with more than 120 slaves. Williams, p. 46.

making baskets, cutting timber, tending other crops, hauling, and working in the gin. Of course the overseers and owners differed significantly in their attention to detail, but in many instances when the key information was not recorded in the Affleck volumes, we were able to extract it from surviving diaries and other farms journals.

Figure 2 shows an example of a "user friendly" page from an Affleck book—one that is legible, reasonably complete, and in this lone case one that was already scanned into a machine readable form. This record comes from the Eustatia Plantation in Mississippi.[52] These records detail the picking of nearly 60 slaves throughout the 1860 picking season. (But there are many records for other planters, so many that it is hard to retain any romantic notions of a sleepy plantation system run by pre-capitalist masters.) Note that this page shows the overseer's calculations of the daily totals. Such sums prove valuable in allowing us to check the accuracy of our work although in many cases, the record keepers' sums are not quite right. Obviously, our problems and costs soared when the pages were harder to read, when the overseer changed the order of the names from page to page, and when the data were incomplete.

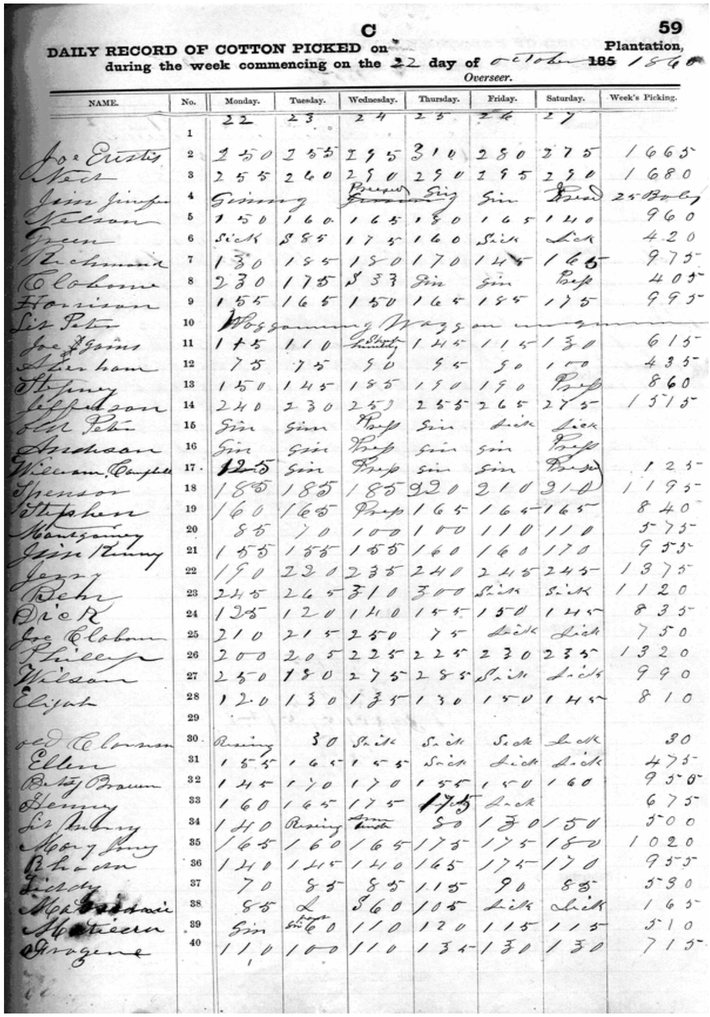
We entered these data on individual picking into Excel spreadsheets.[53] In collecting the data we were especially careful to avoid entering false positives. At present we have about 360,000 individual picking entries, spanning the years from 1811-1862. These records include data from 54 separate plantations, with many more plantations to still be entered. The quantity and quality of the data differ greatly from plantation to plantation. For 11 plantations we have data for only one picking season or for part of a season. At the other extreme we have data for 22 years for the Leak plantation located in Tippah (now Benton) County, MS. We have only 60 entries for the Bassett plantation in Hanover County, VA, whereas we have over 10 thousand entries each for five different plantations. The Leak plantation sets the standard for the most entries for a single plantation at 79,602 and for a single season at 5,454.

Our sample is concentrated in the Mississippi Valley with 21 plantations located in Mississippi and 14 in Louisiana. The years of coverage for these two states stretch

[52] http://dbs.ohiohistory.org/africanam/page.cfm?ID=13902 This plantation book is on the PBS "Slavery and the Making of America" website at http://www.pbs.org/wnet/slavery/experience/living/e4.html
[53] We have not utilized plantation records displaying only picking totals and aggregate numbers of pickers. Some plantations report only such aggregate data and others do so for selected periods, typically early in the season. Such aggregate data provide no means of controlling for the composition of the picking crew.

from 1811 to the end of the Civil War with at least some data for almost every year in this period of over one-half century. The data become more abundant in the 1850s. Over all of the states, we have 8,887 observations for the years before 1820; 15,680 for the decade of the 1820s; 39,199 for the 1830s; 95,835 for the 1840s; 142,158 for the 1850s; and 49,139 for the 1860s. The disruptions caused by the Civil War are evident as the records become less abundant and many males disappear from the samples.

Many of the records we used are found in the University Publications of America microfilm series *Records of Ante-Bellum Southern Plantations: From the Revolution through the Civil War*, edited by Kenneth M. Stampp. We owe a great debt to Kenneth Stampp and others associated with this project for making accessible the records of about 1500 plantations. But the UPA project overlooked many plantation records. To expand our sample we searched the catalogs and consulted with special collection



