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CHAPTER FOUR

Capital and American Economic Growth, 1774–1980

4.1. Introduction

This chapter greatly expands the temporal scope of our analysis of the capital stock in the nineteenth century. It links the decadal data from the 1840–1900 period to comparable aggregate series for the twentieth century and, more ambitiously, pushes back estimates to 1774. The United States achieved "modern economic growth"—that is, a high sustained rate of annual per capita income increase—during the period between 1774 and 1860. Changes in the capital stock provide clues into the timing and nature of this transformation.

A virtue of a capital stock series as an indicator of growth is that the short-term movements of such a series are likely to be much less violent than, for example, the short-term movements of a true income series. If estimates are available only at intermittent years, the rates of growth computed from the former are much less likely to be influenced by transient phenomena than are the rates of growth of the latter. As we will see, the capital stock evidence indicates that the American economy began to experience the process of modern economic growth after the War of 1812, and that by the 1840s the modern components of the economy were large enough and growing rapidly enough to have an observable impact on the rate of growth and the structure of the economy.

Gallman published the substance of this chapter as Gallman 1992; Rhode reordered and revised the text to enhance its fit and flow in this volume. Rhode also recalculated the growth rates on a continuously compounded basis, creating slight differences from the numbers appearing in Gallman (1992).

If the direct relationship between real capital and material well-being is to be examined, the capital stock series should be deflated by a consumer price index. That is, the stock should be appraised in terms of its equivalent in consumer goods. If, on the other hand, one is concerned with productive potential, proper deflation is in terms of the prices of the components of the capital stock. Both forms of deflation are employed in this chapter; the capital stock is treated as an index of both the material well-being of the society and its productive power.

The concept of capital is elastic. Some analysts have included land and investment in humans as elements of the stock. For most purposes, it is best to treat land as land and human capital as a characteristic of labor. In the present instance, the second preference makes a virtue of a necessity: there are no comprehensive estimates of human capital covering the full period of interest here. This chapter introduces a set of estimates of the land stock, but they are not treated as part of the capital stock.[1]

Although land is not included in the capital stock series of this chapter, improvements to land are. Most capital estimates include structures but omit other important improvements, such as the clearing and first breaking of land. In this chapter, a conventional series that omits the value of improvements to land is presented and is linked with estimates extending well into the twentieth century, for comparative purposes. But the series that is subjected to the most intense examination is one that includes the value of land clearing and breaking. These activities took up a substantial part of the work time of agricultural workers and made an immensely important contribution to the capital stock before 1860. They cannot properly be ignored.[2]

The United States (for convenience, the term will be applied to the colonies of 1774) began life as a debtor nation and gradually shifted to the position of a creditor nation. Ignoring recent experience, the national capital stock—which measures the net capital holdings of Americans—grew very much more rapidly over time than did the domestic capital stock, defined as capital physically located in the United States, regardless of who owned it. Most attention will be devoted to the domestic capital stock.

Section 4.2 deals briefly with the nature of the data underlying the estimates and the broad rules guiding the estimating procedure. Section 4.3 discusses estimating problems and tests of the consistency of the capital stock series before and after 1840. Section 4.4 treats the rates of growth of the real capital stock and the real capital stock per capita, with the

purpose of putting growth over shorter intervals into long-term historical perspective. Economic development involves structural shifts as well as growth in the aggregates. Section 4.5 treats the changing composition of the capital stock and shows its connection to the nature of American economic development. Section 4.6 brings together estimates of all three factor inputs and combines them into several series describing the growth of total factor inputs. Estimates of changes in total factor productivity are presented. Section 4.7 concludes.

4.2. The Estimating Procedures

In addition to capital stock figures for 1840–1900 at decade intervals, estimates were made for the years 1774, 1799, 1805, and 1815, and for various dates in the twentieth century. The twentieth-century figures were assembled by splicing the nineteenth century estimates to Raymond Goldsmith's (1982) series, which are based on perpetual inventory procedures. In tests conducted with data from the post–Civil War period, census-style and perpetual inventory estimates appear to be roughly comparable.

The estimates for the years before 1840 come from a variety of sources quite different from the censuses. This increases the risk that the capital stock estimates based on them may not be consistent, one with the other, and all with the figures for the years 1840 onward. (See chapter 14.) The data that are farthest removed in type from census data are the ones underlying the capital stock figure for 1774. These data were taken chiefly from Alice Jones's (1980) work with probate records, which value the property of a deceased person. The figures for 1799, 1805, and 1815 rest principally on sources that are more likely to be consistent with census records: the direct taxes of 1799, 1813, and 1815 (Blodget 1806; Pitkin 1835; Soltow 1984). The 1805 estimate is based on the work of Samuel Blodget (1806) and on Raymond Goldsmith's (1952) adjustments of Blodget's work. The principal underlying source is the direct tax of 1799. Blodget apparently carried the 1799 data forward to 1805 at a rate of growth he believed most probable. The 1805 estimate falls out of line with those of 1799 and 1815, and is probably too high. The history of the period leads one to expect a higher rate of growth between 1799 and 1805 than between 1805 and 1815, of course, but not quite so high as the Blodget data suggest. It is possible that the 1805 figure is close to the truth and that the other two are too low; it is also possible that the bias was introduced by the adjustment of the Blodget data (see table 4.1). But neither seems likely.

TABLE 4.1 **Capital and wealth, estimates of Jones, Goldsmith, and Gallman, measured in current prices, 1774 and 1805, in millions of dollars**

	1774	1774	1805	1805
	Jones	**Gallman**	**Goldsmith**	**Gallman**
All structures			370	352
All land improvements		180		732
All privately owned real estate	250			
Shipping		8	40	80
Other producers' durables	13[a]	15	32	65
Inventories	20	39	100	336
Animals	42	42	60	160
Total domestic capital			602	993
International claims			–80	–57
Total national capital			522	936
Total domestic capital, including land clearing		284		
Total private domestic, plus land	327			

Note: [a]Includes household equipment.
Sources: Jones 1980, 90; converted to dollars by means of the exchange rate in Jones 1980, 10; Gallman, see text; Goldsmith 1952, 315.

The 1774 through 1815 estimates depend on the sources listed above, augmented and adjusted so that the same concept of capital underlies each final aggregate figure, and so that the same estimating principles are applied in each case. The last point is an important one. While accurate estimates were sought in each instance, it seemed clear that it would be better to have a series for which the general level might be wrong, but which describes the rate of growth in a reasonably accurate way, than to have one for which the individual estimates might be closer to the truth, but which gives a more strongly biased account of the rate of growth. The choice made was always for consistency rather than for perfect accuracy.

Table 4.1 compares some of the details of the new estimates with those provided by Jones and Goldsmith. As will be evident, the adjustments made to the Jones figures were relatively unimportant, so that the new estimates tell very much the same story as do the data taken from Jones. The differences between the current estimates and Goldsmith's are greater, and are particularly pronounced with respect to inventories of all kinds. Goldsmith's estimates seem too low; for example, imports in 1805 ran around $150 million, and imports represented a relatively small part of total economic activity even in 1805. Even a very modest estimate of the fraction of imports held, on average, in inventory across the year would leave very little for inventories of domestic goods, were we to accept Goldsmith's figure for total inventories. But the question of the appropriate *level* of

inventories in 1805 is perhaps not the important issue. The important point is the one made in the previous paragraph. The goals of the procedure to build the inventory estimates for all of the years, 1774–1900, have been to follow consistent methods and to pay more attention to consistency than to the specific level of any one estimate. Consistency permits appropriate comparisons to be made across time, an important desideratum. Users of capital stock series for the nineteenth century, then, would be well advised to use either Goldsmith's estimates or those presented here, but not some combination of the two.