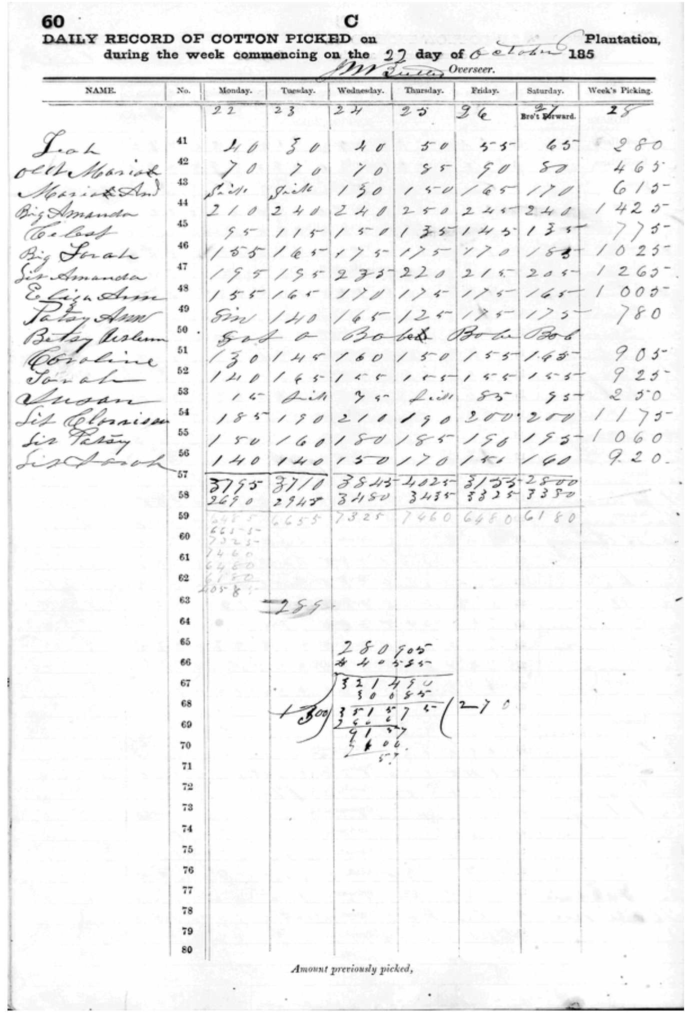


Figure 2: Sample from Eustatia Cotton Book

librarians in dozens of university, state, county, and municipal libraries located across the South. There have been far more dry holes than gushers. The collections at Louisiana State University, the University of Mississippi, the Mississippi State Archives, the University of North Carolina, the University of Texas, and Duke University have proved particularly rich. Some of our data came from private individuals whom we identified on the web through their postings of genealogical research.

We are in the process of converting the individual slave picking data to Stata files so we can take full advantage of the panel dimensions of the micro data and more fully capture the nuances and implications of the changes over time. The aggregate data will have to suffice until these datasets are ready.

Summary Results on Picking Productivity

Figure 3 shows our summary results for the 1811-1862 period. These results are both preliminary and incomplete, but the panels of the Figure reveal a clear upward march in picking rates roughly in conformity with the claims of the "broader history literature." Each data point represents the mean or median amount of cotton picked per day for a "plantation year." Thus a plantation with 300 entries covering only part of the picking season has equal weight as a plantation with 5000 entries spread across the entire season. The labels of the plantations indicate their locations by state (MS=Mississippi, LA=Louisiana and so on).

The panels in Figure 3 for the means and medians also include two sets of time trends which were calculated from the regression results displayed in the Table 3. The first set estimates the time trend including linear and quadratic time trends without any further adjustments. By these estimates, the mean pounds increased almost 2 percent per annum, rising from 45.9 pounds in 1811 to 119.7 pounds in 1860. This represented an increase of 2.6 times. The median pounds picked grew by similar magnitudes. These increases are not as large as the purported quadrupling from 50 to 200 pounds over the 1800-60 period as suggested by Legergott, but the changes in output per day are, nonetheless, highly impressive. For both the means and the medians, the quadratic terms indicate the grown process was slowing down.

The second set of time trends attempts to control for the effects of changes in plantation size as measured by the average number of pickers working per day. Across the plantations in our current sample, the average number of pickers increased by 0.9 percent per annum, rising from about 17.7 hands in 1811 to 28 in 1860. In our sample, plantations with larger picking crews tended to have higher rates of picking per person (which is consistent with economies of scale, positive correlations between size and managerial efficiency, and other explanations).[54] Controlling for the (log of the) number of pickers reduces somewhat the estimated time effects; the mean pounds by this measure increase by 1.7 percent per annum. This is still rapid enough to yield a more than doubling in the picking rate over the 1811-1860 period. (The results also suggest that the measured increase in the number of pickers can account for about 15 percent.)[55] The adjusted time trends in the panels hold the number of pickers constant at their (geometric) mean level.

The Figure and regression results also reveal an enormous variability in the data across plantations, regions, and nearby crop years. The R-squares are relatively low, and the variance even within a given decade, such as the 1850s, is high. (See below for a breakout of the plantations in the Lower Mississippi Valley, excluding Leak who is an outlier both in the sense of having low picking rates for the region and being located in the uplands far off the Mississippi River.)

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[54] The measured effect of (the log of the) size of the average number of pickers appears quite large at 0.19. This would imply a doubling in the size of the crew leads to a roughly 20 percent increase in daily output per picker. Note that most of our plantations are larger than the average southern farm and, given the available data, we include no free labor operations.

[55] To control for the possibility that picking rates increased because slave owners learned over time to better utilize larger picking crews, we also ran regressions interacting the year and log of the picking crew size. In both the regression for the mean and median picking rate, the coefficient of the added term had a statistically insignificant effect and its inclusion provided no additional explanatory power.

Figure 3: Mean and Median Daily Picking Rates by Plantations, 1811-62

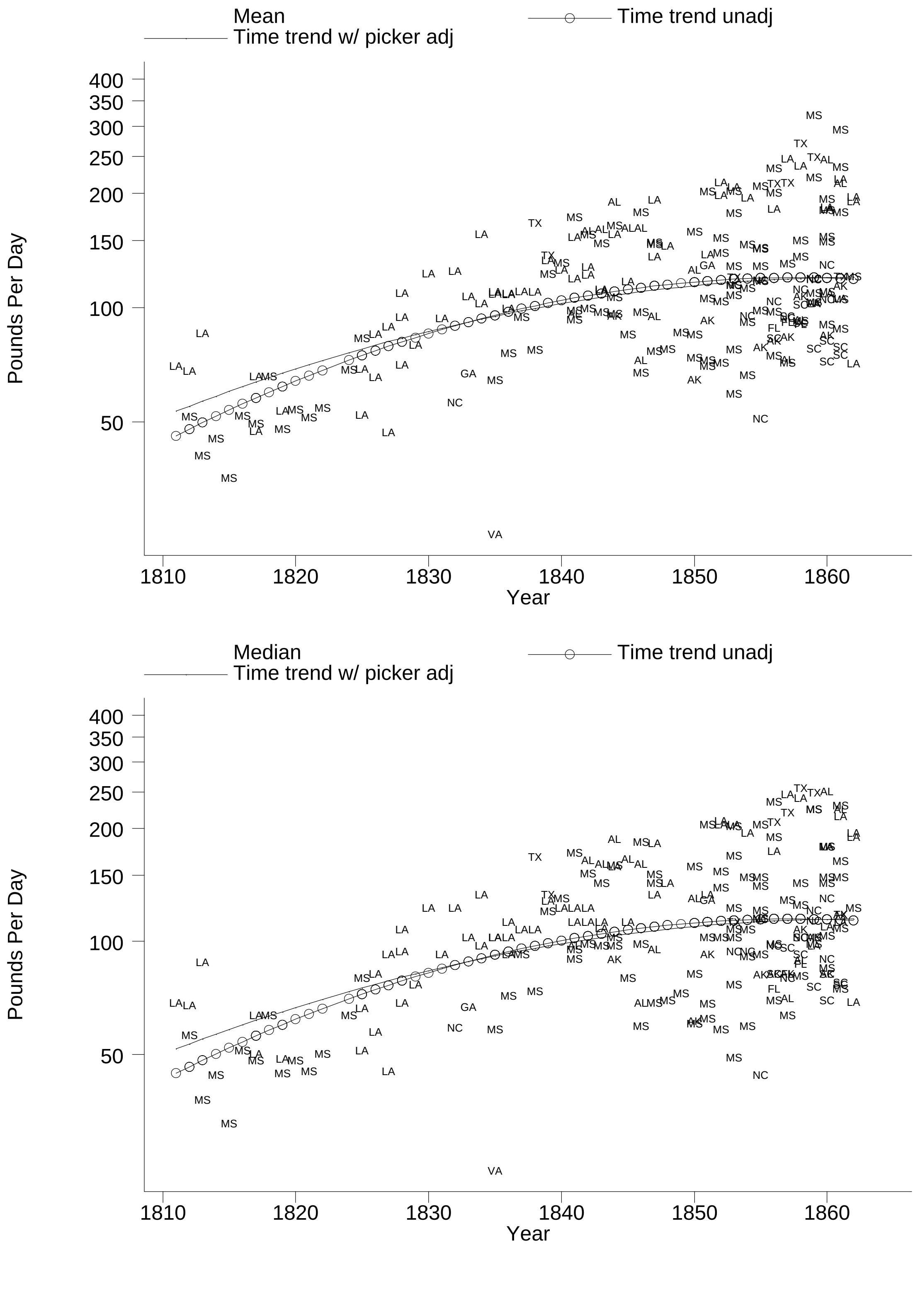


TABLE 3: Estimating Picking Time Trends, 1811-62

		Log(Mean Picking)		Log(Median Picking)	
		(1)	(2)	(1)	(2)
Constant	Coeff	-20.362	-18.928	-19.736	-18.314
	St. Err	(3.826)	(3.378)	(3.831)	(3.339)
Year	Coeff.	0.01354	0.01243	0.01318	0.01208
	St. Err.	(0.00208)	(0.00182)	(0.00208)	(0.00180)
YearSq	Coeff.	-0.00044	-0.00030	-0.00044	-0.00030
	St. Err.	(0.00013)	(0.00130)	(0.00014)	(0.00013)
Log(Pickers)	Coeff.	--	0.1912 --		0.1898
	St. Err.	--	(0.0400)	--	(0.0415)
R-squared		0.273	0.352	0.252	0.326
No. of Obs. (Plantation-Years)		187	187	187	187

YearSq is the component orthogonal to Year.
Standard Errors are robust.

<u>Summary Statistics:</u>

Variable	Obs	Mean	Std. Dev.	Min	Max
lmean	187	4.655	0.428	3.207	5.748
lmedian	187	4.615	0.438	3.178	5.501
lpicker	187	3.201	0.655	1.099	4.353
mean	187	115.038	50.099	24.7	313.7
median	187	110.768	47.900	24.0	245.0
pickers	187	29.530	16.384	5.3	77.68
year	187	1846.69	13.30	1811	1862

Disaggregating the Data: Age, Sex, and Season

One can raise many objections to these preliminary results based on the aggregate data, but it will be best to wait to make refinements until the disaggregate data are available. Disaggregating and building a panel of the individual data will help us address the many problems inherent in the numbers presented in Figure 3. For example, we know children did not pick as much as adolescents or adults. For many plantations we have the ages of the slaves. With this information we can make reasonable adjustments in comparing rates over time and between plantations. In addition we should be able to provide firmer estimates of the relative productivity of children at different ages. In a similar fashion we are interested in the gender division of labor. Many accounts assert that women were better pickers than men. We shall see.

The data also need to be adjusted for seasonality. Picking rates tended to be much higher at the peak of the season when the crop was ripening fast. The general pattern appears to be that rates are relatively low in August, then rise in September, October, and November, before dropping off sharply in December. It is important to determine if the data show any changes over time in the length of the season, the timing of the peak periods, or in the relative intensity of the peaks. Seasonality adjustments will also affect the relative productivity of children and women versus adult men. This is because at the start and end of the picking season and during other periods when the cotton crop was light, it was common for males to perform non-picking work (i.e. ginning, pressing, hauling, cutting timber and clearing land, etc.). In addition, according to Gray "It was customary to pick a field three times, the several pickings being designated successively the 'bottom,' 'middle,' and 'top,' crops. The middle picking furnished the largest product...." For these reasons to compare the efficiency of men and women requires us to know when they are picking and to essentially compare days when both genders worked.

We also must check how representative the plantations in our sample are. We intend to link these establishments with the censuses of 1850 and 1860 to improve our understanding of this issue. We suspect that plantations in our sample will be larger and more oriented to cotton production than the typical operation in the census, but will be roughly comparable to the types of plantations with surviving archival records.

Diffusion of Easy Picking Cotton

It would also be desirable to link the picking records with the plantation diaries to determine better which cotton varieties the plantations were actually growing. There are many claims in the history literature about the diffusion of picker-friendly cotton. With more entries we hope to be able to better document this process. At this point we do not see any distinct breaks in the data for the plantations for which we have a long spread of years starting early enough to be reasonably confident that the plantations were initially growing black or green seed varieties. The conversion process appears to be more gradual, consistent with the planters experimenting with a new variety and gradually adopting it.