All of the capital figures are expressed in market prices or in net reproduction costs. The two are virtually identical, where it has been possible to run a test. They are net of retirements and of capital consumption—with one exception, to be discussed below.

The cost-of-living deflator is the one assembled by Paul David and Peter Solar (1977), the only series that covers the full period. According to Claudia Goldin and Robert Margo (1989), the index rises too little or falls too much before the mid-1840s. If they are correct, the rate of growth of the capital stock deflated by this series is too high in the period before the mid-1840s, a point to which we will return. Dorothy Brady's (1966) investment goods price indexes, extended to the years before 1840 in a variety of ways, were the chief bases for the deflation of the capital stock, viewed as an input. The Brady index numbers refer to census years. They had to be adjusted modestly to make them relevant to the dates to which the capital stock estimates refer (the last day of the census year). Conceptually, these index numbers are exactly what are required. They were augmented in various ways to permit the deflation of inventories and certain types of farm improvements, for which Brady supplied no indexes.

4.3. Estimating Problems and Consistency Tests

This section addresses in detail the chief problems encountered during the construction of the capital stock estimates before 1840, with special attention to the difficulties of linking with the estimates from 1840 on. It also describes the tests that were run to check the estimating decisions that were made. (See also chapter 14.)

Land Clearing and Breaking. The largest item in the more unconventional but more meaningful concepts of capital employed in this chapter is the value imparted to land by the processes of clearing and first breaking.

The estimating procedure was simple. For each year, the following variables were established: the number of acres of improved farmland of each relevant type (land originally under forest, land originally under grass) in each state or region, the number of labor hours per acre required to improve land of each type, and the cost of farm labor in each state or region (Primack 1962; Lebergott 1964). Simple multiplication and addition produced the final figures. Constant price estimates were obtained by substituting technical coefficients and wage rates relevant to 1860 for those relevant to the current year. For the years 1840–1900, but not earlier, estimates of the value of fencing, drainage, and irrigation works were also made.

Certain characteristics of the series that may be associated with biased rates of change are immediately evident. The weight attributed to the clearing and breaking series is incorrect; it is probably too low, especially for the years before 1840. Since the clearing and breaking series exhibits relatively low rates of change over time, giving it a heavier weight would tend to reduce the rates of growth of the aggregate capital stock series, particularly before 1840. Thus the acceleration of the rate of change described previously in this chapter would be enhanced.

The weight attached to the series is too low because the estimates ignore all elements of clearing and breaking cost except labor. Labor was, no doubt, the principal cost, but it was not the only one. Second, the only improved land treated is agricultural land; no account is taken of land under houses, factories, shops, and so forth. Third, for the years before 1840, important elements of improvement—particularly fencing—had to be ignored. If it had been possible to treat all of these phenomena, the improvement series would have had a larger weight.

There are, however, certain offsets. First, the value of fencing may very well have increased faster than the value of clearing, before 1840; it is almost certainly true that the volume of land under houses and so forth increased faster than the volume of improved land in agriculture, at least after 1840. Introducing these elements into the analysis might raise the rate of change of the improvements series, though probably not by much.

Another factor may appear at first blush to be more important than any so far discussed: the estimates make allowance for land retirements (land allowed to go back to nature), but not depreciation. The reason depreciation has been ignored is that land improvements, if properly maintained, do not depreciate. Bad farming practices may erode the fertility of the land, and the opening of Western farms may reduce the value of Eastern

farms, but these changes have to do mainly with the value of land, rather than with the value of improvements. Now, in a sense, this characteristic of improvements is shared with other elements of the capital stock. Properly maintained, houses and ships and even machines can last very long indeed. The difference is that most of the houses, ships, and machines that existed in eastern Pennsylvania in 1774, for example. are gone today, while much of the improved land of that period is still improved. A substantial part of it is now under houses and shopping malls and highways, rather than under maize cultivation, but it is still improved. Furthermore, in the cases of buildings, machines, and so forth, one can devise reasonable depreciation rates that properly describe the average lifetime experiences of these elements of capital, and that are roughly relevant to long reaches of history. That is not possible for land improvements.

The discussion above implicitly introduces another issue. The improvements series consists of reproduction cost estimates. Various tests have shown (see Gallman 1987) that the reproduction cost and the market value of structures and manufactured producers' durables were, on average, about the same in the nineteenth century. Is this also true of land improvements? If not, then how is the analysis affected? The few simple tests that have been run seem to suggest that they are alike. At least two efforts have been made to estimate the market value of clearing and breaking at midcentury: one by Stanley Lebergott for the Midwest, the other by Stanley Engerman and Robert Fogel for the South (Lebergott 1985; Fogel and Engerman 1977). Comparisons are not easily made, and the efforts reported here may be polluted by wishful thinking. The results suggest that estimates computed along the lines laid out above are very similar to the ones obtained by Lebergott and by Engerman and Fogel. The suggestion, then, is that the market price and the reproduction cost of land improvements were about the same, on average, at midcentury (see also chapter 7).

The same may also hold for 1774. At least it is true that when one subtracts from Alice Jones's estimate of the value of real estate, the current estimates of the value of land clearing and structures, and a rough allowance for other elements of land improvement (a relatively small part of the total), the remaining value, divided by the number of acres of land privately held (derived from Blodget 1806), yields an average price of land per acre—exclusive of improvements—that is almost identical with Blodget's estimate of the average value of unimproved land in 1774. The test is very roundabout and places much weight on a residual, but it

encourages us to think that market price and reproduction cost may have been about the same, on average, at that date.

There is some evidence to the contrary, however. Specifically, Blodget's estimates of the average value of improved land per acre in 1774, 1799, and 1805 are substantially lower than the current estimates of the cost of improving land per acre. Bear in mind that Blodget's figures include the value of the land itself, while those presented here do not. The margin is so great that if Blodget's figures are truly market-price figures, and if those presented here are truly reproduction cost figures, one is left with the impression that farmers of the late eighteenth and early nineteenth centuries were behaving irrationally, improving much more land than could be justified by the market.

The estimates here are based on the assumption that all of the land improved at each of these dates had originally been forest land. That is probably not correct, and since forest land costs more to improve than grassland, this assumption probably leads to an overstatement of the value of cleared land at these dates. But the overstatement is tiny, and is surely more than offset by the fact that the cost of factors other than labor was left out of account.

It is also assumed that the labor hours per acre required for clearing were the same at these early dates as at midcentury. Primack (1962) believed that there were no important improvements in clearing techniques until after the Civil War, and while his interests were confined to the last half of the century, his remark is probably relevant to the early dates treated in this chapter as well. If this is wrong, the estimates *understate* the value of improvements at these dates, not *overstate* them.[3]

A more promising source of disparity lies in the way in which labor time was valued. It is assumed that the opportunity cost of the labor employed in clearing and first breaking could be approximated by the agricultural wage rate. In fact, however, one would suppose that clearing and first breaking would have been conducted by farmers in the off-season, when real opportunities may have been restricted to maintenance tasks around the farm, hunting, fishing, and so forth. The wage rate, then, may overstate the opportunity cost of labor. That seems not to have been the case at midcentury, when, as indicated above, reproduction cost and market value of improvements were very similar. It may be that by midcentury, clearing and breaking were more commonly hired out (e.g., to prairie sodbusters) than they had previously been, and that farmers themselves had better opportunities for off-season work. If that were the case,

the estimating technique might work better for the mid-nineteenth century than for the earlier dates. But that would be a relatively unimportant matter. Our concerns are chiefly with the constant price series, which are properly a function of the techniques and wage rates of 1860. The contrast with Blodget refers exclusively to the current price estimates.