Conjectures about the Impacts on Southern Development

Two implications of the increased picking efficiency are clear. The set of technological innovations raising picking rates would (1) improve the competitiveness of U.S. cotton in world markets and (2) lead the ratio of the price of slaves to the price of cotton to rise. Most other implications become entangled in assumptions about the elasticity of the long run demand curve for cotton, the nature of the production functions, and a host of other conditions.

One difficulty with drawing other firm implications is that the voluminous empirical literature on the cotton markets has failed to generate much consensus about the precise price-elasticity of demand for the U.S. cotton crop. Table 4 shows a sample of the estimates. Wright's estimates "put the elasticity of demand at roughly 1.0 during 1830-1860, 1.5 for the period 1866-1895, but back to 1.0 for 1879-1913."[56] Wright's earlier (1971) study as well as Surdam's 1998 investigation indicate a more inelastic demand over the 1830-60 period whereas Irwin's 2001 working paper supports a more elastic estimate for the U.S. product. Irwin does take an important step by accounting explicitly for quality differences; he adopts an Armington framework that treats different countries' cottons as differentiated products. One complication for our quest to examine the impacts of the introductions of the new varieties is that none of these studies considers changes in the quality of the U.S. crop. It is worth noting that only Surdam's study suggests that demand was sufficiently inelastic to generate the conditions of immiserating growth, implying the increased productivity reduced cotton incomes.

[56] Gavin Wright, "World Demand for Cotton during the Nineteenth Century: Reply," *Journal of Economic History*, 39:4 (Dec. 1979), p. 1023.

Table 5: Selected Estimates of the Price Elasticity of Cotton Demand

Source/Crop	Price Elasticity	Period	Authority
British Demand for US Crop	-0.31 to -0.65	1830-1860	Wright 1971, p. 119.
Foreign Demand for World Crop	-0.60	1830-1860	Surdam 1998, p. 126
Foreign Demand for US Crop	~ -1.0	1830-1860	Wright 1971, p. 119
	~ -1.5	1860-1895	Wright 1979, p. 1023
	-1.49	1820-1859	Irwin 2001, p. 23.
	-0.88	1830-1860	Surdam 1998, p. 117

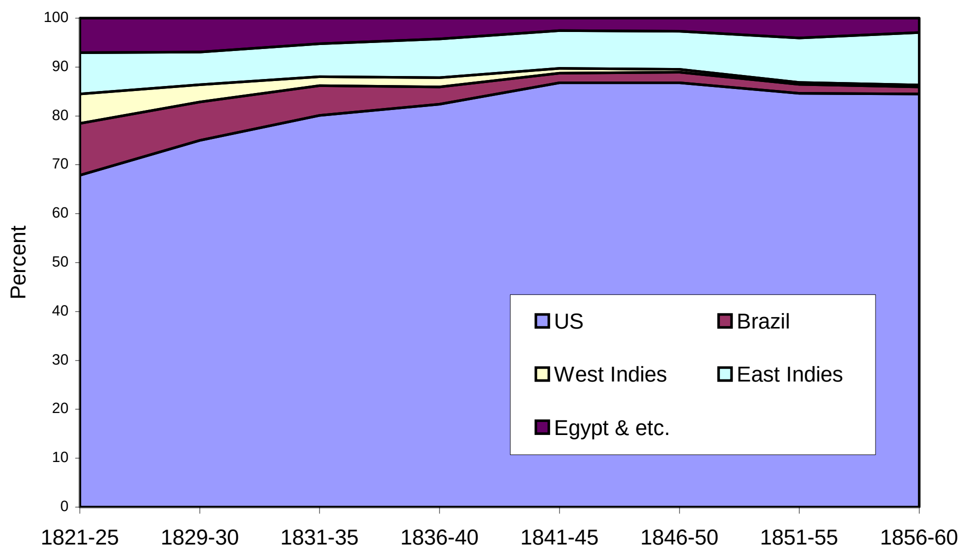
Sources and Notes:
Gavin Wright, "An Econometric Study of Cotton Production and Trade, 1830-1860," *Review of Economics and Statistics*, 53 (May 1971): 111-20; "World Demand for Cotton during the Nineteenth Century: Reply" *Journal of Economic History*, 39:4 (Dec. 1979): 1023-24; David G. Surdam, "King Cotton: Monarch or Pretender? The State of the Market for Raw Cotton on the Eve of the American Civil War," *Economic History Review*, 51 (Feb. 1998): 113-32; Douglas A. Irwin, "The Optimal Tax on Antebellum U.S. Cotton Exports," NBER Working Paper No. 8689 (Dec. 2001).
Surdam's econometric estimates p. 131 relating the US crop and price over the 1831-61 period also yields an elasticity of approximately –1.

The Effect on Cotton Production and Prices

The increase in picking efficiency should have lowered the cost of producing cotton. There would have been super normal profits to early adopters, but these should have been gradually competed away as cotton supplies increased. Given that diffusion of the new seeds probably took decades and that there was a flow of new innovations over time, it is possible that planters near the center of innovation maintained some advantage over decades. The long run outcome would depend on the long run elasticity of demand. Assuming that cotton farming was competitive in the output market, the observed record of cotton prices falling at a time of rapidly growing supply implies individual firms (plantations) on average were moving toward new lower cost equilibria.

The increase in picking rates should have increased the competitiveness of U.S. cotton producers relative to those in the West Indies, the East Indies, Brazil, and Egypt. Over the period from 1820 to 1860, the U.S. share of the world commercial market for cotton (as measured by consumption in Europe and America) increased from roughly 67 percent to over 80 percent. Figure 4 graphs the relevant data. The growing dominance of the U.S. South in this important market depended on the expansion of productivity in its cotton sector. Given that the learning was location-specific, adaptations made to fit the environment of the U.S. South very likely did not immediately spillover to benefit competing regions.

Figure 4: Shares of Cotton Consumption in Europe and America, 1821-60



Sources: Thomas Ellison, *The Cotton Trade of Great Britain*, New York: Augustus M. Kelley, 1968, (orig. pub. 1886), p. 99; U.S. Treasury Department, Bureau of Statistics, *Finance, Commerce, and Immigration of the United States* (August 1895), SS3450, p. 304.