In any case, it appears that Blodget is simply wrong on the matter of the value of improved land. The check of the current estimates against Jones's estimate of the value of real estate and Blodget's estimate of the value of unimproved land seems reasonably strong. Furthermore, in comparison with Jones's estimate, Blodget's figures on the values of improved land seem very much too low. The improvements series—particularly in constant prices—arguably gives a reasonable view of what it purports to describe; it does not appear to be strongly biased in one direction or the other or as generating strongly biased rates of growth.[4]

Structures. The estimates for the 1850–1900 period rest chiefly on census data: for 1840 on the work of Seaman (1852), for 1815 on the direct tax of 1813–15 and the work of Pitkin (1835), for 1805 on the work of Blodget (1806) and Goldsmith (1952), for 1799 on the direct tax of 1798 and the work of Soltow (1984), and for 1774 on the work of Jones (1980). All of these data have been heavily processed, frequently with the object of extracting one element from a larger aggregate or dividing the aggregate among its components. In each case but two, however, there is a substantial component of real data that bears directly on the estimating problem. The weakest links are the ones for 1805 and 1840. There are no data expressly relevant to these dates, and the sources of evidence are Blodget and Seaman. Blodget extrapolated his estimate from an earlier date, for which real evidence is available, and Seaman both extrapolated from an earlier date and blew up partial estimates to encompass the universe. These figures have been tested, but they are less trustworthy than the rest.

We now turn to the treatment of deflation. For the years 1850–1900 there is no serious problem relating to deflation; indeed, the price index number situation is unusually good. For most of these years, Dorothy Brady's two sets of deflators—for houses and churches on the one hand, and for factories and office buildings on the other—are available. These are true price indexes, which makes them quite unusual among construction deflators. Usually it is necessary to make do with cost indexes. Brady's data need modest adjustment to make them expressly apposite to the task of deflating the capital stock, but no heroic efforts are needed to put them in proper condition for this purpose.

The serious problem appears in the years before 1850, for which Brady's indexes are not available. One possibility for this period is to follow the lead of David and Solar (1977), who linked Brady's housing price index to a construction cost index and then carried it back to the late eighteenth century. Since the relative importance of factories and office buildings before the 1840s was probably slight, and since construction techniques in this period may not have varied much between residential construction and commercial buildings (except at the cutting edge of factory design and construction), an extension of the housing price index would be an entirely adequate way to deal with the deflation problem for all kinds of structures. David and Solar, however, did not use Brady's published series; they used the unrevised figures that Brady prepared for the Income and Wealth Conference from which the 1966 volume originated. It turns out that in most instances the differences between the published and unpublished series are slight—matters of a point or two. There is one exception. In the published conference volume, Brady (1966) dropped her estimate of the price index of housing in 1839.

The Brady unpublished index falls from a level of 128 in 1839 to 94 in 1849, and then rises to 100 in 1859. Available construction cost indexes fall much more modestly and rise more sharply over these two decades, implying that, if the unpublished Brady index is correct, productivity in construction must have been rising quite dramatically. David and Solar believe that the experience reflects chiefly the diffusion of the balloon frame, which was invented in 1833. They therefore suppose that the annual rate of productivity improvement realized in the 1840s was also achieved in the period 1834–39. They construct a building cost index and employ it with the Brady price index to estimate productivity gains for the period 1839–59, and they then use it, together with their estimate of the rate of productivity improvement for the period 1839–49, to extrapolate the Brady price index number for 1839 back to 1834. They assume that there were no important productivity improvements before 1833, and extrapolate the 1834 price index number to earlier years in the century on their construction cost index. The productivity improvement for the period 1834 through 1859 implied by their calculations is a little more than 36 percent.

The procedure is ingenious, and surely adequate to the purposes of David and Solar. It is not so clear that it is adequate to the purpose of creating a deflator for the most important component of the conventional capital stock series. First there is the matter of Brady's decision to suppress her 1839 estimate. Does this mean that she had had second thoughts

about the strength of that estimate? Presumably. Nonetheless, there remains evidence that Brady believed that construction prices did fall in the late 1830s and early 1840s. Her price index for factories drops very sharply between 1836 and 1844, for example. But this index refers to factories, not residences.[5]

Is it reasonable to suppose that the balloon frame led to a rise in productivity of 36 percent in the first twenty-five years of its existence? Probably not. The balloon frame saved on framing, which had accounted for about 25 percent of the cost of a building. Consequently, even if the balloon frame eliminated the expense of framing, and even if the balloon frame was adopted throughout the industry within this period, the rise in productivity could not have come close to reaching 36 percent. And neither of these conditions was actually met.[6]

The framing of a building called for many workers. Barn-raising parties were organized expressly for this purpose. The balloon frame eventually changed all that. With the new system, a man and a boy could frame a house by themselves. Thus, the innovation became immensely important to the farming community, particularly for people on the frontier, for reasons that transcended normal cost considerations. It also diffused quickly in new Western cities, places under intense demand pressure and without established artisanal power groups. (Chicago and San Francisco were both balloon-frame cities.) But it did not immediately spread to the East.

There were other innovations during this period, so that the rise in productivity that David and Solar identify need not to have been the result exclusively of the balloon frame. The principal changes that seem to have been taking place involved the transfer of some activities from the building site to mills. For example, it is said that it became more common to use manufactured nails, windows, and doors, which presumably lowered costs. But the census returns of 1810, 1850, and 1860 suggest that manufactured nails were already widely used before the 1830s. Mill-made sashes, doors, and blinds do not appear in the census returns—not separately, at least—before 1860, when their output amounted to a value of about $9.5 million in a year in which the total value of conventional construction (exclusive of railroads and canals) ran to about $345 million. Mill-made windows and so forth were therefore by no means negligible by this date, but they did not bulk large enough to suggest that their introduction led to a major improvement in productivity. Furthermore, it may well be that their contribution to productivity actually came after 1849 rather than before. At least the treatment of these lines of production by the census suggests that

this was so. David and Solar find most of the productivity change (almost three-quarters of it) occurring before 1849.

The general idea behind the David and Solar treatment of construction prices is clearly reasonable, and their execution of it may have solved their problem satisfactorily. The technique is less likely to solve our problem satisfactorily, however. Unfortunately, there is no option that is clearly superior. Nonetheless, the estimation procedure uses adjusted indexes based on Brady for the years 1849 onward. It then extrapolates the adjusted 1849 (1850) index number to 1840, 1815, 1805, 1799, and 1785 on the Adams (1975) variant B (allowing for input substitutions) construction cost series. The index was extended to 1774 on a construction cost series based on the David and Solar common wage index, a Maryland farm wage rate taken from Adams (1986, 629–30), and the Bezanson-Gray-Hussey arithmetic average price index for Philadelphia (US Bureau of the Census 1975, series E-111). The last two steps need further discussion.

The Adams (1975) construction cost index was made with exceptional care from good basic data. It is an excellent construction cost index, and the version used allows for factor substitutions due to shifts in relative input prices. For present purposes, however, it has certain potential shortcomings. The ideal index is a true price index, an index that allows for changes in productivity. The Adams index does not do that, except insofar as productivity changes are associated with shifts in factor proportions. As proxy for a true price index, it will exaggerate any long-term price increases and understate any long-term price decreases, so long as productivity improvements are taking place. The capital stock series that it is used to deflate will then exhibit a rate of change that is biased in a downward direction. In the present instance, the bias would exaggerate the observed acceleration in the rate of growth of the capital stock. If the bias were serious enough, it would account fully for the acceleration. That seems highly unlikely, however. The sources of productivity improvement in construction do not appear to have been important before the mid-1830s, and even in the period between the mid-1830s and the beginning of the true price indexes in 1849, the amount of productivity improvement is unlikely to have been very great. In any case, the Adams index has other shortcomings for present purposes, and it turns out that at least one of these may introduce a compensating bias, in direction at least, and perhaps in amount as well.

The Adams index refers exclusively to Philadelphia. How successfully does it represent the United States? Two questions immediately arise.

First, housing price levels varied by region, and as time passed, the relative importance of the various regions changed. Did the shifts in regional weights affect the trend in the national average of housing prices? Probably not, and if they did, they tended to *raise* average prices a little. By ignoring the effects of the regional shift, one can perhaps compensate slightly for whatever bias is present from the use of a cost index in place of a true price index. These conclusions are based on the results of the following test.

The 1840 census requested information on the numbers of two types of houses constructed in the census year, those built of brick and stone and those built of wood, as well as the value of both types of houses taken together (US Census Office 1841, 91). Regressions using the state data generated an intercept value and coefficients for each of the two types of houses. These data were then employed to value the houses constructed in each state, and the figures thus obtained were divided through the census returns of the value of houses built to get an index number for each state (see also chapter 14). The index number compares the value of the houses constructed in the state with the value that would have obtained if prices had been at the level of the national average. Clearly, the index numbers reflect not only variations in building prices—which are required for the proposed analysis—but also differences in average size and quality of new houses, from state to state. Since cost, size, and quality were likely to have varied together—frontier areas having lower building costs, smaller houses, and houses of lower quality than the well-settled areas—the index numbers almost certainly exaggerate the regional variations in building costs, a point to be borne in mind as the analysis unfolds.

The individual state index numbers were then used to deflate the state returns of the value of real estate in 1799, according to the direct tax. The sum of the deflated returns was then divided through the aggregate current price value of real estate in 1799, according to the direct tax. The result was an index number of 0.932, which compares with the 1840 index number of 1.000. That is, according to these calculations, the shifting weights among states tended to raise, very slightly, the true price index of structures between 1799 and 1840.[7] The index numbers almost certainly overstate the true impact of the redistribution of the value of structures among states in this period, because the state index numbers probably overstate (for reasons previously given) the true variation in building costs among states. It appears unnecessary, then, to adjust the Adams cost index to take into account the effects of the shifting real-value-of-structures weights among states. This is particularly the case in view of the fact that

the Adams index is a cost index and is likely, therefore, to exaggerate the extent to which the prices of buildings rose, or to understate the extent to which they fell during this period. Finally, if the bias is slight between 1799 and 1840, it is almost certainly negligible between 1774 and 1799.

There is another aspect of the regional specificity of the Adams index that must be considered. Do changes in Philadelphia costs properly represent changes in costs in other regions? The strong suggestion that one gets from looking at price and wage indexes from New England and New York (Rothenberg 1988; David and Solar 1977; Warren and Pearson 1933) is that they do not. Adams's cost index moves in step with the Bezanson-Gray-Hussey general price index for Philadelphia (US Bureau of the Census 1975, series E-97), while the Rothenberg, David-Solar, and Warren-Pearson indexes also move more or less together, but quite differently from the Philadelphia indexes. (At least these statements apply to the benchmark dates relevant here.) David and Solar report that a construction cost index they assembled from materials prices from New York (Warren and Pearson 1933) and from common wage rates from Philadelphia (Adams 1975) and the Erie Canal (Smith 1963) exhibits a less pronounced decline between 1809 and 1834 than does the Adams index. An index is constructed from Warren-Pearson materials prices and David-Solar common wages (using Adams's weights and his procedure for allowing for factor substitutions) for all the relevant dates. The Adams index shows a much more pronounced drop over time than does the index constructed from the Warren-Pearson and David-Solar series. There is the strong suggestion that, over the long run, a properly derived national construction cost index would exhibit more pronounced price increases and less pronounced price declines than would a Philadelphia index. The bias imparted to the real capital stock series from using a cost index to proxy a price index is, then, compensated for by the fact that Philadelphia prices moved differently from national average prices, at least after 1799, and probably from 1774 as well.

There is one final problem with the deflator: it represents the costs of commercial construction in a city. A substantial fraction of the stock of structures in the years 1799 through 1840 must have been built in the countryside by unprofessional labor. The matter may not be very important, however. According to Adams, Philadelphia construction and Maryland farm wage rates moved in roughly similar ways among the dates 1785, 1799, 1805, 1815, and 1840. One cannot claim great accuracy for the deflator, but on the whole it seems satisfactory.

Animal Inventories. There are at least two problems with the animal inventory estimates. First, they include only farm animals from 1840 onward (animals used in the mines are part of the "equipment" estimates in mining) and probably only farm animals at earlier dates as well, whereas ideally one would like to have all domestic animals throughout. The omissions are not trivial, but neither are they of overwhelming importance. In 1860, just over 12 percent of domestic animals, by value, were located off farms (US Census Office 1860, cviii, cxxvi, 192); in 1900, the fraction was just under 7 percent (US Bureau of the Census 1900, cxliv). The suggestion is that the total stock of animals increased a little more slowly than did the stock of farm animals, but correcting for this shortcoming would probably not affect very substantially the conclusions previously reached.

The second problem has to do with deflation. The constant price series was made by applying base-year prices (1860) to estimates of the numbers of animals in each year. The assumption is that a pig is a pig. In fact, pigs in 1890 were, without doubt, superior animals to pigs of 1830. The deflator, then, is biased, and deflation tends to understate the importance of the growth of the stock of animals. Furthermore, the effect is also likely to be to underplay the acceleration in the rate of growth of the per capita capital stock. The reason is that most of the gains in the quality of animals were realized after midcentury. In earlier decades there were probably periods when, on balance, the quality of animal stocks actually deteriorated. Nonetheless, numbers can reasonably proxy real values before 1840 or 1850, whereas they are less able to perform this function thereafter. There are problems with the evidence on numbers as well, but they seem less pressing and do not deserve a place in this brief treatment of the subject. On the whole, the series, despite these qualifications, is acceptable for the uses to which it has been put.

Other Inventories. The procedure followed is one employed by Kuznets (1946, 228). Inventories were taken as a fixed fraction of the value of imports and the value of outputs of the agricultural, manufacturing, and mining sectors. No allowance was made for changes in the efficiency with which inventories were used—a matter of limited importance, especially before the Civil War. If there were improvements in efficiency, then the estimating procedure tends to exaggerate the acceleration in the rate of change of the real per capita capital stock.

Equipment. The data for the years 1840 onward were derived chiefly from the census, were deflated by Dorothy Brady's true price indexes, and were tested—with considerable success—against perpetual inventory es-

timates (see chapter 6). For the earlier years, the chief sources were Jones (1980), Blodget (1806), Goldsmith (1952), and US Bureau of the Census (1975, for Treasury data on shipping). The series seems adequate for present purposes, but should not be trusted for much more.

In summary, it should be obvious that a substantial margin for error must be allowed for all of the estimates discussed in this book, especially those dated before 1850. On the other hand, it is not obvious that the rates of change computed from the series are subject to large biases.

4.3. Rates of Growth in Historical Perspective

The concern of this chapter is with American economic growth, which means that the measures of central concern to it are real measures, particularly real measures deflated by population. The current price estimates are worth a brief inspection, however. On the whole, they are less processed than the real figures, and may therefore be more reliable. Table 4.2 contains current price estimates of the capital stock, conventionally defined. Three points come through very clearly. The rates of growth are all very high; the total capital stock in 1980 was apparently about forty thousand times as large as the stock of 1774, an extraordinary figure. Although most of the rates were computed over considerable stretches of time, and therefore should not be unduly influenced by transient phenomena, they vary quite widely from one period to another. Finally, it is clear that the experience before 1860 was by no means uniform. In particular, the rates of growth are especially low from 1800 to 1840, and especially high from 1840 to 1860. The second period is short, and the rates of growth computed across it could be influenced by business cycles or long swings. But Abramovitz's (1989) chronology of long swings and protracted depressions suggests that this is probably not a problem.