The Effect on Slave Prices

As with any input, the rental price for slaves was a function of a derived demand dependent on their marginal productivity and the price of the output, in this case cotton. The increase in picking efficiency would have increased the marginal product of slaves in cotton, and all else equal, increased slave prices. It is possible that the increased efficiency could have led to a fall in the price of slaves if the price of cotton had fallen relatively more than the increase in slave productivity. The historical movement in slave prices indicates that the price-elasticity of cotton demand was sufficiently high that this did not happen.

Economies of Scale, Crop Mix, the Gang System, and Geography

Especially pertinent to our analysis is Gavin Wright's finding that a systematic difference in the mix of crops grown on plantations and family farms within the South explains much of the labor productivity advantage attributed to the plantation system. Wright argues that 1859 (the census year for which the estimates were made) was an exceptionally good year for both cotton yields and cotton prices, and thus plantations which were more specialized in cotton production than were family farms appear to have been more efficient. In addition, Wright and others have noted that plantations occupied better land than family farms.[57] Our discussion of the distribution of cotton varieties bears significantly on this debate. There is abundant commentary in the agronomy literature that the superior yielding varieties grown on the fertile bottom lands systematically differed from those grown on less fertile soils. Cotton was not cotton. By overlaying soil quality maps atop our picking data and holding all else constant, we should be able to provide a fresh perspective on many of the questions raised in this prolonged debate.[58]

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[57] Gavin Wright, "The Relative Efficiency of Slave Agriculture: Another Interpretation," *American Economic Review*, 69 (1979), pp. 219-26.

[58] The plantation-family farm efficiency measures assume one average price for cotton. The plantations on average produced higher quality and higher priced cotton so the estimates understate the plantations' true advantage. However, the higher quality and price was a function of the geography, good management, and the varieties grown, not of the presumed economies of scale inherent in coerced gang labor. Fogel and

If our hypothesis on biological innovation bears out, it will lead to yet another reason for the dynamic advantages of scale observed in the mainstream literature. The plantation system did offer an important economy of scale that was not related to the slave gang system forcing workers to toil harder than they would have done under a system of voluntary wage labor. The economy of scale we have in mind has much more to do with the hum of bumble bees than the rythmetic sound of hoes working in unison. Plantations—because of the physical size of the production unit—could isolate prized cotton varieties from other varieties and thus reduce the problem of cross pollination. Wealthy planters could also more readily afford to act as local experiment stations, investing to develop better seeds and practices. As a result plantations were much more likely to be able to maintain the purity of their superior seed than small farmers, giving the plantations a dynamic, self reinforcing productivity advantage over small producers.[59]

Taking a longer view and delving into the sources of southern agricultural productivity in 1859, suggests a different perspective from that found in the existing productivity debate. As our recent work on wheat demonstrated, northern farmers were constantly changing varieties to ward off the evolving threats from insects and diseases and to make profitable the expansion of the wheat frontier. Without these changes, northern land and labor productivity would have fallen substantially below that which history recorded. But for all the importance of biological innovation in wheat production in the antebellum years, there were no breakthroughs that so fundamentally and directly changed land and labor productivity as the introduction and subsequent diffusion of the improved Mexican hybrids. Hence, whatever one's view on the interregional productivity debate, the South's relative advantage over the wheat-producing North in 1859 (if it had

Engerman have taken issue with many of Wright's arguments noting that there is neither direct evidence nor contemporary commentary supporting the contention that output was exceptionally high in 1859. Robert W. Fogel and Stanley L. Engerman, "Explaining the Relative Efficiency of Slave Agriculture in the Antebellum South," pp. 247-49. To support our point about the lack of attention to productivity changes over time, there is very little mention of this issue in the 4 volumes of *Without Consent or Contract*. The exception is Jon R. Moen's contribution "Changes in the Productivity of Southern Agriculture between 1860 and 1880," pp. 320-50. Moen does not consider biological inputs.

[59] See Nancy Virts, "The Efficiency of Southern Tenant Plantations, 1900-1945," *Journal of Economic History*, 51: 2 (1991): 385-95; Alan L. Olmstead and Paul W. Rhode, "Hog Round Marketing, Mongrelized Seed, and Government Policy: Institutional Change in U.S. Cotton Production, 1920-60," *Journal of Economic History* (June 2003): 447-88.

one) stemmed in large part from the different regional patterns of biological innovation over the previous five decades.

Although our evidence lends support to Gavin Wright's view that a number of factors besides the slave labor system could account for the proposed relative efficiency of the plantation system vis-à-vis family farms, we disagree with him on another issue. In *Old South*, *New South*, Wright develops the landlord and labor-lord taxonomy. Wright argues that because so much of their wealth was tied up in slaves, plantation owners had little incentive to maintain the productivity of their land and took few steps to do so. Whatever the analytical ambiguities of this position, it does not account for the enormous success southern planters achieved in developing and adopting a succession of new cotton varieties that dramatically increased both land and labor productivity. In this arena it appears that southerners were at least as active as (and more successful than) their northern counterparts.

New Perspectives on Western Settlement

The territorial expansion of the cotton-slave frontier was one of the most controversial issues of the antebellum era, with claims and counter claims about the importance of new lands in preserving the political and economic power of the Slave South. Much of this literature lies at the foundation of the early debates over the profitability of the slave system.[60] For all the discussion of the political and economic implications of the spread of slavery, there has been no precise measure of the actual spread of cotton culture and little understanding that technological forces may help explain the settlement of the Cotton South.

For all the discussion of western movement, precise measures of the process have been in short supply. Momentarily stepping away from our picking sample can offer a fresh perspective on the geographical movement in cotton production. In the early 1790s,

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[60] Ulrich B. Phillips, *American Negro Slavery* (Baton Rouge: Louisiana State Univ. Press, 1966); Charles W. Ramsdell, "The Natural Limits of Slavery Expansion," *Mississippi Valley Historical Review*, Vol. 16 (Sept. 1929), pp. 151-171; Peter Passell and Gavin Wright, "The Efficiency of Pre-Civil War Territorial Expansion on the Price of Slaves," *Journal of Political Economy* Vol. 80 (Nov.-Dec. 1972), pp. 1188-1202; Susan P. Lee, *The Westward Movement of the Cotton Economy, 1840-1860: Perceived Interests and Economic Reality* (New York: Columbia Univ. Press, 1975).

U.S. production was concentrated along the coast of Georgia and South Carolina. By 1839, as the data in Table 5 reveal, the geographic center (median) of the production of upland cotton was near Greensboro in west central Alabama. And by 1859, the center was across the Mississippi-Alabama border. (Note that it was not until the 1880s that the median geographic center of wheat production was west of this longitude.) The speed of this westward movement before the Civil War is all the more impressive when one realizes that over the entire period from 1860 to 1920, the geographic center of cotton production remained within the boundaries of the state of Mississippi. Valuable information on the antebellum years is offered in Figure 5. It employs Watkin's annual data on commercial cotton output by state to chart the changing regional distribution of production over the 1800-1860 period.[61] As the Figure shows, the shift away from the Atlantic Seaboard states (VA, NC, SC, GA, FL) begins in earnest in the early 1810s. By 1833, their share had fallen from over 95 percent to less than one-half of output and by 1859 to less than one-quarter. Did biological innovation play a significant role in this process?

Table 5: Geographic Center of Upland Cotton Production, 1839-1919

	Latitude			Longitude		
	Census	Recalculated		Census	Recalculated	
	Median	Median	Mean	Median	Median	Mean
1839		32.7616	32.8821		87.6265	87.0840
1849	33.1597	33.2100	33.2298	87.0233	86.9646	86.6876
1859	32.7928	32.8152	32.9535	88.9358	88.9232	88.3614
1869	32.9058	32.8517	33.0524	89.0814	89.0785	88.2932
1879	33.3506	33.3683	33.3633	89.1169	89.1139	88.2498
1889	33.0039	33.0290	32.9795	89.6153	89.6871	88.8661
1899	32.9608	32.9264	32.9220	90.3033	89.9740	89.7322
1910	33.3316			89.7470		
1919	33.5504			90.2249		

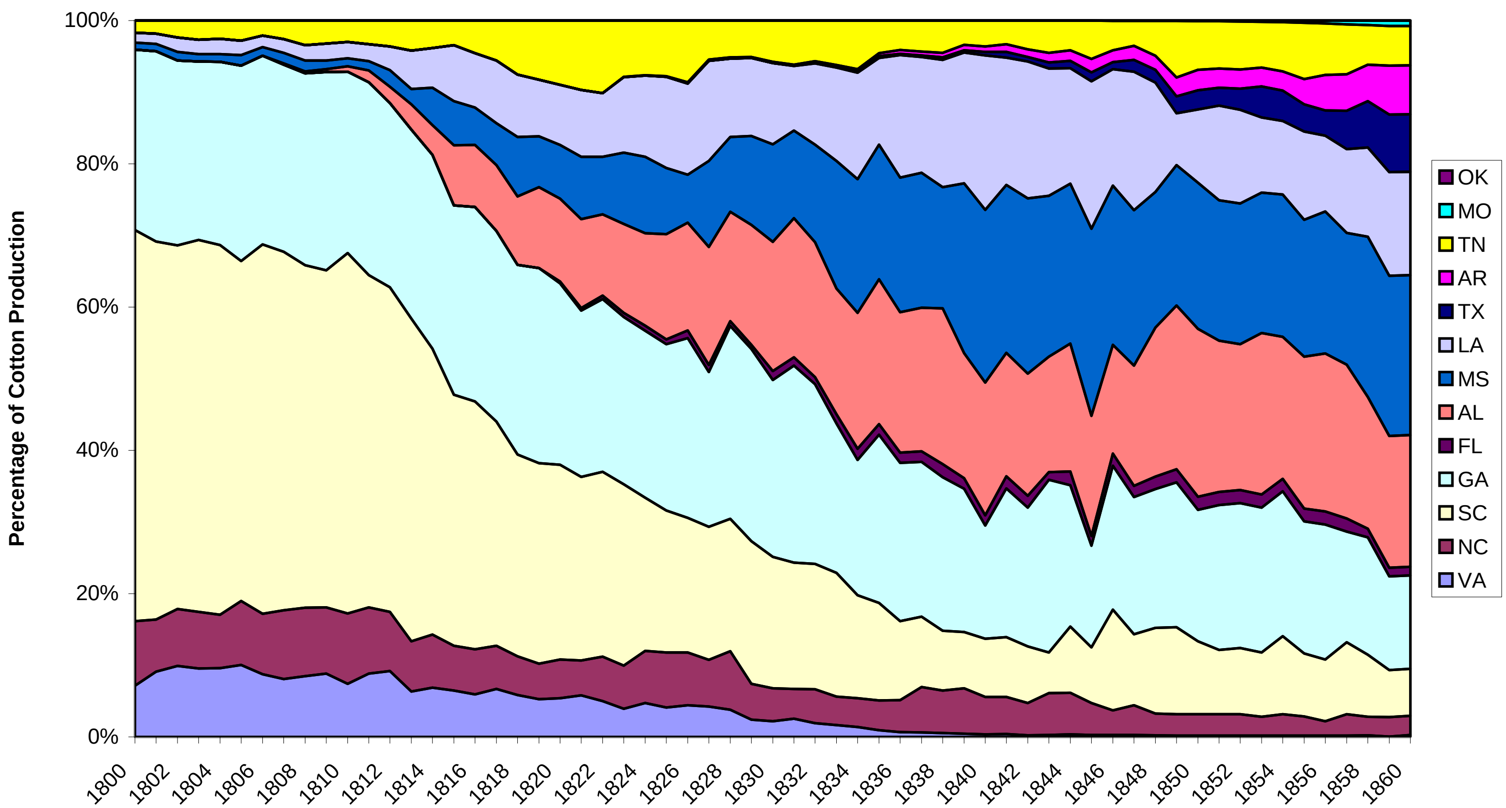
Census numbers are from U.S. Census 1900, *Statistics of Agriculture*, p. 414 and *Statistical Atlas of the U.S.* 1925, p. 23.

The recalculated numbers are derived from the county centroids and production reported in the Craig-Haines-Weiss dataset.

[61] Watkins, *King Cotton*, passim.