The record described by table 4.2 is influenced both by real phenomena and price level changes. The price index numbers in table 4.3 allow one to judge how important the latter developments were. Between 1774 and 1900 the long-term trend of the two price indexes appears to be close to zero, but in the short-term prices were quite unstable. In the twentieth century there is additionally a pronounced upward trend. Notice, finally, that while the two indexes tend to move together, the consumer index is the more volatile. The plan to deflate by two separate price indexes, then, seems to have substantive as well as theoretical merit.

TABLE 4.2 **Indexes and average annual rates of change of the US capital stock, measured in current prices, 1774–1980**

	Domestic capital	Domestic capital and consumer durables	National capital
Panel A. Indexes			
1774	100	100	100
1799	399		415
1805	581		628
1815	999		1,110
1840	1,573	1,503	1,691
1850	2,579	2,538	2,919
1860	5,298	5,274	6,000
1870	8,620	8,751	9,201
1880	11,795	11,761	12,805
1890	20,526	20,198	22,396
1900	27,386	26,457	30,886
1929	138,592	135,343	170,360
1953	444,239	436,493	541,061
1980	3,761,382	3,665,337	4,560,608
Panel B. Average annual rates of change (%)			
1774–1840	4.18	4.11	4.28
1774–99	5.54		5.69
1799–1840	3.34		3.43
1840–1900	4.76	4.78	4.84
1840–60	6.07	6.28	6.33
1860–1900	4.11	4.03	4.10
1900–1929	5.59	5.63	5.89
1929–53	4.85	4.88	4.82
1953–80	7.91	7.88	7.90
1774–1980	5.11	5.10	5.21

Sources: See text.

The deflated series appear in table 4.4. Four matters of interest strike one immediately. First, deflation does reduce the volatility of the series somewhat; part of the short-term movement observed in table 4.2 is due to price fluctuations. Second, it is clear that the real capital stock has grown more slowly in the present century than it did previously. Third, it is also clear that the rate of growth accelerated between the years before 1840 and the years thereafter. The broad pattern, then, is of an early acceleration followed by a subsequent retardation. Finally, notice that these findings emerge from all four series, the national and domestic capital stocks, deflated by the consumer price index and by the capital price index. But the detailed pattern of change differs from one series to the other. For example, compare the results obtained for the period 1929–53. The real

capital stock, viewed as accumulated consuming power, grew much faster than did the real capital stock, viewed as an input to production. Between the two dates, the prices of capital goods increased faster than did consumer prices.

More interesting for present purposes is the pattern across the years 1774–1840. Notice (table 4.3) that consumer prices advanced faster than capital goods prices between 1774 and 1799, and fell faster between 1799 and 1840. Across the full span, 1774–1840, the two index numbers show roughly similar changes, so that the two capital stock series yield about the same results. But the interpretation of the subperiods before 1840 depends entirely on the system of deflation one chooses to use. And the systems of deflation view the capital stock in two quite different ways: as the value of the accumulations of the years, expressed in consumer goods, on the one hand, and as against the productive power of the capital stock, on the other hand.

No doubt the contrast is in some measure spurious, however. Items of construction compose an important part of the capital stock throughout (see table 4.8). The deflators for this component in the years before 1840 were constructed in part from data on wage rates. Wage rates tend to be less volatile than prices (see Margo 1992). The capital stock price index numbers for the period before 1840 may therefore understate the

TABLE 4.3 **Capital stock deflators, base 1860, 1774–1900**

	Domestic capital price index	Consumer price index
1774	81	97
1799	111	148
1805	115	141
1815	157	185
1840	91	104
1850	94	94
1860	100	100
1870	127	157
1880	112	123
1890	96	109
1900	90	101
1929	165	205
1953	357	320
1974		589
1980	1,193	

Sources: See text.

TABLE 4.4 **Indexes and average annual rates of change of the US capital stock, measured in 1860 prices, 1774–1980**

	Deflated by			
	capital price index	**consumer price index**	**capital price index**	**consumer price index**
Panel A. Indexes				
1774	100	100	100	100
1799	289	262	306	271
1805	409	400	449	431
1815	513	525	571	581
1840	1,401	1,472	1,514	1,571
1850	2,212	2,665	2,497	3,007
1860	4,292	5,148	4,849	5,805
1870	5,486	5,335	5,897	5,669
1880	8,462	9,318	9,157	10,071
1890	17,217	18,295	18,665	19,877
1900	24,552	26,347	27,632	29,584
1929	68,472	66,398	77,681	80,390
1953	102,132	137,182	114,109	163,571
1980	223,632		297,638	
Panel B. Average annual rates of change (%)				
1774–1840	4.00	4.07	4.12	4.17
1774–99	4.24	3.85	4.47	3.99
1799–1840	3.85	4.21	3.90	4.27
1840–1900	4.77	4.81	4.84	4.89
1840–60	5.60	6.26	5.82	6.54
1860–1900	4.36	4.08	4.35	4.07
1900–1980	2.76		2.97	
1900–1929	3.54	3.18	3.56	3.44
1929–53	1.67	3.02	1.60	2.96
1953–80	2.90		3.55	
1774–1980	3.74		3.88	

Sources: See text.

fluctuations experienced by the prices of capital goods. It is thus possible that the measured rate of growth of the real capital stock, viewed as an input, is too high across the years 1774–99 and too low between 1799 and 1840. The matter is unlikely to be important with respect to the main point of present concern, however. It seems clear that the rate of growth of the capital stock did accelerate between the 1774–1840 period and the 1840–1900 period.

The capital stock treated so far ignores a component of investment that was important, particularly in the years before 1840: the activities of land clearing and first breaking which engaged so large a part of the working lives of American farmers (Primack 1962). Table 4.5 contains index

numbers describing the change over time in the real value of the domestic capital stock, inclusive of the value of these farm-making activities. The overall rate of growth of this aggregate—3.9 percent over the 1774–1900 period—is much lower than the 4.5 percent recorded for the less comprehensive capital stock treated in table 4.4 (capital stock deflator in each case). These findings reflect the fact that farm formation was a very important part of capital, but one that increased over time much more slowly than the other components of the stock—a point to which we will return.

The acceleration shown by the data in table 4.4 reappears in table 4.5 in a more marked form. But notice that the pattern is somewhat different. The series deflated by the prices of capital now shows a higher rate of growth across the period 1799–1840 than across the period 1774–99, in contrast to the results shown in table 4.4. The explanation is that introduction of the farm-making elements of the capital stock necessarily altered the capital price index numbers. Farm making was carried out by farm

TABLE 4.5 **Indexes and average annual rates of change of the US domestic capital stock, including the value of clearing and breaking farmland, measured in 1860 prices, 1774–1900**

	Deflator	
	Capital price index	**Consumer price index**
Panel A. Indexes		
1774	100	100
1799	227	245
1805	290	332
1815	353	379
1840	913	1,229
1850	1,362	2,140
1860	2,432	3,980
1870	3,004	3,884
1880	4,520	6,543
1890	8,491	12,229
1900	11,807	17,253
Panel B. Average annual rates of change (%)		
1774–1840	3.35	3.80
1774–99	3.28	3.58
1799–1840	3.39	3.93
1840–1900	4.27	4.40
1840–60	4.90	5.88
1860–1900	3.94	3.67

Sources: See text.

TABLE 4.6 **Indexes and average annual rates of change of the US domestic capital stock and structures, per capita, using conventional and unconventional concepts, measured in 1860 prices, 1774–1980**

	Conventional concept		**Including land clearing**	
	Deflated by		Deflated by	
	capital price index	consumer price index	capital price index	consumer price index
Panel A. Indexes				
1774	100	100	100	100
1799	132	120	104	112
1805	154	150	109	125
1815	143	147	99	106
1840	193	202	126	169
1850	224	270	138	217
1860	321	384	182	297
1870	323	315	177	229
1880	396	436	212	306
1890	643	683	317	456
1900	759	815	365	534
1929	1,461	1,461		
1953	1,520	2,294		
1980	2,735			
Panel B. Average annual rates of change (%)				
1774–1840	1.00	1.07	0.35	0.80
1774–99	1.11	0.73	0.16	0.45
1799–1840	0.93	1.27	0.47	1.00
1840–1900	2.28	2.32	1.77	1.92
1840–60	2.54	3.21	1.84	2.82
1860–1900	2.15	1.88	1.74	1.47
1900–1929	1.98	2.01		
1929–53	0.50	1.88		
1953–80	2.18			
1774–1900	1.60	1.67		
1900–1980	1.61			
1774–1980	1.61			

Sources: See text.

laborers, and the value of farm making is the value of the time of farm workers. Farm wage rates thus figure in the estimation of the value of land clearing and breaking, as well as in the deflation of these components of the stock. Farm wage rates rose quite pronouncedly between 1774 and 1840, and that gives the deflator an upward tilt.

All of the series discussed above refer to the aggregate capital stock. A more interesting variable, however, is the per capita capital stock. Estimates appear in table 4.6. Deflating by population produces two important

results. First, the retardation of growth in the twentieth century disappears, while the acceleration between 1774–1840 and 1840–1900 becomes very much more pronounced. The acceleration appears in every variant but is particularly evident in the series describing the most comprehensive measure, deflated by capital stock prices.

The acceleration in the rate of growth of the capital stock reflects in part the increase in the investment rate and the rise in the capital-to-output ratio, which seems to have begun as early as 1800, at least in the case of the conventional measurements, but which was particularly pronounced from 1840 until 1900 (Davis and Gallman 1978; table 4.7). That does not appear to be the only source, however. The rates of growth of real national product per capita from 1840 onward were higher than the rates of growth of real capital per capita in the period before 1840, regardless of the capital concept adopted and the deflator employed (Davis and Gallman 1978; Gallman 1966). Accepting the rate of change of the capital stock series before 1840 as an upper-bound estimate of the rate of change of real national product, the evidence suggests quite clearly that the rate of growth of real national product per capita accelerated in the years before the Civil War.

These results are generally consistent with Thomas Weiss's inferences concerning income, which he derived from his labor force series (see table 4.7 and Weiss 1992). Both Weiss's figures and the capital stock data were assembled from fragmentary evidence and are subject to substantial

TABLE 4.7 **Real GDP and real domestic capital per capita, using conventional and unconventional concepts, measured in 1840 prices, 1800–1860**

	1800	1840	1860
Real GDP per capita (in dollars)			
Conventional, variant A	73	91	125
Conventional, variant B	66	91	125
Unconventional, variant C	78	101	135
Real domestic capital per capita (in dollars)			
Conventional	104	157	262
Unconventional	175	219	316
Capital-to-output ratios			
Conventional, variant A	1.42	1.73	2.09
Conventional, variant B	1.57	1.73	2.09
Unconventional, variant C	2.24	2.16	2.34

Sources: The real GDP per capita estimates are from Weiss 1992. For the remaining estimates, see the text.

margins for error. But both series seem to tell about the same story, and that affords greater confidence that the story is a true one.[8]

4.5. Changing Composition of Capital Stock

Rates of change say something about the process of growth and development; data on the structure of the economy tell more. Development consists of structural change.

The conventional measure of domestic capital, in current prices, exhibits two pronounced compositional shifts: the fraction of the capital stock accounted for by animals drops very far indeed, while the share attributable to structures rises—both developments occurring chiefly after 1815 (see table 4.8). But current price data are not so useful in this context as are constant price data, which tell a very interesting story. They show that the structure of the capital stock changed very little, down to 1840. Thereafter, there were accelerating shifts. The share of animals in the total dropped precipitately and inventories dropped mildly, while the share of structures rose a little and the share of equipment rose very much. There is the strong suggestion of an economy shifting in the direction of industrial activity and modern economic growth: away from agriculture and animal power, and toward manufacturing and mechanical power. There is no question that stirrings can be identified well before 1840—Kenneth Sokoloff's (1992) work shows clearly that important industrial change can be dated to 1820 at least. But these activities could not have carried a very heavy weight in the economy much before 1840, and that is what the data in table 4.8 are showing us. Bias in the estimates may overstate the decline in the relative importance of animals after 1870, and may contribute to the finding of stability in the share of structures in the capital stock before 1840, but these matters are probably not of much importance.

The introduction of the value of farm making into the capital stock produces some expected shifts. Concentrating on the constant price data, the value of land clearing and breaking accounted for more than half of the capital stock in 1774 and something less than half in 1799. This figure dropped modestly to 1840—when it was a little less than a third—and more dramatically thereafter, reflecting the relative decline of the agricultural sector. In this variant, inventories retained roughly the same share of the capital stock after 1799, while the share of structures experienced a strong upward movement from the same date.

TABLE 4.8 **Constituents of the domestic capital stock, expressed as shares in the domestic capital stock, 1774–1900**

	1774	1799	1805	1815	1840	1850	1860	1870	1880	1890	1900
Panel A. Excluding the value of farmland clearing and breaking											
Measured in current prices											
Structures	0.39	0.33	0.35	0.41	0.45	0.47	0.54	0.54	0.55	0.61	0.60
Equipment	0.13	0.14	0.15	0.13	0.14	0.13	0.12	0.11	0.11	0.13	0.14
Inventories[a]	0.23	0.35	0.34	0.26	0.24	0.26	0.22	0.24	0.24	0.19	0.19
Animals	0.25	0.18	0.16	0.21	0.17	0.13	0.12	0.11	0.09	0.08	0.07
Measured in 1860 prices											
Structures	0.40	0.34	0.40	0.41	0.43	0.46	0.54	0.55	0.50	0.49	0.46
Equipment	0.08	0.09	0.09	0.07	0.08	0.09	0.12	0.13	0.16	0.25	0.30
Inventories[a]	0.28	0.35	0.32	0.29	0.26	0.27	0.22	0.22	0.25	0.21	0.19
Animals	0.25	0.23	0.19	0.22	0.23	0.17	0.12	0.10	0.09	0.06	0.04
Panel B. Including the value of farmland clearing and breaking											
Measured in current prices											
Structures	0.24	0.21	0.26	0.33	0.33	0.35	0.42	0.44	0.47	0.55	0.55
Equipment	0.08	0.09	0.11	0.10	0.10	0.10	0.09	0.09	0.10	0.11	0.13
Inventories[a]	0.14	0.23	0.24	0.21	0.18	0.20	0.17	0.20	0.21	0.17	0.18
Animals	0.15	0.11	0.12	0.17	0.12	0.10	0.09	0.09	0.08	0.07	0.06
Land clearing	0.40	0.36	0.28	0.19	0.28	0.25	0.22	0.17	0.14	0.10	0.08
Measured in 1860 prices											
Structures	0.17	0.19	0.25	0.27	0.29	0.33	0.42	0.44	0.41	0.44	0.42
Equipment	0.04	0.05	0.05	0.05	0.06	0.07	0.09	0.11	0.13	0.22	0.28
Inventories[a]	0.12	0.20	0.20	0.19	0.17	0.19	0.17	0.18	0.21	0.19	0.18
Animals	0.11	0.13	0.12	0.14	0.15	0.12	0.09	0.08	0.07	0.05	0.04
Land clearing	0.56	0.44	0.39	0.36	0.32	0.28	0.22	0.19	0.17	0.11	0.08

[a]Excluding animals
Sources: See text.