The existing literature maintains that the West enjoyed a productivity advantage because the land in its vast alluvial basins was inherently better than the land common in the East. Moreover, the virgin land in the West had not yet been mined of its nutrients

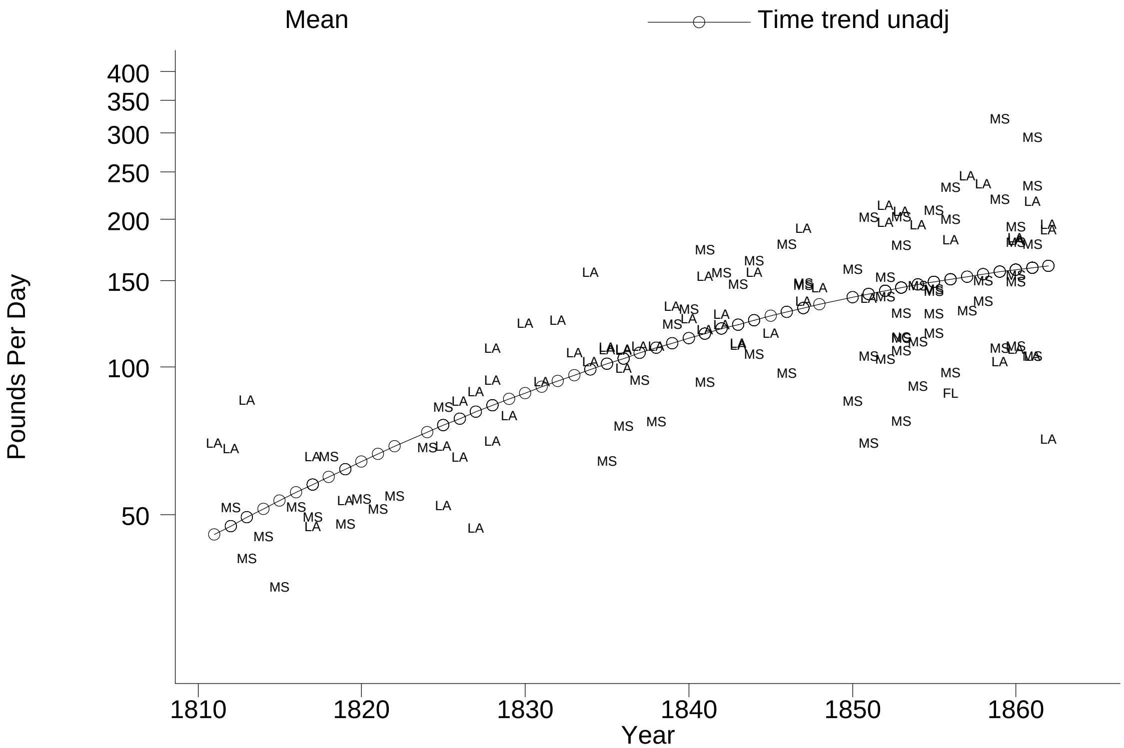
Figure 5: Regional Distribution of U.S. Cotton Production, 1800-60



as had purportedly occurred in the East. The long-standing explanations of East-West productivity differences are seriously deficient. The rapid shift in production in the years before 1833 occurred precisely when western cotton producers likely enjoyed a significant varietal advantage over eastern producers. With more data we hope to better document the movement in the East-West picking efficiency gap. (It is important to emphasize that the picking data tell a larger story, because they are almost surely correlated with improvements in cotton yields and quality.) As the new varieties gained wider acceptance in the East in the 1830s the gap might have narrowed, but not necessarily because biological innovations continued in the West. Moreover, the new biological technologies almost surely were not "soil neutral;" they represented an improvement on a wide spectrum of soil types, but they were particularly suited to the most fertile lands. The large plantation regions of the West had better soils to start with, but in a sense biological innovation made these soils even better.

Figure 6 takes a preliminary pass at some of these issues by decomposing our sample to look at picking rates in the fertile Mississippi Valley. The sample shows all plantations in Mississippi and Louisiana except the Leak Plantation which we know to have been located in the north-central part of the state away from the Great River. Over the period 1811 to 1862, the picking rate (the unadjusted time trend) did increase faster than for the entire sample, roughly tripling. The annual growth in picking efficiency was 2.32 percent a year. This is about 0.3 percentage points higher than for the sample as a whole. With more data we hope to better quantify the dynamics of regional differences in picking efficiency.

Figure 6: Picking Rates in Mississippi and Louisiana (excluding Leak Plantation)



Conclusion

This paper demonstrates the enormous gap separating neighboring cultures—one largely static, associated with cliometrics and the other dynamic, associated with a more literary tradition. The rough parameters of our argument on the role of new cotton varieties in increasing slave picking efficiency has long been a part of the standard historical treatments of the Cotton South. We strongly suspect that little that we have said on this basic issue would have come as a surprise to Watkins, Gray, or Moore. Nor would it have stunned Lebergott, Hayami, or Rattan, who are among the few economists to have peeked across the cultural divide. In our attempt to bridge the gap, we have enhanced their stories with evidence on the evolution of cotton varieties drawn from the agronomy literature, and we have added a measure of precision to long-standing speculations. Most importantly we have sought a better understanding of the dynamic forces that propelled cotton productivity growth, and in doing so, we hope to cast light a wide array of cross-sectional issues. Our scaffolding is built on the solid foundation of over 360 thousand picking samples. We are far from finished; there are more data to be gathered and more sophisticated tests to be made. However, at this stage some preliminary findings seem apparent. Over the 50 years preceding the Civil War, picking efficiency increased at about 1.6 percent a year. The increase in picking efficiency was correlated with yield and quality improvements that further added to the incentives to grow cotton. These changes help make sense of the long run movements in cotton and slave prices. They also provide new perspectives on many long-standing issues, including the westward march of cotton production, the movement of slaves out of industrial and other urban pursuits into cotton, the role of scale, geography, and other factors in determining productivity. A fuller examination of these issues is on our agenda.