TABLE 4.9 **Indexes of per capita real magnitudes, measured in 1860 prices, 1774–1900**

	1774	1799	1805	1815	1840	1850	1860	1870	1880	1890	1900
Structures	100	112	156	150	211	263	438	449	503	793	886
Equipment	100	142	166	133	202	262	479	538	785	1,981	2,867
Inventories[a]	100	166	176	149	178	218	253	258	360	479	526
Animals	100	122	121	130	179	154	154	126	139	148	132
Land clearing	100	81	74	64	73	70	72	62	66	60	55

[a]Excluding animals
Sources: See text.

Table 4.9 is another way of considering the same phenomena. It shows indexes of the per capita supply of each component of the capital stock. The growing importance of structures and, particularly, equipment comes through powerfully, while the value of the stock of land clearing and first breaking is shown to have fallen well behind the growth of population. There were two elements involved in the production of this result. First, the volume of farmland per capita declined over time, as the population became less and less rural and farm-centered. Since American agriculture was able to feed a growing population and expand its overseas sales, the decline in the value of farm improvements per capita went hand in hand with the growing productivity of agricultural land. Second, as population moved westward, out of the wooded areas, the cost of preparing land for cultivation fell. Toward the end of the nineteenth century, then, the real value of farm improvements (exclusive of structures) per acre was smaller than it had been in the eighteenth century.

On the whole, the structural evidence supports the conclusions that one might tentatively draw from the aggregate series: the American economy began to experience the process of modern economic growth in the years after the War of 1812; by the 1840s the modern components of the economy were large enough and growing rapidly enough to have an observable impact on the rate of growth and the structure of the economy.

4.6. The Growth of Total Factor Inputs

The measurements of the capital stock, viewed as an input to the productive process, yield information that clearly bears on the speed and nature of American economic growth. Measurements of total factor inputs would be even more useful. The assembly of the additional required inputs is not

very difficult. Estimates of the volume of agricultural land (the only land input that could be taken into account) already exist. (Gallman 1972, 201–2). Weiss has generated new labor force figures for the years 1800–1900, at ten-year intervals, and they were readily extended to 1774.[9]

Table 4.10, panel A, reports the rate of growth of labor, land, and capital inputs (in total and per capita) for various periods between 1774 and

TABLE 4.10 **Rates of growth of factor supplies, factor supplies per capita, and total factor productivity, 1774–1900**

	1774–1800	1800–40	1840–1900	1840–60
Panel A				
Labor force (LF)	3.09	3.09	2.72	3.41
LF/population	–0.08	0.11	0.20	0.31
Land	2.26	2.80	2.17	2.87
Land/population	–0.91	–0.18	–0.35	–0.23
Capital (K)	3.39	3.45	4.40	5.17
K/population	0.22	0.48	1.88	2.07
Panel B				
Total factor inputs, LF	3.10	3.18	3.20	3.91
Total factor inputs/ population, LF	–0.07	0.20	0.68	0.81
Total factors, inputs, LFQV	3.21	3.44	3.75	4.78
Total factor inputs/ population, LFQV	0.04	0.46	1.23	1.69
Total factor inputs, LFQF	3.25	3.47	3.57	4.41
Total factor inputs/ population, LFQF	0.08	0.49	1.05	1.31
Panel C				
Total factor productivity				
GDP, LF		0.46		0.82
GNP, LF			0.80	0.70
GDP, LFQV			0.25	–0.17
GDP, LFQF			0.43	0.20

Sources: The real GDP estimates underlying the first set of total factor productivity estimates (panel C) are from Weiss 1992 (broad concept, variant C). They are expressed in 1840 prices, as are the capital stock estimates (domestic capital) used with them to estimate total factor productivity.

The real GNP estimates (panel C) were derived from those underlying Gallman 1966. They are expressed in 1860 prices and include the value of all land improvements made in the given year and the value of home manufactures. The capital stock estimates used in the analysis involving the GNP refer to the national capital stock. The labor input series is based on Weiss's labor force figures. LF refers to this series in unadjusted form. LFQV means that the labor force has been adjusted to take into account differences in work time and labor quality, both among sectors and over time (1840 onward); that is, the sectoral "weights" are variable. LFQF means that the labor force figures have been adjusted to take into account differences in time and quality among sectors, but not across time; that is, the sectoral "weights" are fixed. (In fact, the weights employed are those of 1880; only two sectors are distinguished in the fixed weight variant: "agriculture" and "all other.") See text.

The rates of growth of the capital stock, 1840–1900, were computed from the series that incorporates the value of fencing.

The weights assigned to the rates of growth of the individual factors of production are labor, 0.68; land, 0.03; and capital, 0.29. These weights are intended to reflect income shares. Land improvements are treated as capital.

1900. Notice that the labor force grew slightly more slowly than population between 1774 and 1800 and a little faster between 1800 and 1840. Thereafter, with the expansion of immigration and its effect on the structure of population, the labor force participation rate rose faster than before. On the whole, the patterns of change of the other inputs are similar. The volume of agricultural land per capita actually declined throughout, but the rate of decline was less after 1800 than before, while the quantity of capital increased faster than population, the rate rising persistently over time. The strong suggestion of these data is that the per capita supply of all inputs, taken together, must have grown very slowly, if at all, down to 1800, when it began to increase, the increase becoming more marked as time passed.

This, in fact, is what is shown by table 4.10, panel B, which sets out the rates of change of all three factors combined. The rates of growth of total inputs and inputs per capita accelerated over time, the change in the per capita rates being particularly striking.

There are three series describing rates of change of aggregate inputs. In the first, the underlying labor input is measured by the numbers of workers, without regard to the length of the work year or the differential quality of the workers. In the second (LFQV) and third (LFQF), very crude efforts have been made to adjust the labor supply for quality change. (The techniques employed to make the LFQV and LFQF estimates are described in the next subsection.) The adjustments are almost certainly too large. That is, the rates of change represented by LFQV—and possibly by LFQF as well—are probably too large. The three sets of figures, however, may very well establish boundaries within which the rates of change of a properly adjusted labor input series would lie.

4.6.1. Labor Quality Adjustments

This subsection describes the time-quality adjustments that were made to the labor force estimates to create LFQV and LFQF. These adjust, in admittedly crude ways, the labor supply for sectoral differences in the work year, trends over time in the work year, and differences among sectors in the "quality" of workers. In series LFQV, the weights by which the rates of change of the three input series are combined (estimated factor income shares) vary from one year to the next; in series LFQF, the weights are fixed at the 1880 levels. Thus, the Q stands for varying weights, and F for fixed weights.

The adjustments were made in two steps. First, the farm labor force figures were adjusted to take into account changes in the farm work year.[10] Then quality-time weights were devised for the two remaining sectors that could be readily distinguished: mining, manufacturing, and hand trades, and all others. The weights consisted of the ratio of labor income per worker in the relevant sector to labor income per worker in agriculture. Since two of the important factors accounting for sectoral differences in labor income per worker are the relative duration of the labor year in each sector and the relative quality of workers in each sector, one is perhaps justified in referring to these ratios as time-quality weights. Unfortunately, however, other factors irrelevant to the time-quality adjustment also affect intersectoral differences in labor income per worker. Sectoral labor income deviations arose out of shortterm disequilibria in labor markets, as well as from enduring quality differences among workers. Furthermore, some part of the variations in labor income surely reflected regional and urban/rural price differences, rather than real income disparities. It is likely that both of these factors typically operated to widen the gaps between labor incomes in agriculture and the other two identified sectors, each of which enjoyed higher labor incomes per worker than did the agricultural sector. Since the labor forces attached to these two sectors were growing faster than the agricultural labor force, the excessive time-quality weights given these sectors mean that the rates of change of the time-quality adjusted labor series are biased upward. The present status of regional and urban/rural price series does not permit an appropriate deflating of the labor income series, and there is no way of knowing how serious the bias arising out of disequilibria in labor markets is.