To put the pre-Civil War increase in picking efficiency into perspective, the early mechanical reaper, which represents the textbook example of an antebellum labor-saving mechanical innovation, increased wheat-harvest labor efficiency relative to using a cradle by roughly 50 to 100 percent.[62] Our data on the impact of Mexican hybrids suggest that their impact on cotton harvest efficiency easily surpassed that of the reaper on the grain harvest. The total impact of the Mexican hybrids would of course have been even greater because of their effects on yields and cotton quality. The mechanical reaper had no parallel impact on either yields or quality. But the Mexican cottons did have one important point in common with the reaper and many other mechanical innovations. The new easier picking cotton varieties helped smooth out the peak-load labor demands so that the labor hours needed for the harvest more closely approximated those needed for non-harvest tasks. This led to a decline in the often-heard comment that farmers planted more cotton than they could pick, and (as with the diffusion of the reaper) it presumably led to an increase in acres planted. These were some of the ways that biological innovations were reshaping the opportunities cotton farmers faced, fundamentally altering the economic landscape of the antebellum South.[63]

[62] In actuality it was the reaper and the use of additional horsepower that yielded this result.
[63] A number of scholars who are clearly aware of both the biological and mechanical advances of the antebellum era somehow persist in dismissing them as insignificant. For example Charles Post recounts the bare outlines of the importance of Petit Gulf and of mechanization (p. 296) and then repeatedly makes inexplicable assertions to the effect: "There is no evidence of systematic and widespread introduction of labour-saving technology in cotton production." Charles Post, "Plantation Slavery and Economic Development in Antebellum Southern United States," *Journal of Agrarian Change*, Vol. 3, No. 3 (July 2003), pp. 289-332; quote from p. 300.

Appendix A

Important Antebellum Mechanical Innovations

As noted in the text, the antebellum period witnessed important changes in mechanical technologies in cotton as well as biological technologies. In particular there were quality improvements in both plows and hoes with the movement to steel implements after 1840, and a shift away from using the relatively labor intensive hoe for some tasks. We have to look no further than Gray for considerable evidence of mechanical advances. For example, "In the earlier years there was a tendency to make more use of the hoe than in later years.... There was a gradual adoption of implements suitable for shallow cultivation, such as the scraper, skimmer, and sweep. The skimmer and sweep greatly economized labor in cultivation...."[64]

Gray offers a quantitative sense of the importance of some of these advances. "The scraper, adapted to shaving the bed close to the cotton, economized the amount of hoeing. According to Dr. M. W. Phillips, by employing the scraper it was practicable to clean and thin 1¼ acres daily per hand, as compared with only ¾ acre by other methods."[65] Many planters also adopted mechanical seeders in the antebellum years which saved labor at seeding time. The trend was to plant less seed, more carefully, "so as to avoid much of the laborious thinning and cultivation."[66] Thus our data on picking efficiency, as significant as they are, only capture part, maybe even a small part, of a larger story of technological innovation on antebellum cotton farms.

[64] Gray, *History*, p. 701.
[65] Gray, *History*, pp. 700-02.
[66] Gray, *History*, p. 701. Adjustments in the time of planting, the density of seeding, and in plowing practices, all effected land productivity. Early in the nineteenth century, southern farmers generally plowed up and down hillsides, thus unnecessarily creating horrible erosion problems. Enlightened farmers such as William Dunbar experimented with the development of horizontal plowing techniques and campaigned to convince his reluctant neighbors to adopt his new system. Horizontal systems (with gentle slopes and drainage ditches) continued to be perfected and adopted over the pre-Civil War era. The major mechanical improvements of the era occurred in post-harvest operations that included the ginning, pressing, and transporting of cotton. These all added to the productivity growth of the industry. Gray, p. 689-70; Moore, *Agriculture*, pp. 46-47; Moore, *Emergence*, pp. 30-34, 50.

Another Method of Estimating Productivity Gains

In addition to the evidence on picking efficiency presented above there are many claims as to the total amount of cotton a worker was expected to pick in a year. Interpreting these data is even more difficult than assessing the daily data because meaningful comparisons require knowledge of how many hours a picker worked in the harvest, the conditions of the fields, the type of cotton, the extent of coercion and/or incentives offered, and the age, sex, and health of the worker. Acknowledging these caveats, there is ample testimony that annual picking output per worker went up substantially due to the introduction of Mexican cotton. As an example, Moore notes that "Farmers, who in 1800 had hoped to average two 400-pound bales to each field hand, by 1837 were trying to produce crops of six to eight bales to the hand."[67] Moore further notes that "in the years 1833 and 1836 Richard Nutt, son of Dr. Rush Nutt, averaged nine bales of cotton to the hand, a record almost equaled by his brother."[68] Moore's account, based as it is on a few data points, appears to paint an exceptionally rosy picture of slave productivity.

Although there are many other claims of similar high bales per slave achievements, the most thorough investigation of the issues is probably James Foust and Dale Swan's 1970 analysis.[69] This research suggests that Moore's antidotal evidence of bales per hand was not representative. Foust and Swan examined the labor-input and cotton-output data in 1849 and 1859 for a sample of farms in 74 cotton-producing counties. Both the 1849 and 1859 samples contained well over 500 cotton producing farms. They (and Sutch before them) did not rely on direct, individual observations of picking rates as we do, but rather they calculated the output per slave using farm-level cotton output in bales divided by one half of the number of slaves on a given plantation.[70] They found that bales per slave for the whole sample increased from 1.59 in 1849 to 2.11 in 1859. On "Alluvial" lands the increase was from 2.07 to 2.78, for their "Other New

[67] Moore, *Agriculture*, p. 46.
[68] Moore, *Agriculture*, p. 215, fn. 26.
[69] James D. Foust and Dale E. Swan, "Productivity and Profitability of Antebellum Slave Labor: A Micro-Approach," *Agricultural History* 44: 1 (Jan. 1970): 39-62.
[70] Richard Sutch, "The Profitability of Ante Bellum Slavery—Revisited," *Southern Economic Journal* 31 (April 1965): 365-83. Foust and Swan assume that the "field hand equivalent rate" was 0.50 in both years. This adjustment is an attempt to account for children, old folks, house slaves, etc.

South” region bales per slave went from 1.49 to 2.64, and for their “Old South” region it went from 1.47 to 1.48. One might question how sensitive these results are to the various assumptions underlying their estimates and how sensitive the results are to the weather and other conditions in the two years studied. All of these caveats could influence the credibility of their findings on the change in bales per slave over the decade, but probably not our general proposition that Moore’s literary account gives a misleading impression of general conditions. Our method of examining individual picking rates over time requires no heroic assumptions and is relatively insensitive to short run weather shocks. We expect our findings will correlate well with independent evidence on the timing of the introduction of the new varieties.[71]

[71] Perhaps the most interesting aspect of Foust and Swan’s study is not what they said but what they omitted. They offer no systematic evidence as to why cotton per slave increased beyond speculating that it might be due to a shift in production to larger plantations that could capture economies of scale.