There are other difficulties with these measurements.

1. It would be helpful to have detailed breakdowns of the labor force and labor earnings so that a more fully articulated weighting scheme might be developed, but adequate data simply are not available.
2. Sectoral labor income estimates were developed from value-added data. Value-added estimates involve some double-counting. If the extent of double-counting varied from one sector to another, the labor income estimates would not be good indexes of the true relative sectoral labor incomes. It is quite unlikely that this problem is serious.
3. The labor income estimates were taken as residuals, the difference between total sectoral income and sectoral property income. Property income was estimated as the product of the value of capital and land and estimated rates of

TABLE 4.11 **Average sectoral rates of return, percentages per annum**

	1840	1860	1880	1900
Agriculture	11.6	11.0	9.4	7.6
Manufacturing and Mining	13.0	12.6	10.9	9.4
All other	13.2	12.5	10.7	8.9

Source: See text.

return. Since the estimates of inventories could not be distributed among sectors, property income was computed against the value of land and fixed capital only. If the relative importance of inventories varied by sector, the sectoral property estimates are biased. Unfortunately, there is no way to be sure that this was not the case, although it is unlikely that it is a major source of bias.

4. More important, the system of estimating property incomes involved the assumption that the rate of return on property *of a given type* was the same in all sectors. In fact, this is unlikely to have been the case. Bateman and Weiss (1981, 107–8, 114) show that the returns to property in the antebellum South were much higher in manufacturing than in agriculture. The rates of return do vary from one sector to another, as the structure of the capital stock varies; only the rates for individual types of property are constant. But the differences in the average rates that have emerged are small, compared with those observed by Bateman and Weiss. Table 4.11 displays the average rates of return by sector. Bateman and Weiss (1981, 116) report rates of return for large manufacturing firms of 17 percent in 1850, and 21 percent in 1860. Unfortunately, there is no good basis for producing different sectoral rates of return for all types of property for all sectors in all years. We can be quite sure, however, that the procedure followed to produce labor income estimates has led to an exaggeration of the relative levels of labor income in the "mining, manufacturing, and hand trades" sector, and probably in the "all other" sector as well. This in turn means that the time-quality weights attached to the nonfarm sector labor forces are too high and that, therefore, the rates of change of the adjusted labor series are biased upward.

The sectoral value-added series (current prices) were taken from Gallman (1960, 47, 54, 56, 63) and from Gallman and Weiss (1969, 305), and were adjusted in the following ways. The estimates of farmland improvements were dropped from farm value-added, and new estimates derived from data in Brady (1966) were substituted for them.[11] Value added by the "all other" sector was estimated from the value added by construction from Gallman (1960, variant A) plus the total value added by services

from Gallman and Weiss (1969), minus the value of shelter and value added by the hand trades. The value of shelter was dropped because the production of shelter involves the use of practically no labor, and therefore the value of shelter should not figure in the estimation of sectoral labor quality weights. Value added by the hand trades was added to value added by manufacturing and mining, taken from Gallman (1960).

The gross rate of return for each type of property is composed of the net rate plus depreciation, if any. The following depreciation rates were assumed: Land, 0; animals, 0; buildings, fences, irrigation, and drainage works, 2 percent; land clearing and breaking, 0; tools and equipment, 6.67 percent. The net rate of return was taken to be 10 percent in 1860, and was adjusted in the other years on the basis of an index number of the rate of return on New England municipal bonds (Homer 1963, 287–88, linked at 1857–59 to Boston City 5s, 305).

The labor force data were drawn from Weiss (1992). The division of the nonfarm labor force between the two nonfarm sectors was based on Lebergott (1964).

The adjustment for changes in agricultural work hours was based on data in Gallman (1975, 73), and the David, Lebergott, and Weiss series. From Gallman (1975, 73, inclusive of improvements, variant B) and the David and Lebergott farm labor force series, it was possible to compute an index of the hours worked by farm laborers in 1800, 1850, and 1900. With this index and the Weiss farm labor force in each of these three years, an index of the number of hours worked per worker was computed. Index numbers for the missing intermediate years were interpolated on a straight line. The index for 1774 was assumed to be the same as the index for 1800. The aggregate quality-adjusted labor force series were then adjusted for changes in the number of hours worked by multiplying them by the index of hours worked per worker.

4.6.2. Output Elasticities

The section takes up the estimation of the elasticities of output with respect to factor inputs. The procedure adopted to make estimates of the elasticities of output was similar to the one by which labor and property incomes were computed for the three sectors. The only difference was that the calculations were made at the national and not the sectoral level, and that components of capital left out of the sectoral calculations—inventories, the international sector—were here added back in.

These elasticities are necessary to weight the factors of production to make estimates of the combined inputs and total factor productivity changes. The weights assigned to the rates of growth of the individual factors of production are as follows: labor, 0.68; land 0.03; and capital, 0.29. Land improvements are treated as capital. These weights are intended to reflect income shares and the elasticities of output with respect to factor inputs.

4.6.3. Growth Accounting

In any case, the rates of change of the combined input series do describe the same general pattern: an acceleration in the supply of inputs and especially inputs per capita. For the period following 1800, these findings once again parallel Weiss (table 4.7). Furthermore, there was an acceleration not only in the rate of change of aggregate inputs, but also in total factor productivity: the long-term rate of gain was substantially higher after 1840 than before (table 4.10, panel C).

These results are surely not surprising. The period from 1774 through 1815 encompassed years in which the young country engaged twice in major wars. When peace was achieved, American products were frequently prevented from entering their natural markets under reasonably free conditions. There was one period of booming trade, when the Napoleonic Wars created great opportunities for American merchants—opportunities ended by the Embargo of 1807 and then the War of 1812. With the return of peace, the factory system began to spread in earnest, and by 1840 the production of textiles had been virtually completely transferred out of the home and the shop and into the factory. The variety of American manufacturing activities increased markedly in the 1840s and 1850s, and machine building began to assume the central position it was to occupy in American industrialization for the rest of the century. The aggregate statistics are simply the embodiment of these well-known developments. The degree to which the benefits of economic growth were offset by costs unrecorded here, and the extent to which the benefits were shared among Americans, are matters of considerable importance.

4.7. Conclusions

The conclusions of this chapter are readily summarized. The capital stock series suggest that the pace of American economic growth accelerated in

the decades before the Civil War. The evidence for this statement is to be found in the real per capita capital stock figures, the various estimates of aggregate real inputs per capita, and the changing structure of the capital stock. The components that make up the series have their weaknesses, but the review conducted above turned up no compelling reasons to believe that the computed rates of growth and structural changes are biased in important ways.

The acceleration of the rate of growth should not be allowed to obscure the progress made before 1840. The series assembled in this chapter support the view that per capita GDP increased in the decades between 1800 and 1840. Furthermore, the per capita supply of capital seems to have been increasing since 1774, and the combined supply of all factors of production seems to have increased at least as fast as population between the beginning of the American Revolution and 1800. There were bad times as well as good ones, and the standard of life surely sometimes declined, perhaps for extended periods. But if these series are to be believed, the trend was mildly favorable between 1774 and 1799/1800, more clearly favorable from 1799/1800 until 1840, and even more pronouncedly favorable thereafter.

Combining the results of this chapter with those in chapter 3, we observed that expansion of the real capital stock in the United States was more rapid in the 1840–1900 period than in the 1744–1840 period or in the post-1900 period. The next two chapters examine capital formation from a different perspective; namely, from Gallman's series on annual product flows.